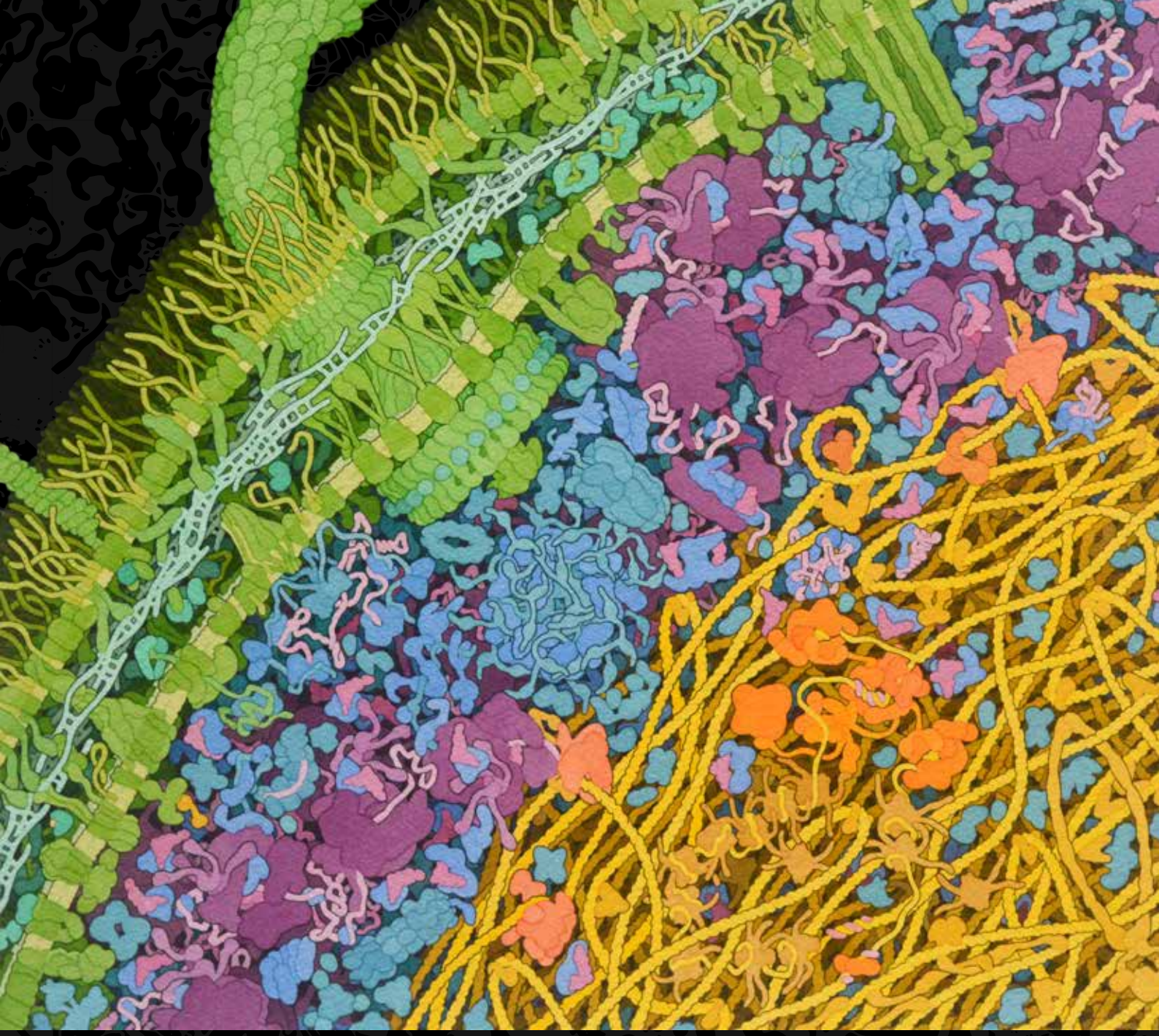

FOOD SAFETY FORESIGHT BEYOND 2030

FIA FOOD INDUSTRY ASIA

Reciprocom

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ONLINE FORESIGHT COLLABORATION

An online foresight dashboard (pictured above) allowed experts to confer and collaborate to provide insights and identify drivers, trends and strategic problem statements in the course of the development of this work. A keyword horizon scanning system updated on current issues, and libraries briefed experts on the past and present food safety situation in Asia-Pacific.

TIME HORIZON—"BEYOND 2030"

2030 is a critical juncture in food and agriculture, with the UN SDGs and other targets reaching maturity. The forecast time horizon of this work extends beyond 2030, keeping in view the typical business cycle of 10 years, the cyclical nature of food safety developments and UNDP's planning horizon recommendation of 25 years.

See UNDP (1986). "Reclaiming our Future."

Cover, back cover, and TOC page illustrations by David S. Goodsell, RCSB Protein Data Bank.

Cross-section of E.coli cell,

doi: 10.2210/rcsb_pdb/goodsell-gallery-028

E.coli is responsible for a range of foodborne diseases, see Global Burden of Disease Study 1990-2016

This work was co-developed by

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EXECUTIVE SUMMARY

Food safety is a vital ongoing task essential to a safe, secure and sustainable food system. Its critical challenges are mired in complex interconnections and hidden relationships. History has shown that the most damaging breakdowns in food safety were largely unexpected, the complex and often chaotic confluence of events surrounding the manifestation of known unknowns.

Gradual improvements in food safety will emerge through more creative thinking as part of multi-faceted, chain-linked, adaptive, and agile approaches. Broad system-level interventions (both food systems and regulatory actions) to address networks of interlinked conditions are keys to building resilience and robustness in food safety and satisfying the reference narratives of food chain actors and consumers.

Foresight assists strategic decision-making through identifying critical challenges today and setting sights on guiding policies as part of coherent actions within the food system. Food safety interventions must be rigorously discussed, designed, and tested, and this work provides a scheme for such, combining creative appraisal and insight across several dimensions. We demonstrate that there is much more to food safety in Asia than building capacity, surveillance systems, and attempts to fix outdated and fragmented regulatory frameworks.

This work is the first to employ morphological analysis in producing food safety scenarios, both baselines and alternatives. These scenarios uncover hidden patterns, interconnections, and implications within a tightly coupled system. Scenarios unmask beliefs around food safety risks that other perspectives—psychological risk perception and health belief models—perhaps fail to recognise.

The baseline scenarios—the most likely futures—show food safety within the food system improving incrementally, resisting turbulence, and through technology and innovation, meeting future threats (whatever they may be) while realising societal benefits.

The alternative scenarios crafted through a VUCA-based (Volatility, Uncertainty, Complexity, Ambiguity) food system worldview showed that strategic clarity could be achieved in positioning food safety within a dynamic food system. Here, food safety risks interact positively and negatively as chain-linked conditions. The configuration or design of multiple actions around food safety will make the "preventative approach", enshrined in food safety regulatory modernisation efforts, a reality. The emphasis on rapid diagnosis, data analysis and mobilisation remains clear.

The VUCA scenarios demonstrate the importance of social-economic-environmental factors and the configuration/interplay of conditions within these dimensions. For greater resilience, food safety governance must look beyond politics, legislation, traceability, and transparency. Never have such areas been so well developed, but food safety threats will be realised, and incidents will occur. The opportunities afforded by robust and resilient systems, particularly in sustainable innovation, across the developed and developing worlds, will only be realised via a coherent framework of policy integration and restructuring with due attention to social, economic, and environmental conditions. Meeting critical challenges requires adaptation, experimentation and even redesign. Harmonisation and modernisation have occupied priority positions in non-market approaches to food safety management. They should be repositioned as part of broader political activities in integration, focus and mobilisation of political will. Sustainable innovation—product, process and marketing—should not be impeded by precautionary standards, particularly those based on subjective risk perception or probabilistic forecasts that reach the unknown.

Understanding the definitive strategic challenges can be significantly facilitated by this foresight approach. Foresight, preparedness, robustness and resilience summarise how this work points to 'Beyond 2030' with food safety a key attribute within a sustainable food system.

INTRODUCTION AND APPROACH

Food safety is complex, or as Ackoff (1974) defined a "wicked problem." It is not easily quantified in several respects (drivers, risks, solutions, outcomes) and presents some unresolvable or "epistemic" uncertainties. It requires a subjective or judgemental approach to analysis, problem identification and action. Food safety is challenged by time, testability, scale, complexity, and uncertainty. A new approach to food safety strategy is warranted, spanning social, technical, economic, environmental, and political dimensions.

Food safety outcomes are defined by periods of inertia where the status quo prevails, and such periods are critical to consumers in shaping food safety attitudes. They help define a "reference narrative": attitudes and beliefs around everyday risks. This is the expectation and confidence that events will go as expected for consumers. Food is generally safe, and consumers have access to a range of information and skills in addition to their innate senses (broad sensory recognition of spoilage—visual, gustatory and olfactory) and cognitive/psychological processes to food stimuli such as food disgust and neophobia. Strong observed preferences for 'naturalness' and 'freshness' in perishables and short shelf-life products can help spot tell-tale signs of spoilage or contamination. Consumers use all the cues available (intrinsic, extrinsic and credence), including label disclosures, to test the reference narrative each time they prepare or consume. Consumers' confident expectations and adaptive reasoning—primarily based on experience most of the time—shine through.

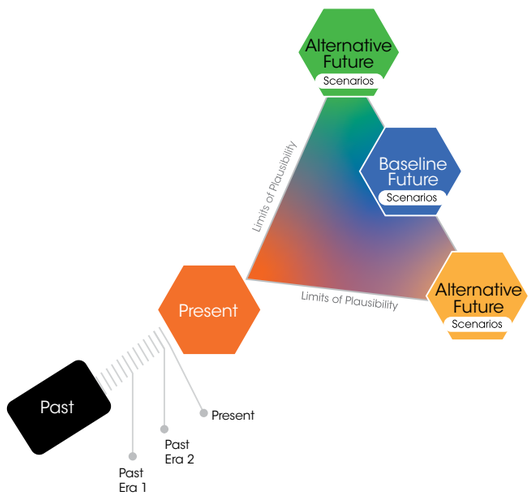


Figure 1. Futures development concept.

