Food and Agriculture Organization of the United Nations

FOOD safety at FAO

Food safety challenges to address in the near future

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Presentation Outline

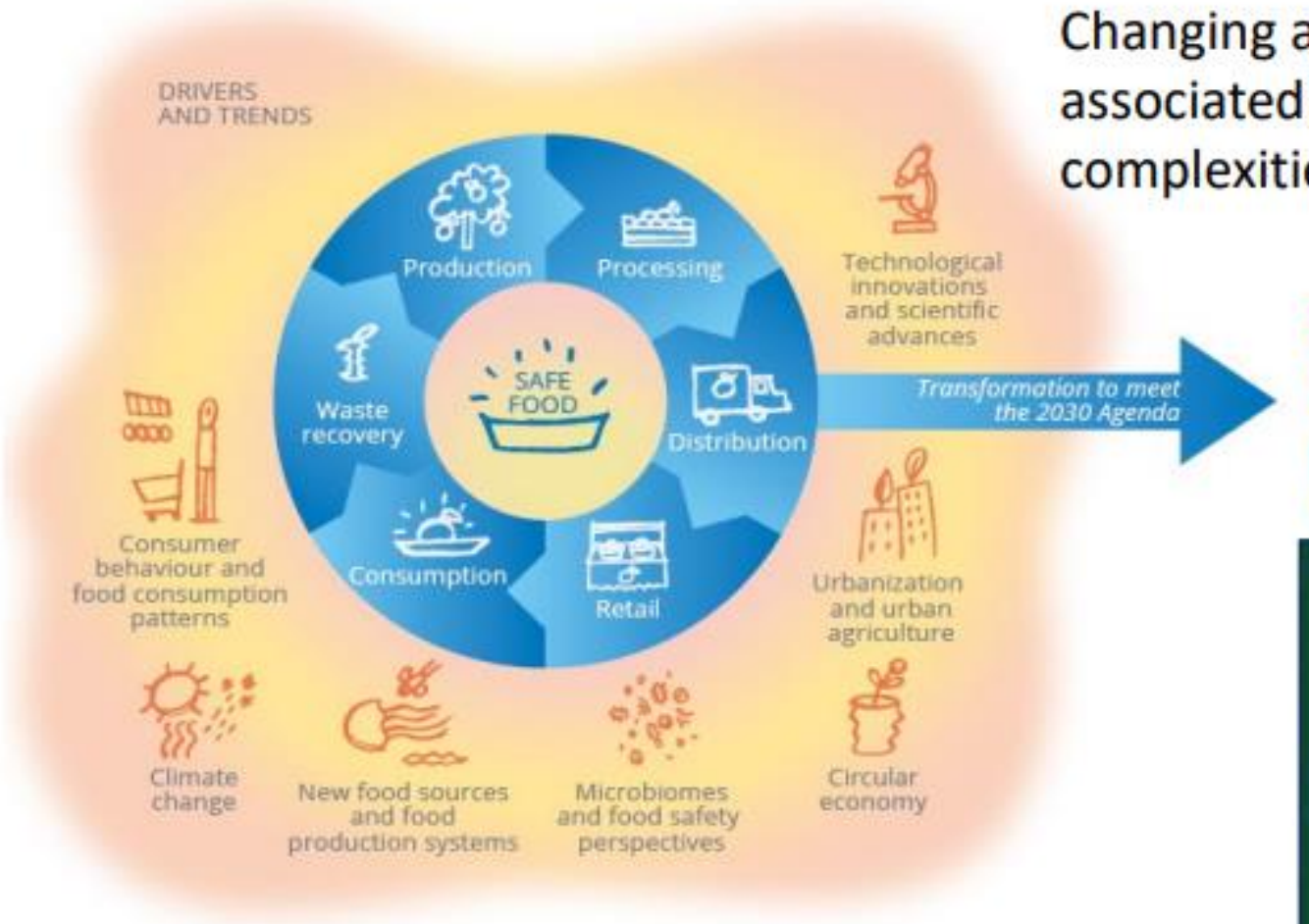
- Key drivers of agrifood systems with impact on food safety
- Major food safety challenges to address
- Next steps, including expectations from national authorities

Global agrifood systems operate in continuously evolving context

- Globalized food trade, changing markets & interconnectedness of countries across regions
- Pressures on food systems: rising population, urbanization and food demand
- Food systems fragility: climate change, emergencies of various nature with potential to affect food safety and food supply *(lessons from COVID-19 pandemic)*
- Evolving and emerging food safety hazards and issues involve unknown, uncertainty and require growing attention to food safety
- Need more resilient, sustainable and safe food supply at all scales (local-national-regional-global)

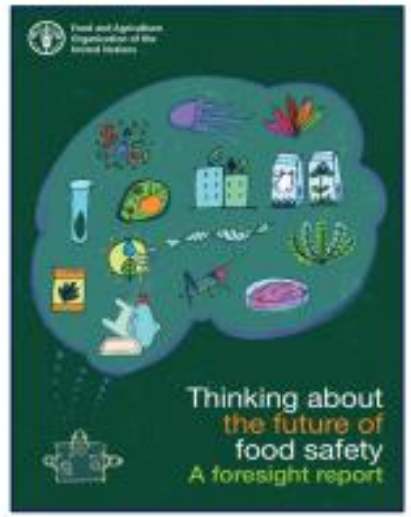
What are food safety challenges to address in the near future ?