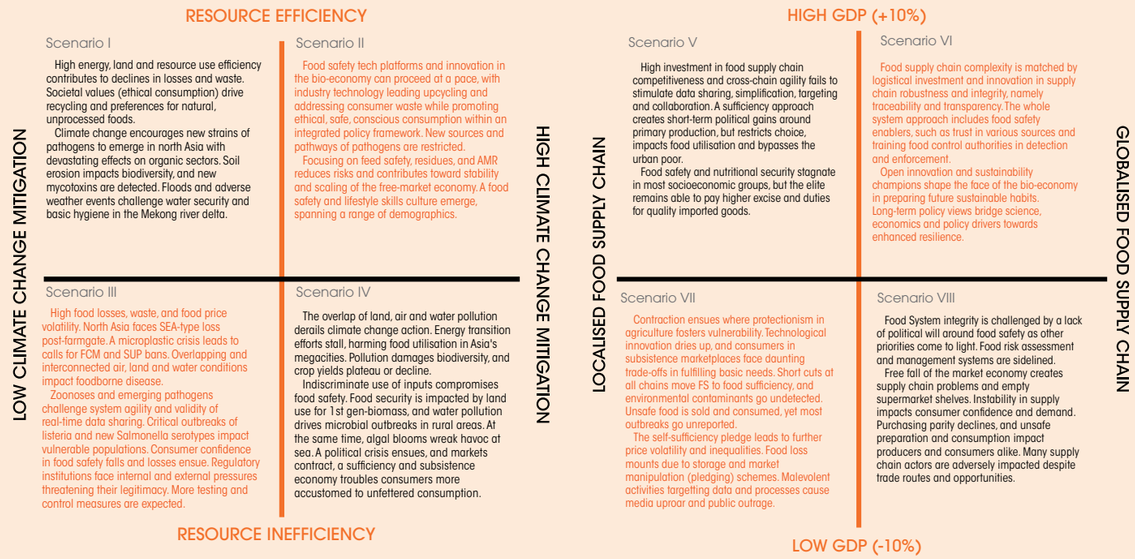
There are, however, times when the confident expectations are not met, turning the anticipation and joy of consumption into a loss—of health, economy, time and lifestyle.

Food safety's most severe adverse events were a confluence of events that combined in unexpected and largely unforeseen ways. Plant failures, human negligence, catastrophic errors, malevolence or organisational failures. These could not be predicted or mapped under any probabilistic approach and are non-linear events. Normal accidents or chaos theory has been used to try and unravel the mysteries of foodborne incidents, the results of "the interaction of multiple failures that are not in operational sequence" (Perrow, 1999; p.23).

No amount of anticipation or emerging risk analysis, assessment, or horizon scanning could have foreseen or even prevented these critical incidents. If it had, then the events would not have occurred. The inertia, norms and status quo were punctuated by discontinuity, volatility and chaos.

THE CONVENTIONAL APPROACH

And yet, much of the approach to food system management, and its guiding policies, are vested in the orthodoxy of what is known and what can be measured or contained by rules, standards, inspections and testability in general. A rigid set of rules for problems that are often unknowable, epistemically uncertain, chaotic and subject to the vagaries of human perception and behaviour. A good deal of probabilistic reasoning is applied to food safety systems that are anything but stationary and owe much



Figures 2, 3. Food Safety Scenarios I-VIII Developed using RDS/GBN Method.

Eight scenarios were developed focused on economic and environmental factors using the "dimensions of uncertainty" method popularised by Shell/GBN. While this method oversimplifies food safety because it only considers two conditions per grid, it can be used as a quick and frugal method to gain preliminary insights, as in this case. Morphological analysis was applied in this work to consider a fuller range of conditions and their real-world interplay.

of their reflexivity to social phenomena. Raising food standards is a common refrain, adherence to which is often assumed and barriers to which—authorities, consumers and small-and-medium-sized enterprises—may not be accounted for.

Food safety is challenging to diagnose in actual strategic terms. It has been treated the same way for decades, defaulting to generalised objectives and hypothetical risk identification. Repetitive cycles of incident-crisis-recovery-regulation persist, but this cycle has limits, as data shows. Despite food never being so safe as today and statute books so voluminous, the burden of foodborne disease is as high as ever. How can the problems of food safety be approached strategically?

Foresight work in food safety could help reshape thinking and open the mysteries to more creative, rigorous, and practical approaches grounded in the reality of narratives and scenarios to foster conversations about the future.

The central aim of this work was to use foresight to explore plausible conversations about versions of food safety in Asia 'Beyond 2030.' The foresight approach is helpful in modelling 'messy' problem systems that are complex, uncertain and difficult to quantify. Foresight can provide compelling evidence toward developing coherent strategic direction, namely in identifying critical challenges, approaches/policies to addressing them, and areas of integration/convergence in implementing actions.

The framework provides logical steps toward identifying various conditions (drivers, issues, past events, eras, viewpoints) that can be assembled according to different lenses or perspectives of the system's future state. The reassembly process is one of "re-imagination" as scenarios, 'versions or frames of the future' with resulting strategic conversations.

The narratives revealed by the scenarios are essential to navigating resolvable uncertainty in food safety. This work's critical value adds to addressing gaps in reasoned deliberation and coordinated, proactive action in the pursuit of robustness and resilience.

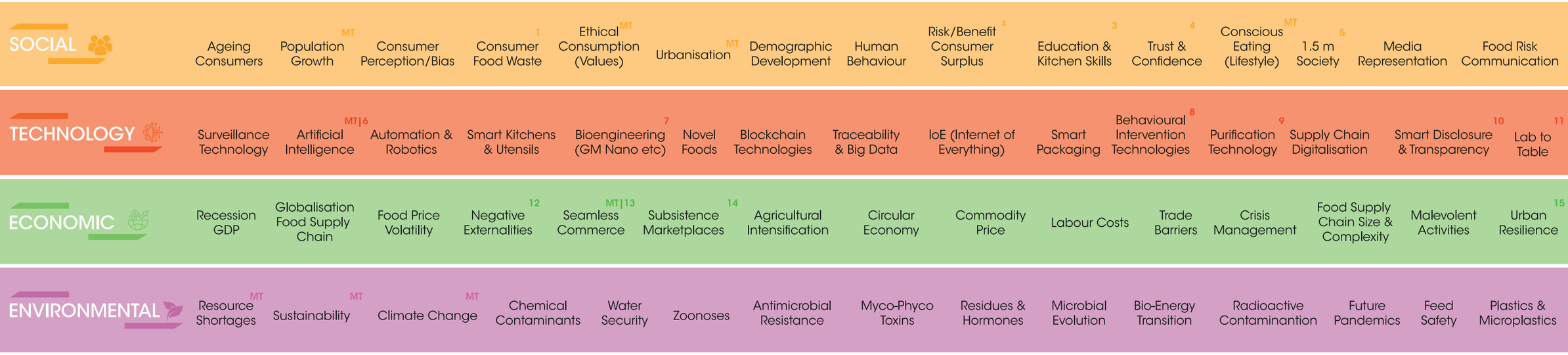
THE FOOD SAFETY PROBLEM UNIVERSE

The food safety problem universe represents the key drivers, trends, and risks of food safety. It was developed in consultation with an industry expert group and through a research process that reviewed all pertinent work in the peer review from 1990 to early 2022. Within the problem universe (see Figure 4), a complex array of conditions and several "megatrends" spanning all dimensions are seen. This is the foundation 'morphological grid,' from which options are narrowed to produce the baseline, stakeholder focus, and alternative scenarios.

STEEP & FOOD SAFETY

STEEP (Societal, Technological, Economical, Environmental, and Political) analysis provided the overall framework for the food safety problem universe. In technical terms, the STEEP dimensions are the 'parameters' around which the food safety conditions are mapped. This was based on the hypothesis that despite advances in technical and political elements of food safety, future outcomes would depend as much upon the social, economic, and environmental dimensions as those in, say, surveillance, testing, information disclosure and regulatory affairs.

STEEP analysis (Aguilar, 1967) looks at the relevant trends/issues/cycles of food safety to evaluate the importance of guiding principles and actions for specific scenarios. STEEP analysis is a critical strategic decision-making tool to give a comprehensive view of threats and opportunities within an organisation, sector, or thematic area.



SOCIAL (SOC.)
1. Food waste classified a social issue but occurs in multiple dimension | **2.** Consumer surplus refers to welfare gains via consumption | **3.** Kitchen skills is merger of food safety education with culinary skill | **4.** Trust in Food Chain Actors, Confidence in Food Safety| **5.** 1.5m society is post-COVID-19 sustained behaviour change of publics.

TECHNOLOGICAL (TEC.)
6. AI is a "megatrend" including Neuromorphic hardware, AI assistants, cognitive computing, creative AI, emotion AI etc | **7.** Bioengineering also includes bionics and biomimetics powered by AI | **8.** Behavioural Intervention Technologies include AI drive chatbots to individually counsel consumers on food safety issues | **9.** Purification technologies include edibility biosensors, the use of plasma, ionization and UV-C | **10.** Smart disclosures include machine-readable labels and "choice engines" (including mobile apps) to interpret data | **11.** Lab to Table covers expansion of bioreactors and diversification of food sources (algae/insects).

ECONOMIC(ECO.)
12. Negative externalities refers to internalisation of costs to tax products to cover external health/environmental cost | **13.** Seamless Commerce refers to developments in platforms and hybridisation of retail/online, and last mile solutions | **14.** Subsistence marketplaces are low socio-economic position economies where communities struggle to meet basic daily | **15.** Urban resilience is the movement towards robust, adaptable infrastructures, focussed on food and energy needs.

POLITICAL (POL.)
16. Governance (Paternalism) on the hard/soft intervention style of government | **17.** Political will to the prioritisation of food safety matters within food/health policy | **18.** Institutional Capacity is the ability of agencies to carry out basic detection/enforcement of standards | **19.** Food system view (UN) refers to the UNFAO/CFS holistic view of sustainable food systems including food security considerations at all points of the food supply chain (supply- and demand-side) | **20.** Food security "Productionism" is a predominantly supply-side view of food security and the population vs. production | **21.** Political focus is institutional and policy fragmentation/coherence across ministries | **22.** Regionalisation covering concepts around regional cooperation and long term food system priorities| **23.** Geopolitical forces include cooperation between international food safety experts and institutions.

MT Indicates "Megatrend" defined as "complex combinations of economic, political, cultural, philosophic, and technological factors, broader in scope, longer in duration and more impactful in scope than normal trends, and extensive in their impact by tending to shape all aspects of society." They "are embedded in the contexts of their time as a product of the residue of previous megatrends." (Mittelstaedt et al., 2014) .

Figure 4. The Food Safety "Problem Universe."