Major drivers and trends relevant to agrifood systems and food safety



Changing agrifood systems is associated with more complexities in food safety

SUSTAINABLE DEVELOPMENT GOALS



Source: FAO. 2022. *Thinking about the future of food safety – A foresight report*. Rome. https://doi.org/10.4060/cb8667en

Drivers and related trends

Drivers are macro-level factors that derive from a broad spectrum of areas: societal, environmental, technological, political and economic

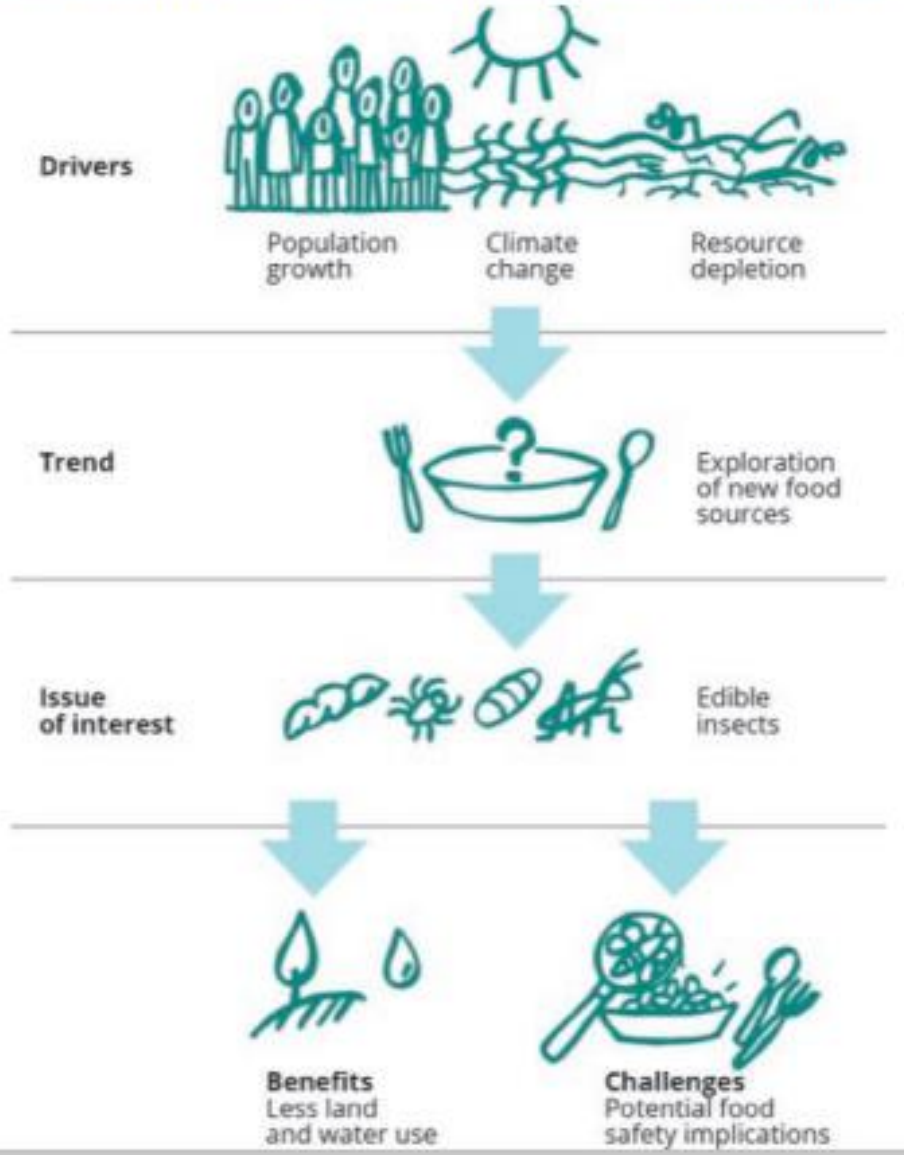
Trends are recognizable manifestations of drivers.

- ✓ Multiple drivers can concurrently cause or affect a trend.
- ✓ Multiple trends can be traced back to a single driver.