THE BASELINE SCENARIO

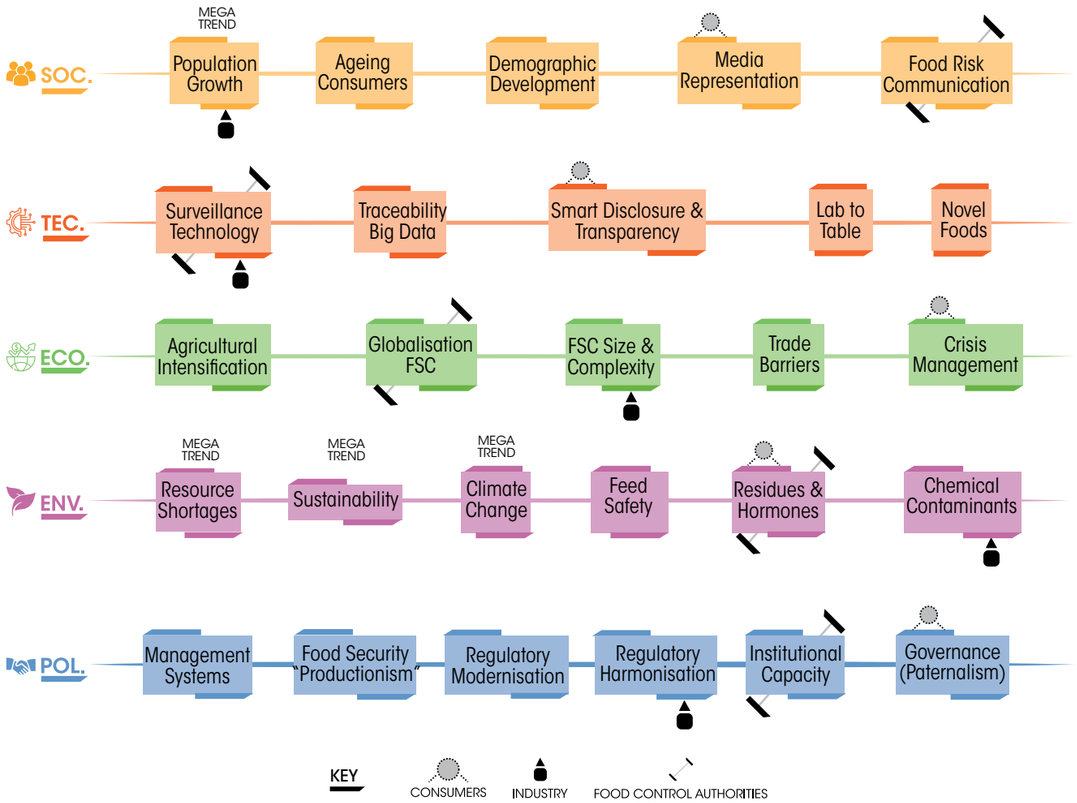


Figure 5. The Baseline Morphological Grid.

The baseline or "business as usual" (BAU) food safety conditions are shown in Figure 5. To develop a 'most likely' version of the future, the number of conditions was reduced to focus on the critical, most probable configurations of conditions determining food safety outcomes in the next 10–25 years.

The above grid, organised by STEEP dimensions, allows the construction of a baseline scenario that reflects the prominent conditions determining food safety within a comprehensive picture of the food system. Between the 27 conditions, food safety outcomes will be realised via complex interactions across multiple STEEP dimensions. This narrative scenario is described in full in the APPENDIX (p. 26).

Figure 5 also highlights the focal concerns of three key stakeholder groups. For example, population growth is a megatrend that has played a critical role in shaping the industrial past, present, and future of food and agriculture. It has profoundly impacted food safety because of the implications of the "productionist" theory, producing more from less, using inputs to address losses and intensifying farming. Food security and its link to food safety have impacted food control authorities navigating a regulatory course through the supply (sufficiency/access) and demand (utilisation/nutrition) side challenges. Media representation has been a focus for consumers as it has impacted their behaviours (attitudes, beliefs, and loss averting strategies) far beyond the objective risks to health.

STAKEHOLDER FOCUS SCENARIOS

Conditions in the baseline scenario were further narrowed from Figure 5 to create three stakeholder focus 'futures wheels,' comprising one fundamental condition from each dimension to reflect the reference narratives or focal concerns of three key food chain actors: consumers, food control authorities and the food industry.

The futures wheels chart a likely future of continued food safety, building upon reference narratives from the perspective of critical actors.

A basic crosslinking of implications illustrates primary and secondary implications as intersections with key dependencies and drivers. Within these confines of the chosen conditions, the results can be revealing and possibly, unexpected.

CONSUMER FOCUS

Two competing axes of interrelationships or dependencies 'compete' for prominence in Figure 6. The media will continue to amplify food safety risks when incidents occur, particularly around poignant narratives such as residues, antibiotics, and growth hormones (involuntary risks). Increasing pressure on "transparency" via consumer disclosure is complicated by politically driven paternalism to modify consumption. At the same time, government agencies will face increased scrutiny on how they communicate risks on agricultural inputs as pressures on food security persist and intensify as SDGs hunger and other targets are missed or 'snoozed' in 2030.

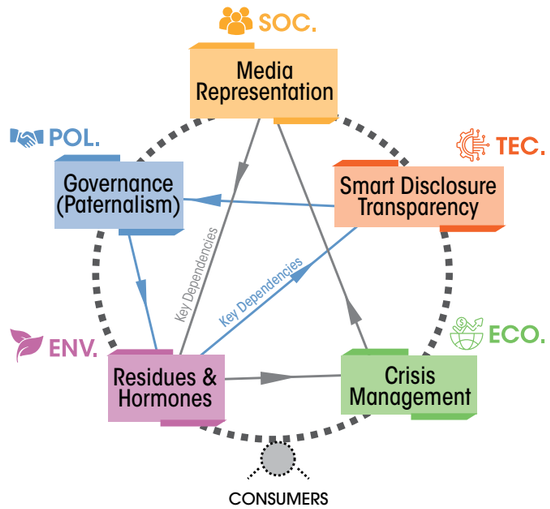


Figure 6. Consumer focus future wheel.

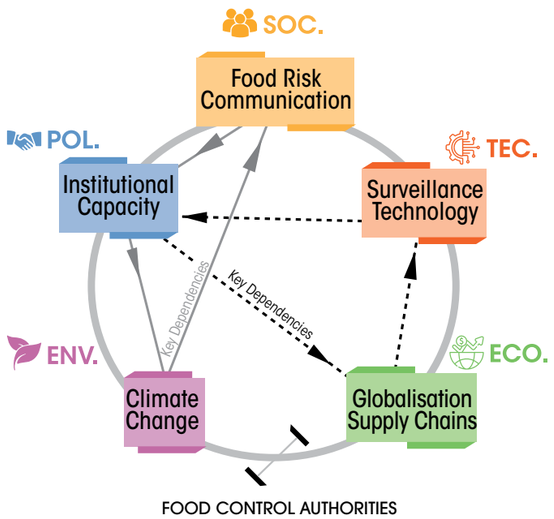


Figure 7. FCA focus futures wheel.

FCA FOCUS

In Figure 7, the key drivers of food safety are plagued by uncertainty and become increasingly volatile, mainly in response to economic and environmental developments. Trade creates cross-border monitoring and traceability challenges to the robustness of systems, which require enhancement and resources (institutional capacity) to cope. Climate change may proceed at a pace to outflank management systems, evidence gathering and legislative process. Food risk communication needs academic alignment and paradigm shift 'transformation' to account for consumer behaviour post-COVID-19.

FOOD INDUSTRY SCENARIO

Population growth will remain in policy discourse on food security and hunger, among various social issues, beyond 2030. Slowing birth rates, ageing societies, and continuing urbanisation will feature in Asia. Another food crisis will be broached, and the system's supposed fragility will be offered as the impetus for change. The system's resilience and "suitability" will be questioned. Food safety will be stressed by production targets, new farm practices, bioengineering, economic volatility, and sustained efforts to address heavy food losses in tropical Asia. Population growth will slow down in some countries due to declining birth rates. Still, the common perception that 'growth' will stretch resources beyond limits will persist.

As a result of growth, the size and complexity of supply chains will continue to increase, economies prosper, markets flourish, and new jobs and opportunities will be created. But, new infectious agents, environmental and chemical contaminants and residues will spread across borders. These increase challenges to time, testability, scope, and resources.

The industry continues to lead the way in testing with its robust internal procedures, but broader market surveillance challenges other stakeholders. The fragmentation of regulation in regional markets demands harmonisation. Still, urbanisation and the emergence of strong local governors and mayors add to layers of political complexity, with food security and sustainability central to agendas. The default nature of governance around food and agriculture remains reactive and contested.

IMPLICATIONS AND PROSPECTS

Population growth, demographic, dietary shifts will continue to confound policymakers as demand-side modifications are urged to address supply-side challenges and transformation narratives. Sustainability and the food system will remain a central issue. The best mixture of long- and short-term policies to protect national interests and embrace critical elements of regionalisation in food security will remain elusive unless coordinated governance stresses a truth: no individual country can realise food security alone.

Surveillance systems will require investment to meet the expansive requirements for various contaminants as scanning extends to emerging and forthcoming risks. All these concerns are moderated by scope and political will. The

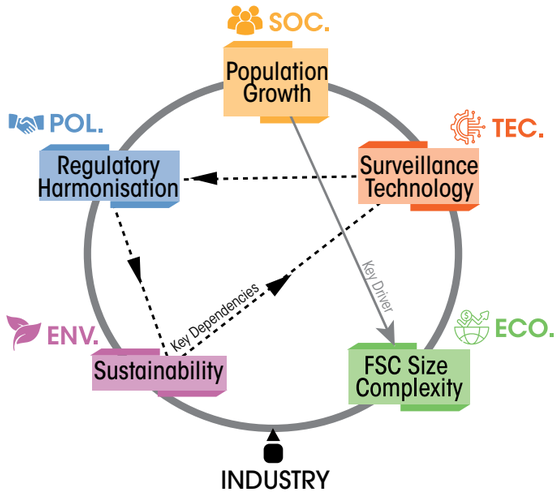


Figure 7. Industry focus futures wheel.