Major drivers and related trends covered in the FAO Foresight report

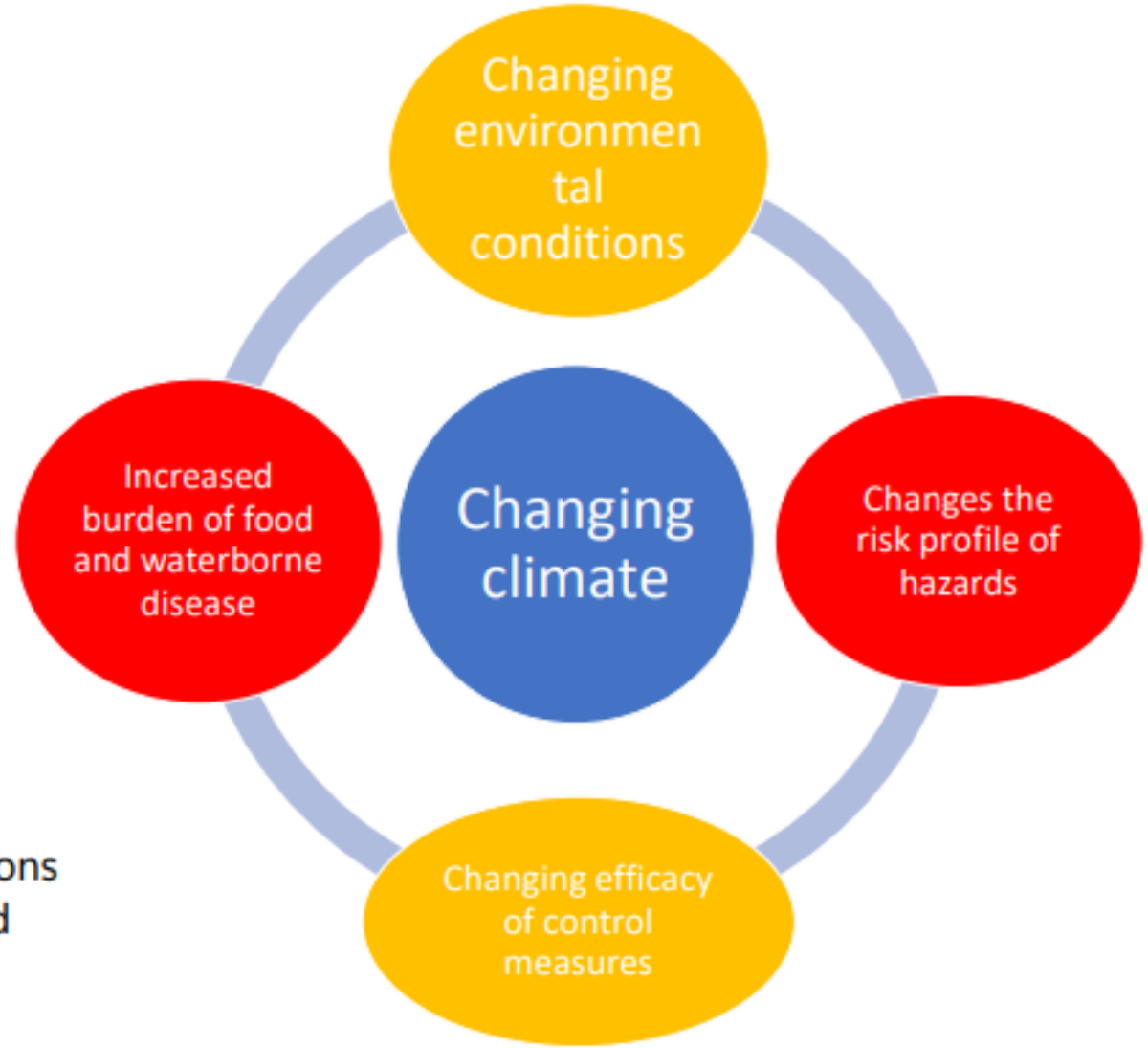
- ✓ Climate change
- ✓ Changing consumer behaviour and food consumption patterns
- ✓ New food sources and food production systems
- ✓ Technological innovations and scientific advances
- ✓ Circular economy and plastic recycling
- ✓ Microbiome science
- ✓ Food fraud

How have they been used for the FAO Foresight report?