INDUSTRY FOCUS

Internal firm surveillance procedures to meet sustainability challenges will assume additional importance, encouraged by the prospects of "emerging" enabling frameworks in cleantech and the circular economy that must integrate, as opposed to fragment, policy and legislation. Population growth will drive the complexity and size of supply chains, impacting food safety at both supply- and demand sides. Industry must focus on demand-side food safety issues related to sustainable food systems and nutritional security in urban environments.

triangulation between these focal concerns lies in need to harmonise often fragmented regulatory risk governance and mitigation structures regionally and globally. Of these concerns, only one (surveillance technology) is directly actionable by firms through their internal procedures. In some respects, this reflects the successful realisation of regulatory 'creep' to raise market standards. Reducing the complexity of the supply chain, directly addressing food safety, is envisaged via improved mechanisms for operations and personalised data sharing. Supply chain integrity in all four forms will become the focal point of economic risks, which appear to be a direct driver of a broad spectrum and potential increased impacts of malevolent activities. Harmonisation via new approaches—restructuring—will be a priority, including policy rationale, participation, smart regulation and policy integration.

BEYOND 2030: ALTERNATIVE SCENARIOS

FOOD SYSTEM WORLDVIEW THROUGH VUCA

The baseline scenarios indicate the need to work on designs and configurations of conditions across all dimensions. Stakeholder must assess the interplay of multiple, key conditions to reduce the threat of foodborne disease. The food system view (including supply- and demand-side) deserves more significant consideration as part of food safety research and practice. The integrity of the entire food system, both global and regional supply chains, is critical. Food safety within a sustainable food system is an appropriate basis for developing alternative scenarios.

A comprehensive picture of food safety as part of a broader food system was broached in the baseline scenarios. Food safety conditions and their interconnections extended far beyond the norms (regulation/tech) usually considered. A vital part of this work brief was to "look beyond" the typical business cycle of 10 years and the generalised strategic objectives and plans proposed in the field. Alternative scenarios may assist in looking far ahead, not only in time but past the current standards paradigm and beyond the policy boundaries determined by the technological and political dimensions.

CREATIVE CONVERSATIONS

The baseline scenarios are forecasts grounded in past evidence and experiences in the context of real-world consumption patterns in Asia. These were informed by experts considering the historical era, current issues, trends and emerging conditions. Alternatives can stretch the limits of plausibility, and the perils of unreliable predictions are too evident in food safety. What can be done here to avoid unrealistic projections?

Various situational and contextual themes are applied in foresight works, such as system collapse, contraction, transformation, or crisis. These may apply to systems prone to disruptive change or rapid discontinuities that lead to recovery and renewal. Over time, the most robust food system trend has been 'growth,' and the most likely trajectory of food systems

is continued growth. Therefore, four alternative scenarios were developed based on an established growth scenario in "Four Futures of Food" (IFTF, 2011; p.6). From this vantage point, the growth scenario was framed via four situational variables or worldviews using VUCA.

DEFINING VUCA

VUCA is a worldview that describes situations that are volatile (where there is a rate of change 'of change' itself); uncertain (where there is a lack of clarity about the present and future outcomes); complex (where there are multiple and competing decision factors); and ambiguous (where there may be a multiplicity of meanings and significance). Much of food safety has concerned stakeholders with the management of uncertainty.

Taking a VUCA-based view of the food system may mean that governments and policymakers must be even more sensitive to heightened levels of uncertainty and be prepared to meet various external forces, risks, opportunities and threats. None more so than when considering the continued safe, secure, affordable, and assured food supply.

Developing a novel approach to food safety strategy is based upon the principle of embracing VUCA principles as an integral part of the food safety problem universe. Using traditional strategy tools and 'foresight' with morphological analysis, future-orientated perspectives grounded within real-world food systems may be produced.

VOLATILITY: "BONFIRE OF THE VANITIES"

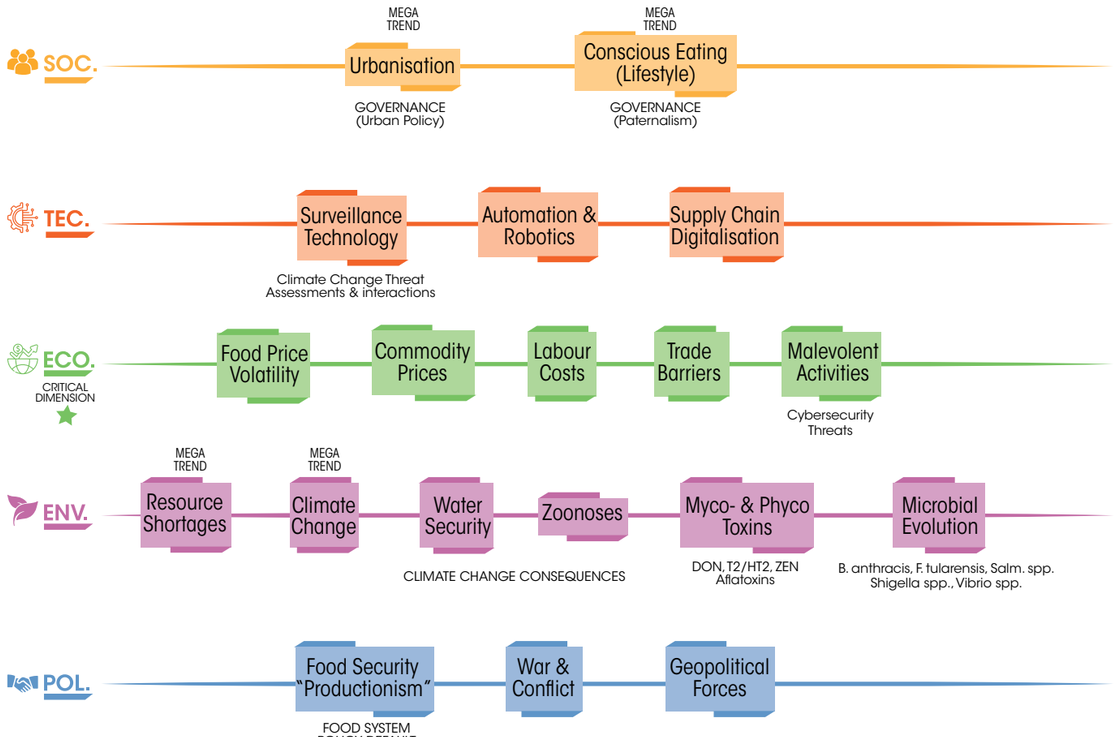


Figure 8. A volatile food system: Morphological grid of food safety conditions by STEEP dimensions.

Volatility is best described by turbulence and means the nature, speed, volume, and magnitude of change are not in a predictable pattern. Food safety represents a complex system and while pertinent information is generally available, time will change its validity and accuracy. At critical junctures, data can be overwhelming in volume, and the rate of change during a crisis can lead to further harm or increase losses. Economic factors are a known source of volatility but changing trade patterns, new dietary trends, and environmental factors present tangible sources of volatility heavily impacting food safety.

In this volatile food system worldview, the bonfire of the vanities, food price and general economic instability persist. Growth in the food system has continued, and seasonality is a thing of the past. Food trade across borders means a cosmopolitan range of affordable foods available at the market. Like other sectors, the market-driven economy is subject to excessive supply and demand and a culture of excess and lifestyle concerns are amplified. The lack of moderation presents for government institutions as they ponder interventions to restrict choice and regulate consumption.

Under food system volatility, food safety incidents are sporadic, unexpected, and chaotic. along with extended duration, as with the most damaging food safety incidents in the past. Time and testability remain significant constraints, and the overall turbulence of the situation strains even well-developed plans. Coordination lapses because of poor inter-chain cooperation and the absence of distributed data.

Economic volatility dominates other dimensions, it impact on food safety is unclear. Some economies suffer a recession, and economic pressures lead to crimes in and around the food supply chain. Political prevarication compounds volatility and limits responses to environmental conditions, which emerge as predominant sources of volatility. Technological developments in the food chain help mitigate the worst aspects of system volatility on food safety.

STRATEGIC IMPLICATIONS

	CRITICAL CHALLENGES	GUIDING POLICIES	COHERENT ACTIONS
SOC.	Urbanisation, food safety and food utilisation (waste and nutritional security) in Asia's megacities. Conscious eating, consumer mindfulness and consideration of all aspects of safety/ nutrition as part of policy dilemmas that are interrelated.	A Milan-type policy pact in Asia, strengthening local government focussed on food utilisation and food safety. Advocate closer integration of food safety/nutrition practices and policies. Consider impacts of megatrends (conscious eating, ethical consumption, and societal values/ priorities) on food safety.	Information and messaging, framing current research and evidence for policymakers on the Milan pact in relation to food safety and nutritional security in Asia. Present the overwhelming evidence on the benefits of integrating food safety/nutrition policy as lifestyle concerns intensify and turbulent policy developments take place to address consumption challenges.
TEC.	Implementation of robust technologies such as traceability, data sharing via distributed ledgers scoped towards climate change mitigation (threats and configuration of agile solutions).	Enhanced system tools, testing, reporting of outcomes, and transparency. Redundancy in automation, AI, digitalisation of food supply chain and personalised tech (smart advisors, wearables and connected homes) to manage the pace of change and data sources to intervene when and where necessary.	Information and messaging on the robustness and resilience that tech-enabled traceability brings within the food safety arena. Communication to consumers in real time, contextually adapted to maintain relevance during change. Integrating system and consumer level data to meet consumer references re: transparency.
ECO.	Productionism a default policy, as food security concerns impact food security in unknown ways. Malevolent threats to food integrity (people, products, data, processes). Geopolitical destabilisation's knock-on effects to supply chains.	A collective, regionalised approach to food security to moderate impacts through expert cooperation and resisting trade disruption. Bolster the food safety research agenda on economic impacts. Agility to prepare, detect and react to cyber security threats.	Enhance capabilities on economic impacts on food safety through investment in novel, scoping-research. Change of tack on cybersecurity, food industry lags other sectors in investment in securing critical infrastructure that may be exploited to impact food safety.
ENV.	Climate change and emerging risks amplified by genuinely volatile weather cycles and known pathogen evolutionary risk and emerging contaminations. A zoonotic event, antimicrobial resistance (AMR) and changes to water security are likely known volatile threats.	Focus on known risks and their interplay. Monitoring, contingencies, and effective mobilisation following incidents.	Investment in surveillance and testing should be scoped towards high probability microbial pathogenicity events and mycotoxins, but other threats from extreme weather and changes to water security. Focus and prioritising on known existing threats but resilience will come through preparedness for realisation of a confluence of risks resulting from rapid environmental degradation.
POL.	Agility, resources and will to adapt to a pace of change and find new solutions that go beyond a reversion to one country's "Productionism" in the face of global supply chain and other geopolitical challenges.	The Asian regionalisation agenda is central to food safety as part of an increasingly volatile food system. No single country can ignore the interrelatedness of the food supply chain, trade, food security and the potential for impact on food safety.	Cooperation between experts, sharing of information, and a collective impetus to radically change the food security and food safety cooperation agenda beyond 'platitudes' of "working together." Communities of practice that accept the collective agenda and regionalisation prepared for turbulence.