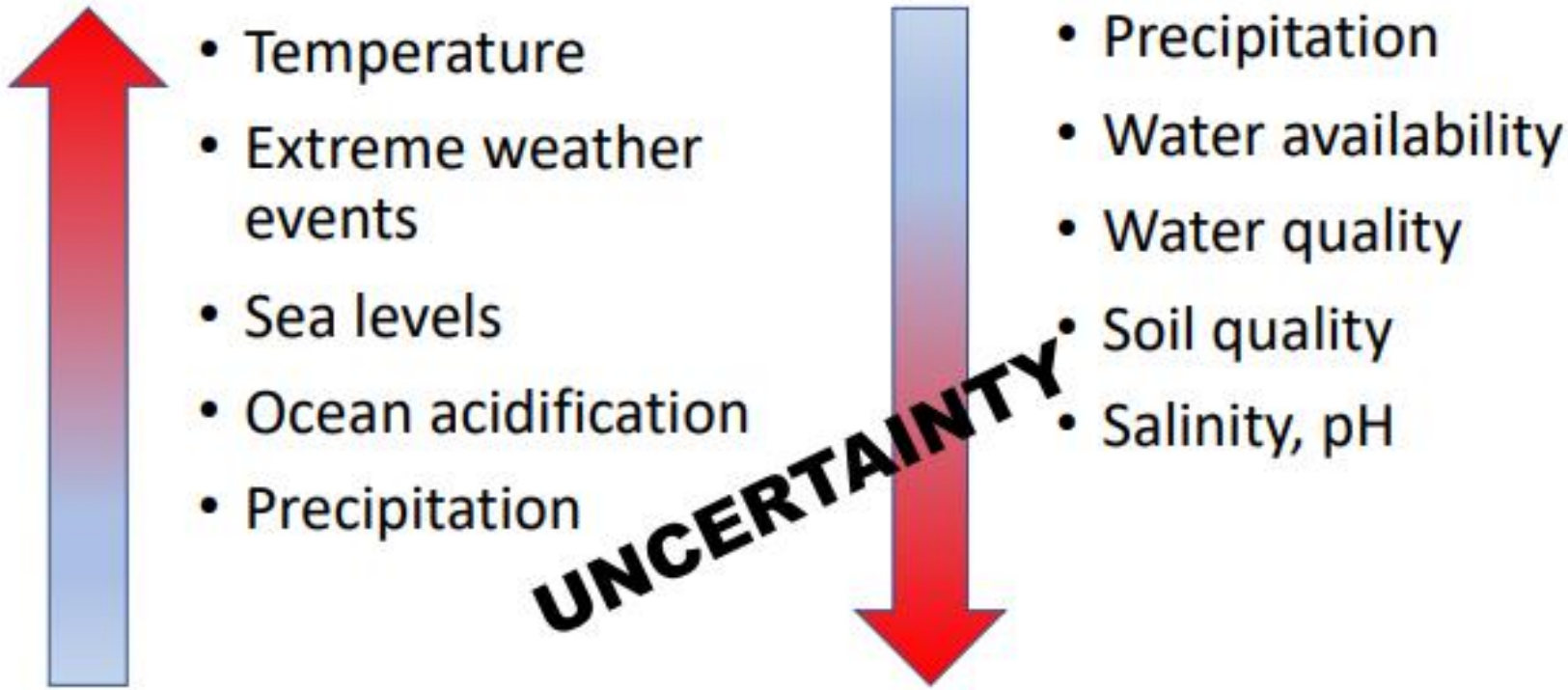


Why should the food safety community be concerned?

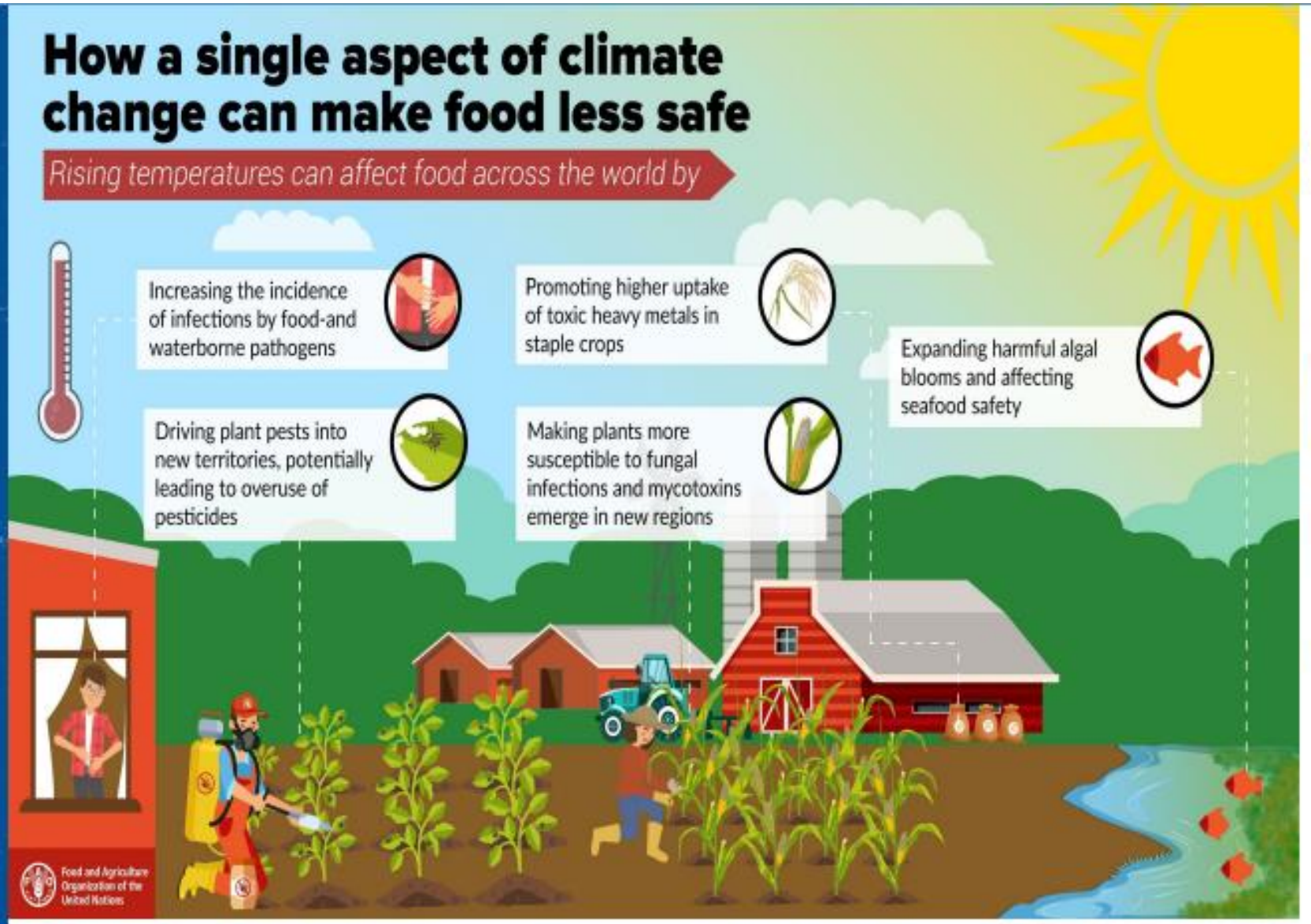
Changing environmental conditions have serious implications for both biological and chemical contaminants in food and water by altering their occurrence and severity



Climate change – changing environmental conditions



Climate change and food safety impacts



Direct effects – increase in occurrence of existing hazard

Indirect effects – actions to mitigate a problem e.g. plant pest or animal disease my lead to a food safety risk

FAO, 2021

Foodborne pathogens

Nontyphoidal *Salmonella*

- High human health impact
- Estimated 93.8 million illnesses, of which an estimated 80.3 million are foodborne annually
- Estimated 155,000 deaths each year.