Table 1. Strategic Implications by STEEP dimensions: Volatile food safety future.

UNCERTAINTY: "A TALE OF TWO CITIES"

Uncertainty is critical to effective food safety risk management and communication, yet can be dismissed as if there were perfect clarity of outcomes and predictability, particularly during foodborne incidents.

One critical challenge of food safety is coping with the uncertainty of outcomes and developing concrete strategies for resilience.

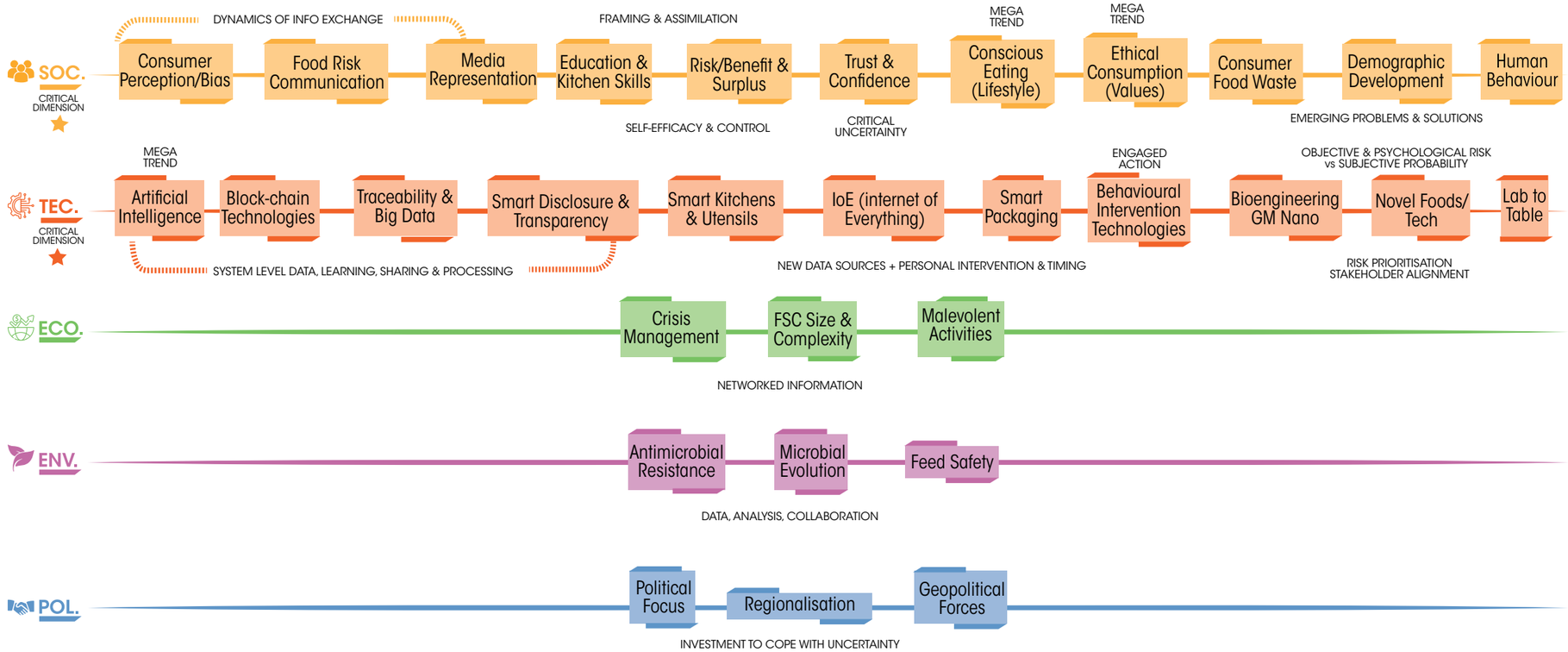


Figure 9. An uncertain food system: Morphological grid of food safety conditions by STEEP dimensions.

Uncertainty has preoccupied stakeholders in food safety risk management. Yet, uncertainty tends to be confused with risks or neglected as if there were perfect clarity of outcomes and inherent predictability. Culturally, uncertainty may be an undesired state of affairs suggesting bases were not covered, or competence was lacking.

Appropriate treatment of uncertainty in assessing food risk management is central to a robust and resilient reference narrative. Indeed, it is quite possible to diagnose one critical challenge of food safety—not that of inherently reducing foodborne disease—more in coping with the inevitable uncertainty of outcomes.

In the uncertain worldview scenario, over-supply, over-demand and present bias—short-sighted individual lifestyle choices—prompt restrictive policy reactions. Lack of moderation and unchecked consumerism persist as consumers reject regulation of the individual, the view of government experts and legislation restricting individual choice. Uncertainty in the system manifests through unintended consequences. Common ground between food control authorities and other stakeholders lapses through misaligned motives, priorities and fears. Food system discourse continues to be plagued by policy fragmentation and ambivalence that largely stems from prioritising national over regional agendas. Demand trajectories and gaps in shared consumption data across supply chains further disjoint perspectives. A meaningful analysis is lacking, and the necessary feedback to review and reflect on actions is absent.

In this uncertain food system, the increased availability and access to food, the result of continued growth, agricultural intensification and progress in addressing food loss, is undermined by growing levels of consumer food waste in industrialised Asia. The demands of the circular economy further uncertainty and fears around the use of wastes as substrates in novel bioengineering processes.

In food safety, uncertainty is managed by control strategies, the setting and adherence to standards, or the probabilistic risk assessment approach where uncertainty doesn't exist or can be "reduced" using economic or probabilistic models. Food safety is treated as stationary, and reflexivity of this socially driven system does not exist. But knowledge is often missing or is simply unknowable at a given time. When faced with growing uncertainty, precautionary approaches usually prevail, at the cost of innovation, without addressing real sources of uncertainty or dealing with the pace of change in a volatile world.

In this uncertain food system, positive food safety outcomes hinge greatly upon various interlinked social and technical conditions. These must converge in rational design to transform information disclosure and knowledge management to prompt, amongst other outcomes, consumer behaviour change. While the technological conditions develop through new business models and seamless commerce, social conditions move at a much slower pace, and future progress cannot be guaranteed.

Of all the alternatives, the uncertainty scenario is the most challenging to food safety since the current system tends toward superficial uncertainty management through rigid controls. This approach may have had moderate success in the past. But future challenges of the environment and sustainability demand addressing the challenge of uncertainty through robustness and resilience while allowing innovation. If the uncertainty of outcomes dominates in this future, contingent actions to prioritise foresight and preparedness instead of a blanket "raising standards" or "precaution" should represent the industry's overriding priority.

STRATEGIC IMPLICATIONS

	CRITICAL CHALLENGES	GUIDING POLICIES	COHERENT ACTIONS
SOC.	Provision of information, not just on facts (which will never be 'complete') but values, beliefs, and emotions. The credibility of sources and willingness to engage and listen to consumers on their priorities. A broad range of social conditions require attention and some of which rely on food chain actors other than industry to affect change.	Transformation to a social and dynamic approach to deal with food safety within a food system. Enhancing the information and communication '2-way' process can be facilitated via technology, and market-driven tech through seamless commerce and other hybrid approaches/business models.	Information and real-world demonstrable experiences to change the behaviour of food handlers. Personalised, relevant, and showing benefits of change. The cultural approach to food safety has merits, but changing culture is exceptionally difficult and would take >15-20 years.
TEC.	Quality data and analysed information at the system level and its availability across the food supply chain, and personalised information, to meet complex social values, consumer priorities and preferences.	Data is analysed into usable information in time frames previously unheard of. AI is made a reality so that human resource pressures can be alleviated and complexity is not increased. Information delivered in 'real-time' and relevant to the consumer via sensors, smart tools, packaging, and utensils.	A pre-competitive stance on food safety to help develop new platforms and models to share information, though much of the personal data is proprietary and commercially valuable. Tech breakthroughs are available but constrained by legitimate concerns about security and usage.
ECO.	Preparedness for the inevitable incidents in effective crisis management systems. Efficacy of incident management is stressed by increased supply chain complexity, and economic threats to supply chain integrity via economically driven malevolent activities.	A resilience platform with global and regional food supply chain integrity in view would help all stakeholders cope with the inevitable economic losses that will occur because of foodborne incidents. Robustness and resilience must be the key guiding principles.	Addressing known vulnerabilities in economically motivated crime has been a priority for the industry given past events and all points of food integrity must be considered as part of resilience platforms and food defence.
ENV.	The most impactful and novel environmental threats to food safety are the most uncertain and ambiguous (cause and effect). The circular economy could create a critical inflexion point around AMR/pathogen evolution and feed safety amongst other threats.	Environmental threats to food safety with the highest magnitude of harm warrant foresight and preparedness in terms of linking causes and effects of multiple risks and drivers. Preparedness in terms of evidence collection in areas where data is lacking (AMR). Rapid analysis and sharing to enable predictive capabilities and early warning.	Feed safety, zoonoses, future pandemics, AMR. Areas of very significant environmental uncertainty that require preparedness and both collective industry and firm action.
POL.	Regulatory fragmentation and lack of focus continue to harm the industry and will be amplified if uncertainty is not accounted for and coped with in more concrete ways. Increased uncertainty must not mean regulatory extension and overreach.	Regulatory agility and flexibility have emerged as positive attributes post-pandemic. Leverage of such successes, via digitalisation, would be an appropriate policy response toward coping with uncertainty. Agility must extend in the direction of diversification of regulatory actors, 3rd parties and social control mechanisms.	The food industry faces difficulty in coherent actions in this area since many of the institutional challenges in the political arena are "locked in." Information and messaging on complex systems, the interrelationships and design of solutions rather than the 'remedy' of new regulation. Sustainability imperatives demand transformation from "precautionary" regulatory measures. Continue to advocate for inclusion and trust-based regulation.

Table 2. Strategic Implications by STEEP dimensions: Uncertain food safety future.

> "Uncertainty management or optimisation has grown out of favour in the last decade, and strategies have emerged to cope with uncertainties, particularly regulatory uncertainties and impacts on food firms. Dealing with inevitable food safety uncertainty occurs through effective knowledge management as the new ways to maintain resilience and robustness of stakeholder reference narratives."

COMPLEXITY: "A NEW EDEN"

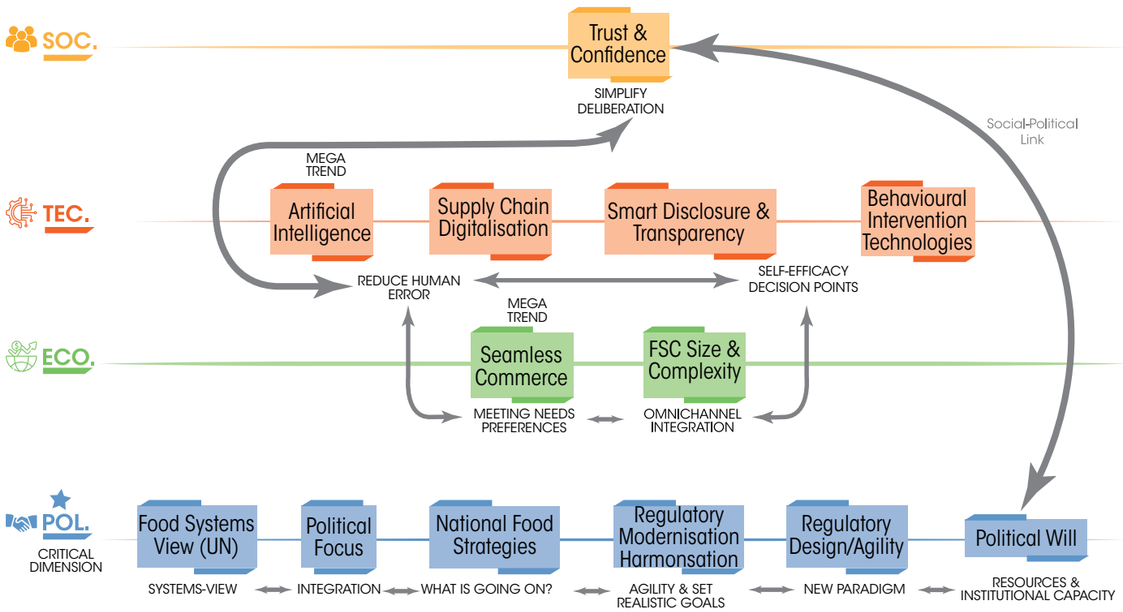


Figure 10. A Complex food system: Morphological grid of food safety conditions by STEEP dimensions.

Complexity is the number of variables in the information space relevant for a particular decision and the amount of interaction between those variables. The sheer complexity of supply chains—competing actors and how they are regulated—in various arrangements reveals the need to process an overwhelming amount of data.

In the New Eden food system scenario, complexities place limits on growth, with competing demands of stakeholders. The disaggregation and slowdown of the market economy furthers uncertainty and prompts disparity in the levels of moderation. The lack of effective global strategic food governance is exposed. Complexity leads to inertia, risk aversion and ultimately, further market contraction.

From a high-level perspective, complexity defines a dynamic social system, encompassing food's purchase, preparation, consumption, storage, and 'reuse'. Industry complexity is vested in reams of regulation and diverse political systems/levels of democracy. Portfolios of food and agriculture governance spread across sometimes 10-15 ministries. Market requirements, tariffs, barriers, inconsistencies, and logjams are challenging to navigate.

Food firms adapt to complexity through structural change. They align with the environment to take advantage of their management competencies. Complexity is a symptom of the additive nature of food policy, remedial in design, often isolated and arrived at without inclusion. A system vested in rules and layers of bureaucracy will be inherently complex.

Few would dispute the complexity of the supply chain, but complexity often prompts further calls for 'transformation.' Complexity extends to the number of conceptual dilemmas, working parts, challenges and competing interests of stakeholders.

Food safety is not inherently complex; cause and effect and practical information are generally available. Precision and timing may be challenging, as are the novelty and unfamiliarity of risks. Looking at the food safety problem universe, many interrelationships, and interactions are unknown in scope and impact. Factors can be positive or negative in direction, or both, depending on circumstances.

COMPLEXITY SOLUTIONS

Solutions in the food safety area to deal with inherent system are highlighted in this version of the future in which complexity is coped with through a design of multi-dimensional approaches. These approaches are underpinned by a restructuring of political considerations, all chain-linked.

In the New Eden, complexity in food safety flourishes through the volume of regulations, standards, testing arrangements, surveillance (both internal and external) procedures and trade barriers. At the social level, different attitudes to food risk, belief systems, and even the complex 'unknowns' of food risk perception have gone unchecked and left to media sensationalism and social media outcry. Marked differences in human behaviour contribute to complexity.

Figure 10 focuses on conditions that will alleviate food safety-derived complexity based upon the principle of political restructuring—mainly an integrative approach. Technology has its role in simplifying the decision-making process and not overwhelming stakeholders with unprocessed data. This overload can harm choice environments and cause default or compromise effects to derail effective decisions. Technology must help interpret data to deliver timely, high-quality information that garners understanding and is personally relevant.

Pivotal solutions are trusted food chain actors and confidence in food safety. Trust in food chain actors is essential for consumers because it allows them to simplify decisions. Where there is trust, there is the benefit of the doubt, speed, ease and positive expectations in decision-making when faced with risk. Confidence in food safety is the expectation that food will be consumed without adverse events, meeting quality, and providing satisfaction, if not "euphoria", as past reasoning and experience confirm. In the complexity scenario, these core attributes require careful implementation, particularly by institutional actors with political oversight.

STRATEGIC IMPLICATIONS

	CRITICAL CHALLENGES	GUIDING POLICIES	COHERENT ACTIONS
SOC.	Building and maintaining trust in the food industry, and in food chain actors (farmers, regulators, retailers) in general. With trust, confidence in food safety is likely to be the predominant reference narrative of consumers.	Being trustworthy is the only guiding policy toward food chain actors' trust. Trustworthiness has come under threat in recent times with the paucity of trust in political actors exemplifying an anything-goes culture (provided it aligns and confirms with existing views).	Focus on the responsibility of industry for both people and the planet. Investment in social causes. Leadership on sustainability, citing outcomes and achievements. These attributes speak to industry benevolence and integrity and are the critical dimensions in building trust.
TEC.	Overwhelming amounts of food chain data can stifle stakeholders.	Simplification, visualisation and automation. Reduce human error. Realising scale through mobile cloud computing to make food safety information personalised and engaging.	Mobile internet, cloud computing, AI, emotional technologies implemented to make disclosure and transparency efforts real to the consumer. Actions to reduce complexity, via trust and confidence, may follow.
ENV.	The demands of sustainability, planet centricity, ethical consumption, the circular economy, and zero waste will further increase the complexity of food systems with direct impact on food safety conditions.	The circular economy is a key focus for food safety control authorities, effective prioritisation in reuse and recycling would help avoid novel causes and effects. Preventing another "BSE" type upcycling catastrophe is imperative.	Advocacy around biotechnology and bioengineering for the circular economy, development of value from waste appears timely, and framing such as opportunities for innovation in food safety appears a plausible focal point.
POL.	Fragmentation of outdated regulations and regulatory creep driven by food safety incidents or predictive risk assessment without ample evidence moves the food safety systems towards levels of unresolvable complexity. Global food governance seeks a change agenda on food/ag that further complicates the policy environment.	Urging a progressive transformation agenda, to restructure regulation to meet challenges Beyond 2030-50. National food strategies and integration of policy and ministerial responsibility offer plausible routes.	Advocacy for a more ambitious future of regulatory systems, where efficiency, automation, integration, and accountability thrive. Adopting an entirely new strategy posture, via national food strategies, may move the political conversation beyond apparently intractable issues such as modernisation/harmonisation but achieve them via a new route.

Table 3. Strategic Implications by STEEP dimensions: Complex food safety future.

AMBIGUITY: "MALTHUS RETURNS"

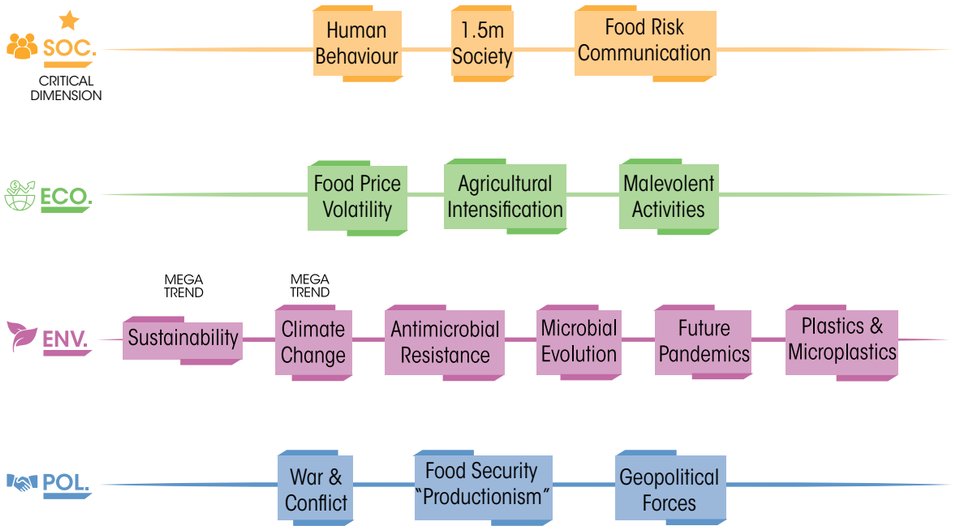


Figure 11. An ambiguous food system: Morphological grid of food safety conditions by STEEP dimensions.

Under conditions of ambiguity, causal relationships are not clear. In the food system, ambiguity is a problem that creates confusion and clouds strategic decision-making. When investigators try and map emerging, forthcoming and conceptual risks and delve into the complex and chaotic, they may overreach. Ambiguous evidence can inform food policy, causing losses and adding complexity, confusion, and fear.