Majowicz et al, 2010

- Persistence and adaptability
- Associate with a wide range of foods

Vibrio spp

- responsible for the majority of human diseases attributed to the natural flora of aquatic environments and seafood
- Raw and undercooked seafood
- Temperature plays an important role

Why this is a real concern for Salmonella

- Increasing temperature, precipitation, extreme weather events can lead to increase in proliferation and prevalence of Salmonella serotypes
- Salmonellosis associated with an increasingly broad range of foods of animal (meat, eggs, dairy (infant formula) and plant origin (spices, nuts, sprouts, fresh fruits and vegetables, chocolate)
- Ability to persist in challenging environmental conditions
- Can cause illness at low doses
- Already a high disease burden – could increase – greater challenges for control

Salmonella and increasing temperature – examples of some of the findings in this area

Association between increasing temperature and Cases of salmonellosis

European study

- An increase of 1 °C in the weekly ambient temperatures resulted in a 5 to 10 percent increase in salmonellosis cases (Kovats et al., 2004).

US study

- Each degree (°C) rise in temperature increased the risk of reporting a case by 1.3 to 5.9 percent (Uejio, 2017)

Australian study

- higher daily mean temperature and precipitation increase the risk of contracting salmonellosis. (Stephan & Barnett, 2016)
- Increasing disease notifications with increasing temperatures (Robertson et al 2022)

Association between increasing precipitation and/or extreme events and cases of salmonellosis

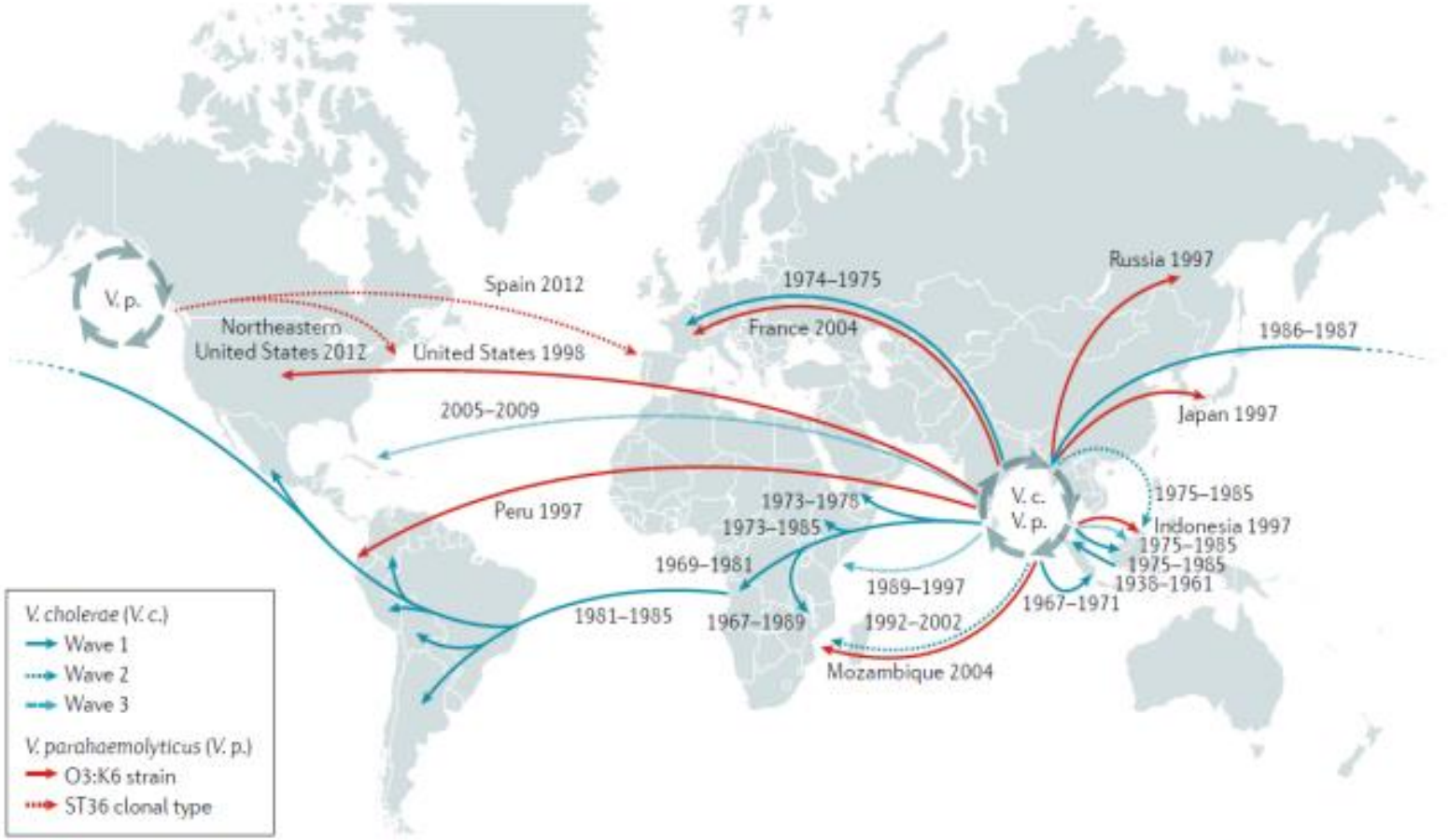
US study

- for every 1 unit increase in extreme temperature events there was an increase of 4.1 percent in risks related to Salmonella infections; (Jiang et al 2015)
- 5.6 percent increase in the salmonellosis risk was associated with a 1 unit increase in extreme precipitation events (Jiang et al 2015)
- Extreme precipitation event linked to increase in cases of some Salmonella serotypes (Morgado et al, 2021)

Australian study

- Without mitigation, increasing temperatures will lead to an increase of approximately 50 percent in the morbidity burden (calculated as Years Lost due to Disabilities or YLDs) of Salmonella infections by 2030 in Australia (Zhang, Bi and Hiller, 2012).