Absolute ambiguity results in unprecedented scenarios. It is tempting for some parties to suggest that the most damaging food safety incidents result from "unknown unknowns." Still, while we cannot attach probabilities to these events (BSE, horse meat, E. coli 0157, novel Salmonella sp. serotypes etc.), we can conceive of such states. They may, and no doubt will, occur at some time in the future, however improbable. A truly ambiguous situation in food safety is beyond comprehension, but weak signals can be assembled as part of risk assessment horizon scanning or foresight. The most ambiguous states in food safety are shared appreciation of problems and priorities. Ambiguity also manifests in language, that of legislation and standards, which is often unclear, loosely defined, and open to interpretation.

In an ambiguous food system scenario, "Malthus returns", the system shows unconstrained development and unsustainable consumption. This mass growth results in unpredictable outcomes affecting producers and consumers alike. Natural resources are plundered, and sustainable consumption is side-lined. Waste and nutritional insecurities predominate. The cause-and-effect relationships are potentially unprecedented and a perilous state for food safety.

In the ambiguous worldview, popular political sentiment and the self-interests of nations provide a potential environment where ambiguity may flourish. Critically, geopolitical relationships become increasingly fraught. Ambiguity in the food system takes on two forms: the conditions subject to the most variation and least prediction and the outcomes of such ambiguity in terms of inertia and return to default choices.

Human behaviour around food safety departs from self-reported best practices and is highly variable and individualistic. Expert views are rejected by a society segmented on cultural and identity grounds. Radical changes to consumer attitudes stemming from years of lockdowns and the "1.5-metre space" society have resulted in diverse behavioural patterns where ambiguous outcomes are entirely possible. The real causes of foodborne disease are questioned, as is the efficacy of the food standards approach. Trust in regulation decreases, but consumer confidence is maintained as optimistic bias flourishes.

Food and commodity price fluctuations revive the "green" agricultural intensification, the production mantra, and the political default of agricultural productionism. Producing or storing more food and considerations of self-sufficiency leads to the manipulation of markets and regional discord. More fossil fuel inputs are used, and increasing dependency on them marginalises producers and leads to recurring infractions on MRLs. Alternative food markets emerge where affluent consumers pursue conscious and ethical consumption while most urban poor struggle with nutritional security. Market fluctuations create tension between food security and food safety. This policy tension is wholly unsuitable for dealing with malevolent activities, circular economy, climate change (pathogen evolution), foodborne antimicrobial resistance and future pandemics.

Ambiguity is not the natural landscape for food safety, but the future poses questions. The circular economy represents ambiguity in cause and effect, such as the use of wastes as novel substrates or feeds in innovative bioengineering applications. The latter may be regarded as novel, unusual, exotic, and unfamiliar. By this definition, such innovations may be considered a 'food safety' issue with attendant regulatory burdens.

Recycling and reuse in volatile policy environments may introduce ambiguities that cannot be effectively dealt with under current system parameters. A precautionary approach will result in delays threatening the UN's and other global agencies' environmental goals and SDGs. In a genuinely ambiguous food safety future, all known pathways to safe food must be redrawn, and re-evaluated through a re-invigorated research agenda.

STRATEGIC IMPLICATIONS

	CRITICAL CHALLENGES	GUIDING POLICIES	COHERENT ACTIONS
SOC.	Several research gaps in the social dimension, such as human behaviour post-COVID-19 and decision-making as risk/benefit evaluation in real-world contextual food safety decision-making. Risk communication effectiveness at an all-time low.	Undertake a much more ambitious research agenda on behaviour in preparation, with a few focal areas that bring together experts from technical and social backgrounds.	Funding to address the most difficult social conditions and their interplay. A long term commitment to understand well characterised departures from "rationality," such as the illusion of control in handlers. Address new paradigm of food risk communication and understanding of post-COVID-19 behaviour on food preparation and handling.
TEC.	The new normal of food and commodity price fluctuations cannot be allowed to create perpetual food crises or continue to re-ignite self-sufficiency or return to production at all costs. Economic cause and effect on food safety are unknown.	Research production to better characterise the impact of economic/physical access to food and food utilisation (food safety, nutritional security) across a range of economic positions in Asia.	Mobilise research and greater investment in experimentation to prevent ambiguity. Investment in cyber security of food supply chains to build slack into systems and reduce threats from ambiguous economic impacts.
ENV.	Unquestionably the biggest source of ambiguity and threat to the knowledge of cause and effect is environmental in nature with high magnitude threats across all parts of the food supply chain that cannot be considered in isolation.	The chain-linked food system approach to joining up the impact of environmental risks as dynamic elements is tackled through coordinated designs with medium-term targets that are flexible proximate objectives, not grandstand targets designed to replace coherent actions.	Experimental models and simulations, even on weather patterns, and looking deeper to first, second and even third order implications. Most countries focus on CC, AMR and microbial evolution, but future pandemics are likely to dominate public health investments and action.
POL.	Ambiguity in regulation due to lack of evidence or differences in definitions. Ambivalence on food safety and related political debate on collective approaches to food and nutritional security.	A regionalisation agenda in sustainable food systems, a term that will eventually supersede "food security" and the disparities between supply and demand-side priorities.	Meaningful collaboration networks with real wins for participants. Sharing of data as a minimum, sharing of quality, validated information and analysis of social trends and preferences is a more appealing proposition and a win-win.

Table 4. Strategic Implications by STEEP dimensions: Ambiguous food safety future.

CONCLUSIONS

Food safety scenarios are suitable for prompting strategic conversations and developing alternate solutions to the many unresolved issues in the area. However, scenario development in food safety is in its infancy. This is the first work to apply a more comprehensive approach beyond the normal Shell/GBN works common in corporate foresight.

Understanding everyday attitudes to food safety are essential, and viewpoints such as reference narratives provide a grounding for a better overview of how stakeholders frame food safety problems. As noted in this work, these narratives, the baseline focal scenarios, differ significantly. Through in-depth foresight, narratives can be explored, challenged, and enhanced. This work developed alternative scenarios via the food systems VUCA lens. Equally appropriate frames could have been through the imperatives of sustainability, the impact of a net-zero food production system, or urban food security and subsistence in Asia's megacities. STEEP dimensions as parameters can be replaced by solutions to a specific problem, under which conditions are listed to develop a scenario matrix or futures wheels.

Foresight reveals unique arrangements and solution designs. In foresight, there is an acknowledgement that the future remains unknown, but through conversations, patterns emerge toward systems-based solutions in the present.

The most likely future, the baseline, showed incremental progression in food safety governance along current lines. The technical/regulatory paradigm, standards-setting and technological evidence generation via data will continue in the coming decade and 'Beyond 2030.' In the uncertain and unpredictable world of food safety, incidents will occur, and the ability of all stakeholders to adapt, cope, and recover is vital. In this regard, food control authorities must ensure such incidents do not escalate into fully blown crises. This is their baseline reference narrative, but such resilience cannot be based upon control measures and regulations alone.

Volatility is a real threat to food safety as it is realised in two areas with significant barriers and research needs. Economic factors and environmental conditions can change at a pace that could outflank surveillance data, information sharing, consumer disclosures, and the development of evidence-based policies. Economic volatility triggers alarm bells across ministries, often resulting in short-term interventions with untold consequences on food safety. More pointedly, the social-economic-environmental nexus represents a linkage that is not typically unknown but is not well characterised, as highlighted by the volatility scenario.

Volatility demands preparedness and anticipation, more nuanced and rigorous than theoretical risk analysis and case-by-case interventions in a system that requires a joined-up response. The volatile future holds the most threat to the reference narratives of industry, consumers and food control authorities. Actions are urgently needed to enhance systems resilience and negotiate that resilience jointly to build cooperation. As noted in several other works, international expert collaboration needs augmenting on several grounds.

A food system beset by uncertainty aptly describes food safety today. But the system is well prepared in most cases to gather evidence, produce data on existing and emerging threats and meet 'unknowns' and resolvable uncertainties head-on. There is robustness in current traceability systems, but those systems have a ceiling, as food safety is beset by imperfect information. A new active platform is needed to interpret and share quality analysis and implications during inertia and turbulent states. Technology can provide such through blockchain, bridging all stakeholders in an anonymous but verifiable way.

While many elements of an uncertain food safety future are manageable, certain aspects remain in need of attention. The constant aims of reducing uncertainty are greatly challenged now that food control extends to consumption dilemmas. Sustainability, conscious eating and ethical considerations will be far advanced in 2030 to the point where consumer disclosures may need to include health, safety, provenance, recycling and other aspects of sustainability. The conventional labelling of these product attributes will be conflicting and confusing for consumers. Education on pertinent matters may be largely ineffective unless it corresponds with culture, values and needs.

On complexity, a solutions-based morphological grid was created in this work. Several interrelated conditions were linked to provide insight into how a chain-linked approach to a largely intractable problem can be approached. The food system will become more complex in the next 25 years. If business-as-usual (BAU) prevails, this will be matched by waves of new standards, fragmented legislation and potential conflict between health, safety, and sustainability regulations. This is a serious concern that political restructuring married to social progress, in various configurations, will address, as shown in Figure 10.

Developments in artificial intelligence may mitigate parts of the complexity challenge as AI develops beyond machine learning to genuine cognitive computing with the necessary creative and cultural appreciation highly relevant to food safety. However, disruptive innovation in system data processing may compromise the trustworthiness of food chain actors due to transparency and other disclosure requirements. This complex food safety scenario requires appropriate technology, investment, and governance restructuring. This is tied to consumer trust in governments, democracy, and confidence in the validity of participatory systems, defining a link between social and political dimensions.

Despite the unexpected nature of many incidents, ambiguity is not a current feature of the food safety system. But sustainability imperatives could render the system liable to unprecedented levels of ambiguity driven by social and economic forces. Of all alternative scenarios, the ambiguous system is threatened most in the environmental dimension. Current system ambiguities also present considerable barriers to sustainable product and process innovation.

The ambiguity of language in legislation and standards will continue to be problematic and is tied to system complexity. Restructuring, as per complexity, is one possible recourse. The possibility of states of food safety that are unknown and unexpected will always be a reality. Still, a renewed research agenda may mitigate the "Black Swan" food safety crises that were so damaging in the past.

For the food industry, VUCA imperatives all point to a deliberate advocacy strategy. This represents a strategic "change of tack" to merge harmonisation, modernisation and pressing issues under one goal: developing national food strategies that integrate goals with enabling features of the smart regulatory paradigm. This is the necessary restructuring that would significantly enhance food safety.

Beyond 2030, a more complex issue in many countries will be reconciling consumer priorities on food risks that confront novel foods and ingredients, food processing technologies and potentially 'lab to table' foods. Concerns around psychological risk have plagued these innovations. Still, they are generally considered under 'food safety.' Currently, food safety frameworks are ill-equipped to reconcile qualitative risk factors, relying on probabilistic risk assessment. As a result, psychological risk factors such as dread, involuntariness, and perceived fairness have delayed innovations for decades.