Spread of *Vibrio* spp.



Baker Austin et al 2018

Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Sudan and South Sudan has not yet been determined.

Final status of the Abyei area is not yet determined.

Future scenarios of risk of Vibrio infections in a warming planet (Trinanes & Martinez-Urtuza, 2021)

Disease burden estimates and predictions

- the major increase of reported *Vibrio* cases to date, particularly in those areas reported in this study with the highest risk:
  - the North of Europe
  - Atlantic northeast
  - Pacific northwest
  - Southeastern China
- First global estimate for *Vibrio* infections - around half a million of cases worldwide in 2020.
- Anticipated expansion of both the temporal and spatial disease burden for Vibrio infections, in particular at high latitudes of the Northern hemisphere.
- Largest increase from 1980 to 2020 so more moderate increase is expected for the future

Future scenarios of risk of *Vibrio* infections in a warming planet (Trinanes & Martinez-Urtuza, 2021)

At risk population

- Population at risk in suitable regions almost doubled from 1980 to 2020 (from 610 million to 1100 million under the scenario of medium challenges to mitigation and adaptation)
- Increment will be more moderate in the future and stabilizes after 2050 at 1300 million

Future scenarios of risk of *Vibrio* infections in a warming planet (Trinanes & Martinez-Urtuza, 2021)

At risk areas

- increase in coastal areas suitable for Vibrio could cover 38000 km of new coastal areas by 2100 under the most unfavourable scenario

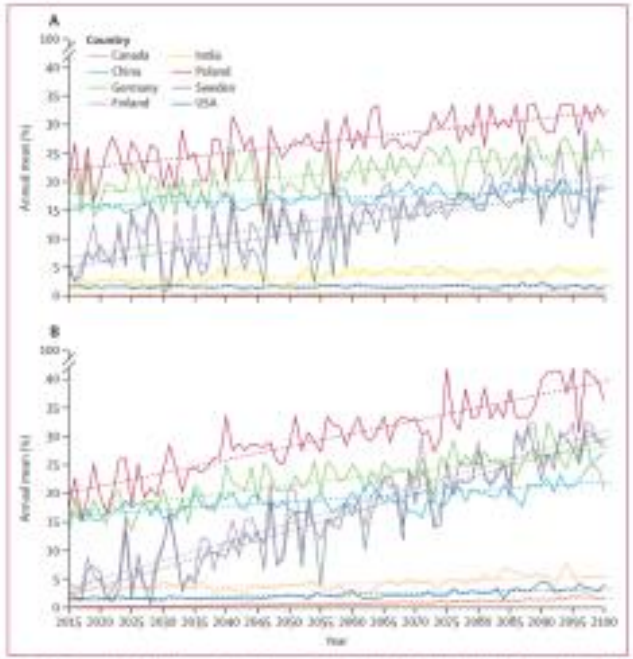


Figure 2: Time series showing the variation of shoreline with suitable conditions for Vibrio for a selection of countries

Risk management - Codex work and *Vibrio* spp.

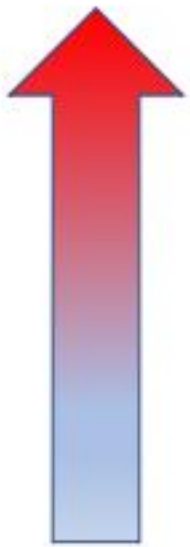
- Guidelines on the Application of General Principles of Food Hygiene to the Control of Pathogenic Vibrio Species in Seafood (CXG 73-2010)

  Since then: emergence of highly pathogenic strains, geographical spread of infections of *Vibrio* spp. in association with climate change, and potential demographic effects on increased risk in densely populated coastal regions

  Changes to be made

  - updated microbiological monitoring methods including molecular-based approaches;
  - latest data on new pathogenic strains, their geographical spread and clinical incidence;
  - detection and characterization of *Vibrio* species;
  - novel methods including remote sensing-based techniques, satellite imagery and whole genome sequencing which would facilitate predicting periods of elevated risk and better control the viruses; and
  - practical interventions related to seafood, including pre-harvest interventions (e.g. relaying at harvest such as reduced cooling times), and post-harvest treatments (e.g. high-pressure processing, freezing and pasteurization), contributing to the reduction of risks of vibriosis associated with the consumption

Other foodborne pathogens



- Increased occurrence of parasites in freshwater fish and plants
- Increase pathogen shedding
- Increase in mastitis, animal disease (use of medicine, AMR)
- Decrease in some viruses