In most cases, these innovations were later scientifically determined to be 'generally recognised as safe.' Governments must capture consumers' belief systems and values, specifically in the context of food safety. In doing so, government institutions will be in a better position to effectively communicate the food safety of innovative foods. They will also have formal mechanisms to listen to consumer concerns, understand their reasoning and logic, and engage them in a 2-way communication process.

This work is one of few to explore food safety from the perspective of narratives, scenarios, and conversations about the past, present, and future. Foresight techniques, despite some flaws, are well placed to facilitate such discussions. What emerges is a wealth of perspectives and possibilities, not predictions.

RECOMMENDATIONS

This foresight work has provided evidence for several recommendations for further strategic conversations around food safety from the industry and individual firm views.

REC 1. FORESIGHT FOOD SAFETY

Foresight is a method to develop a range of specific food safety scenarios that help diversify conversations about food safety and pinpoint problems while being able to propose designs for meeting challenges. As the scenarios reveal, more involvement in narrative development would advance food safety practice and collaboration across sectors, which is vital to future challenges, such as high magnitude food risks and conditions that point towards them being realised in the next 25 years.

For example, antimicrobial resistance (AMR) is arguably the most significant threat to public and animal health worldwide. Food and its microbial contamination are contributory sources to AMR. Murray et al. (2019) estimated the global burden of AMR at 1.27 million deaths directly attributable to resistance and 4.95 associated with bacterial resistance in 2019. Preventing infections in the first place through improved water, sanitation, and hygiene is central to this. There are overlaps and synergies with food safety in Asia that are unexplored. Many challenges (reliable data, complexity, uncertainty) are shared with food safety.

Foresight is a tool to develop scenarios around the food system and safety to evaluate options and prompt conversations in areas like AMR, climate change—evolution in pathogenesis; sustainability/circular economy— and feed safety.

REC 2. KNOWLEDGE MANAGEMENT AND COPING WITH UNCERTAINTY

The provision of information has been the traditional route to 'manage' food safety uncertainty. However, there will never be perfect information on food safety. The search for emerging, forthcoming and even conceptual risks assumes knowledge and context, not in evidence and is beyond the capabilities of predictive systems. Yet, a great deal of time and resources are invested in predictive systems that focus on food risks and assign probabilistic assessments to them.

Better coping strategies and the ability to make rapid decisions in the face of unresolvable uncertainty are necessary. A first step is to change the narrative around uncertainty, its acknowledgement and its strategic approach. The quest for information has its limits. Too much information, without context, relevance, or analysis, leads to complexity. There is a need for more effective consumer communication processes around food safety and related areas that align with their cultural preferences and cognitions in the realms of values, beliefs, and worldviews. The entire decision-making process around ill-defined food safety problems should be explored, and foresight narrative scenarios are an ideal way of bringing the human element into coping with inevitable uncertainty and, in some cases, volatility, complexity, and ambiguity. This could be a unique role for the food industry to pursue via its efforts in sustainable consumption. Understanding food values via research production would be part of this, as will a complete revaluation of the processes of food risk communication considering the disconfirming evidence on the effectiveness of theories and practices that emerged during COVID-19.

REC 3. EVIDENCE AND FOOD SAFETY MODERNISATION

The food industry should stress the need for enhanced data collection, advanced processing, analysis and sharing to make modernisation concrete. The regulatory modernisation movement should focus on advanced data capture through traditional surveillance and testing and a network of sensors and shared devices in the home. This is an untapped data source on actual food safety behaviours, as the EU's `SafeFood' program has illustrated, spanning all preparation and handling settings. Innovation and progressive regulatory authorities should look to integration, agility, adaptive capabilities and complete data sharing (through distributed ledgers) to provide accurate information and fill gaps in evidence that persist between theory and observed behaviour around preparation. Data on threats should provide an evidence base that is evaluated and shared, and through such data, modernisation and prevention will take a step forward.

REC 4. FOOD SAFETY RESILIENCE

FIA could champion the conceptual approach towards robustness and resilience of food safety practice, regulation and consumer behaviour. The resilience of FSC has come into focus after SARS Cov-2.

The most consequential impacts on food safety in the next 25 years will originate through climate and other environmental variabilities. Price shock impacts on food safety are not well characterised and should be the subject of further research. The 2008 food price crisis pushed 130 million people into poverty and 75 into malnourishment (Heady, 2011) through economic pressures on nutrient content and related challenges to domestic food safety. Volatility through the resilience of the entire FSC has been approached in a limited way, primarily focused on food supply shocks of maize, rice and eat and gross agricultural production figures around rainfall and temperature. Sufficiency and productionism thinking in this area, as in others, should be redirected to include research and analysis on entire food baskets, expand the scope of environmental variability and links to sustainability, nutrition, health and food safety.

REC 5. FOOD INTEGRITY—AN INDUSTRY PERSPECTIVE OF NEGOTIATED RESILIENCE

Food safety resilience is closely related to food integrity, focusing on four key areas: product, process, people and data (Bouzembrak & Marvin, 2016). This topic is of interest to FIA members and the entire food industry and could be an important area for collective effort, research production and coalition building. Food integrity and food safety resilience would benefit from clear boundaries, clearly answering the four questions to understand what resilience is sought—of what, to what, for whom and over what period (Helgott, 2018). A concept of negotiated resilience could be one bridge to make constructive "working together" for industry and other stakeholders.

APPENDIX

BASELINE NARRATIVE

Food safety remains deeply rooted in the social dimension via the population growth 'megatrend', the eternal dilemma of population growth versus the ability to produce enough food. At times, the social dimension of food safety has been relegated to the periphery, but all indications direct otherwise in the coming decade and beyond.

Questions of food accessibility (physical and economic) and utilisation, particularly in Asia's urban settings, persist and are on top of many Asian countries' political agendas. This will remain the case. A long-standing concern around food safety has been a "demographic shift" regarding ageing and increasingly vulnerable consumers. Much repeated in health discourse, observed changes in the socioeconomic status of populations in Asia, particularly in China, where affluence and ambition change preparation techniques and expectations around hygiene and impact individual health and lifestyle. Meanwhile, buying patterns, attitudes and opinions change as family size and educational level play a part in mediating the resulting behaviour.

Media representation of food safety remains significant, providing the social construction of food safety risk and attention to the psychological dimensions (dread, novelty, crisis). Accessibility to poignant food safety incidents continues to amplify some types of food safety risks far beyond their objective probability or magnitude of loss. Food risk communication techniques struggle to address the expert-public gaps or differences in priorities between consumers and food control authorities. The future information and communication environment looks complex and unlikely to yield improvements in consumer/handler behaviour.

Surveillance technology occupies a privileged position in the technological dimension to detect contaminants before they cause harm and attract media attention. Both traceability and transparency systems play a vital role in the robustness of the modern food supply chain and in addressing sourcing requirements, authenticity, and provenance, along with information voids and asymmetries, while lowering transaction costs. The adaptation and implementation of these abilities continue to develop in Asia. Still, they depend on regional inter-organisational collaboration and penetration at the small enterprise level, not just big corporations. Technological developments in processing and novel or alternative sources of foods and those produced via bioengineering will stress the need for new food risk communication techniques, including a cultural theory to address values and emotions around food and food culture.

Agricultural intensification to address crop yield plateaus remains the productionist's remedy to population growth but takes on new significance in the sustainable food system. Sustainability prompts new approaches to agricultural innovation beyond sufficiency. Food security now extends to the demand side of the food supply chain providing additional impetus to address crop losses post-farmgate and creative solutions to food waste at the consumer level. Cleantech imperatives prompt changes in inputs to shift away from fossil fuels, and biomimicry (artificial photosynthesis) plays a vital role in the 'zero waste' circular economy.

Critical economic areas define the globalisation and complexity of the food supply chain, barriers to trade that exist in the guise of food safety regulations and associated short-term, reactionary regulatory steps that are not specific to product life cycle and value.

These are coupled with the economic impacts and primacy of effective crisis management during the inevitable foodborne outbreaks. Some food safety crisis management steps have been flawed in all phases of practice. Crisis management, fuelled by time (answers) and testability (impact on such events) limitations, has profoundly affected the economic outlook of specific product categories and some value chains regarding international competitiveness. Regrettably, these management steps remain vulnerable and isolated incidents create economic and health losses that damage confidence in food safety.

Under the environmental dimension, two megatrends have dominated food system discourse for three decades: resource shortages/efficiencies in various guises (including food security) and sustainability imperatives. The challenges related to food safety inherent in food security and sustainability continue to frame much of the problem statements around food systems. The subject of much debate is how they impact food safety in a sustainable food system. Environmental concerns have shaped much of a regulatory landscape; concerns over feed safety and zoonotic disease are palpable, as are continued and largely intractable issues around residues and growth hormones in developing countries. These are compounded by complicating factors—resource allocations, time, and political will. The omnipresent threat of contaminants places strain on surveillance systems. Calls to invest in slack, agility, robustness, and resilience are tempered by firefighting and inter-ministerial conflict, particularly balancing the demands of infectious disease and the continued public health priorities around NCDs.

The political dimension is primarily shaped by the effectiveness of food safety management systems, policies, legislation, and certification. Rules and standards continue to be the default to drive higher levels of safety, but there is a ceiling for such. Beyond 2030, with greater empowerment and choice, consumers will play an even more significant role in shaping societal norms around safety, health, lifestyle and sustainable consumption. The top-down command and control approach will continue in some countries with limited resources but be prone to catastrophic failure. Trustworthiness will suffer as a result, and food systems will become more complex, costly, and time-consuming to navigate.

By far, the most significant strategic interventions in the last two decades concern regulatory modernisation and harmonisation, which are heavily related to institutional capabilities and capacity at the national level. The growing spectre of interventions being made in consumption makes such strategic objectives more distant but, conversely, more pressing.

FOOD SAFETY FORESIGHT BEYOND 2030

FIA FOOD INDUSTRY ASIA

Food Industry Asia (FIA) was formed in 2010 to enable major food manufacturers and B2B ingredients suppliers to speak with one voice on complex issues such as health and nutrition, food safety, sustainability, and regulation & trade. From its base in Singapore, FIA seeks to enhance the industry's role as a trusted partner and collaborator in the development of science-based policy throughout Asia.

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