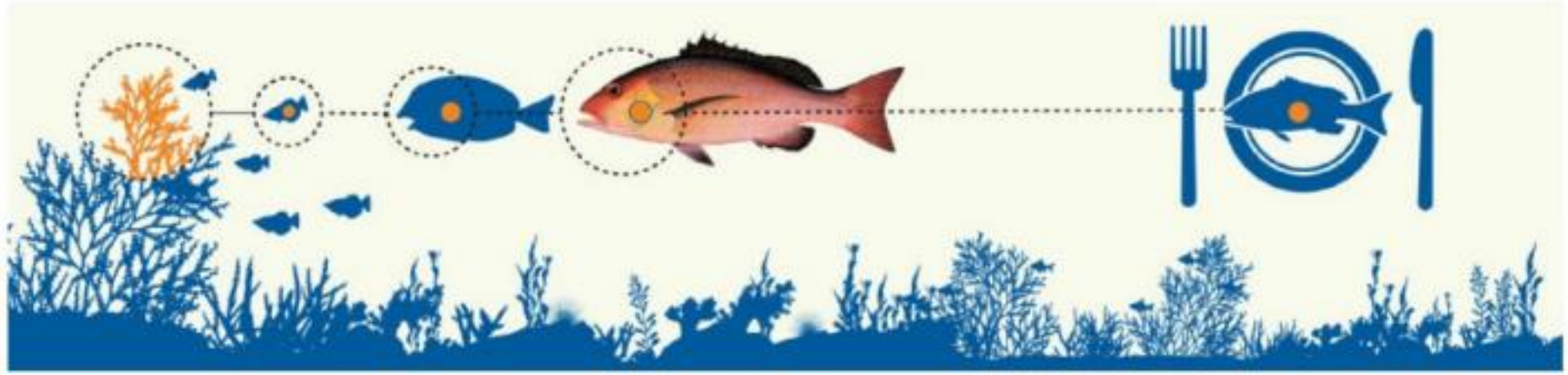
- Internalization of pathogenic *E. coli* and *Salmonella* in leafy green vegetables
- Increased faecal contamination due to run-off
- Contamination due to splash, flooding

Algal blooms

- Algae are a natural component of the aquatic ecosystem - algal blooms occur when certain algae grow out of control due to various environmental and anthropogenic conditions
- Some produce toxins - can bioaccumulate in fish and shellfish and induce toxic syndromes in humans when consumed
- Climate change: harmful algal blooms expanding to new areas, most of which are not prepared to address the challenges of detection and surveillance, risk to public health and trade

Algal blooms – Ciguatera in fish

Changes in coral reefs



Proliferation of toxic dinoflagellates → Toxic dinoflagellates eaten by small herbivorous fish → Small fish eaten by larger carnivorous fish → Fish eaten by human

The toxic dinoflagellates, mainly *Gambierdiscus*, can produce Ciguatoxins (CTXs)

Ciguatera fish poisoning (CFP)

Algal blooms – geographic spread of Gambierdiscus (ciguatera)

FAO, 2018

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Mycotoxins

- Already a big problem in particular in tropical areas
- *Temperature, relative humidity, and crop damage by pests* - influence fungal growth and mycotoxin production in crops.
- With cooler temperate zones becoming warmer and more conducive to agriculture – potential new habitat - fungal species producing mycotoxins are now quite established in other geographical zones and regions.
- Inadequate storage and transportation infrastructure, especially under climate change conditions and lengthening food chains - increase the risk of production and dissemination of mycotoxins

Heavy metals

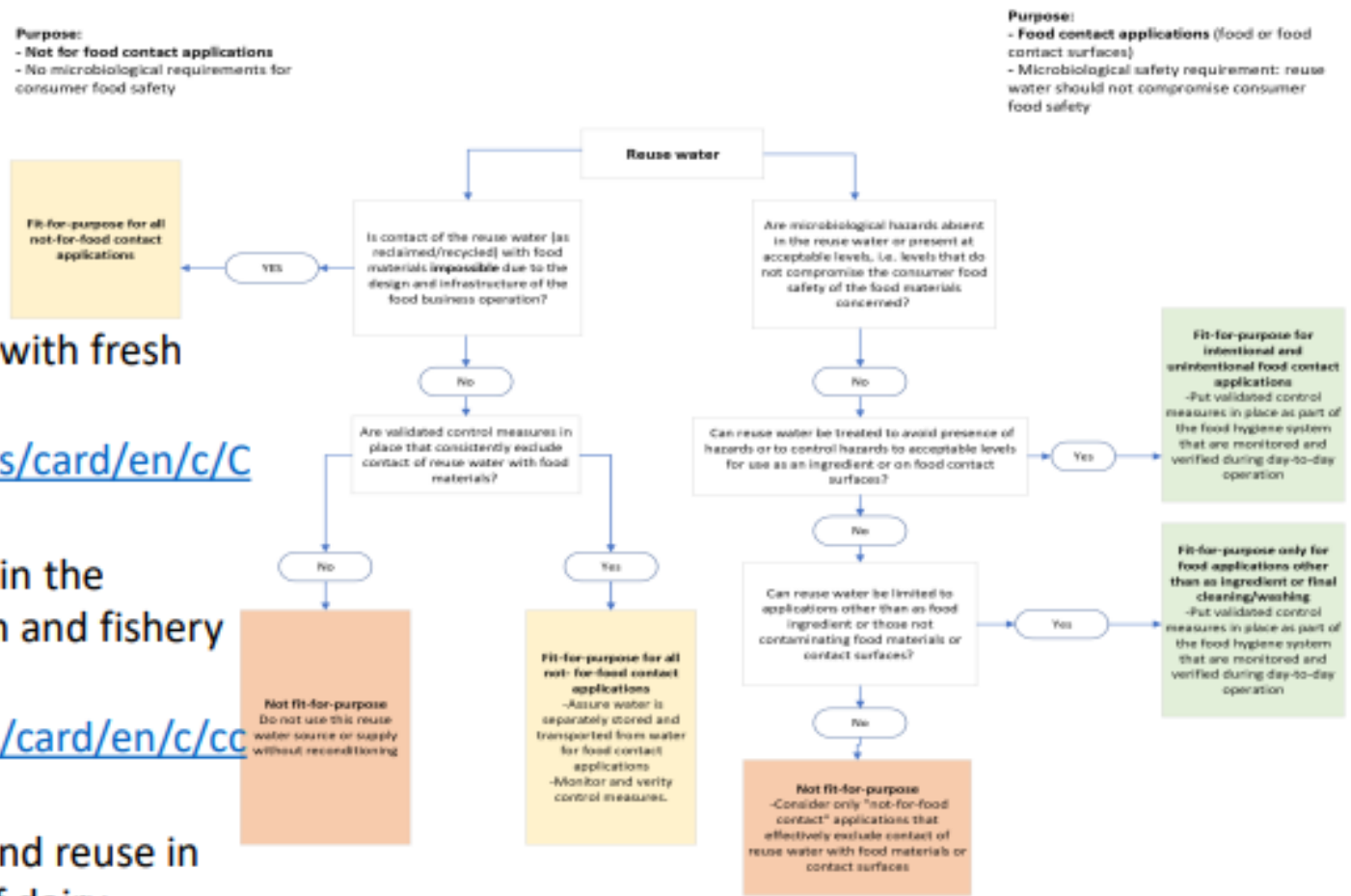
- Warmer water and acidification - Increase in bioaccumulation of methylmercury in fish
- Extreme weather conditions – rainfall, flooding – spread of toxic metals eg form mining areas to food production areas
- Increasing soil temperature – uptake of arsenic

Food safety concerns relate not only to hazards: use and re-use of water

- Access to clean water
- Cost of dealing with waste water
- Maintaining safe food through a risk based approach

Fit-for-purpose water

Science to Codex Guidelines on safe use and re-used of water



- Safety and quality of water used with fresh fruits and vegetables (MRA37) https://www.fao.org/publications/card/en/c/CB7678EN
- Safety and quality of water used in the production and processing of fish and fishery products (MRA 41, 2023) https://www.fao.org/documents/card/en/c/cc4356en
- Safety and quality of water use and reuse in the production and processing of dairy products (MRA 40) https://www.fao.org/food-safety/resources/publications/en/

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Changing consumer preferences and food consumption patterns

Changes in food purchasing habits and consumption patterns of consumers trigger changes in dietary risks arising from potential contaminants found in food

Consumer preferences are constantly evolving in response to a multitude of different factors (environmental concerns, animal welfare, health, etc): need to identify emerging allergens & contaminants in new food sources, establish standards & risk management solutions (functional foods, nutraceuticals)

Consumers' food safety awareness is shaped by how they search for and share information: Importance for availability and accessibility of information from trusted sources/counteracting misinformation

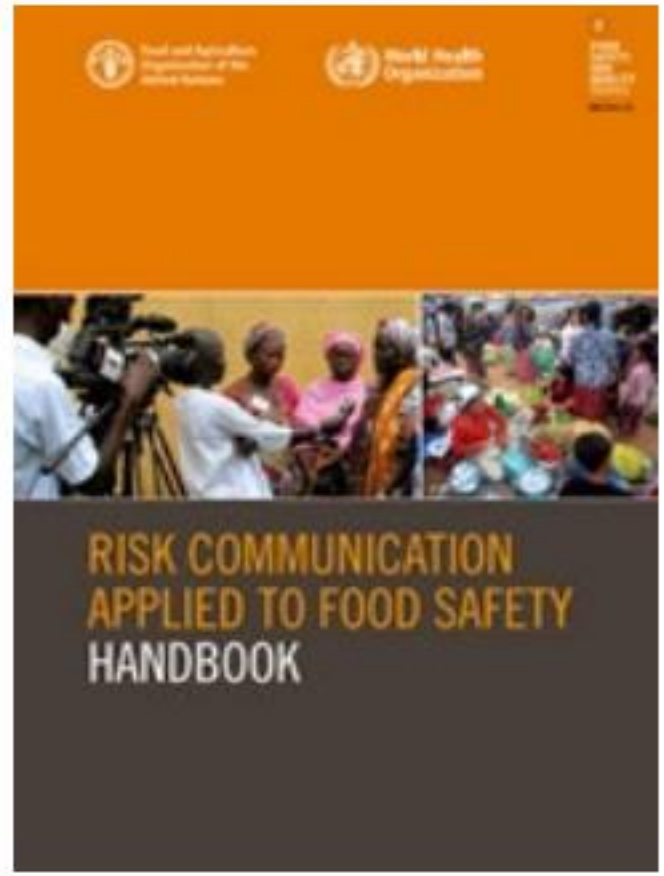
Increased e-commerce requires infrastructure adjustments, renewed adherence to food safety and GHPs, regulatory solutions

Essential features of food safety risk communication

1. *Trust* in information and governing institutions is essential for effective food safety risk communication
2. Risk communicators should actively work to demonstrate credibility, honesty and care
3. Food safety risk communication should be founded on good communication principles

Principles of Good Risk Communication

- Accountability and Trust
- Openness and Transparency
- Timeliness and Responsiveness
- Preparedness and planning
- Coordination and Cooperation



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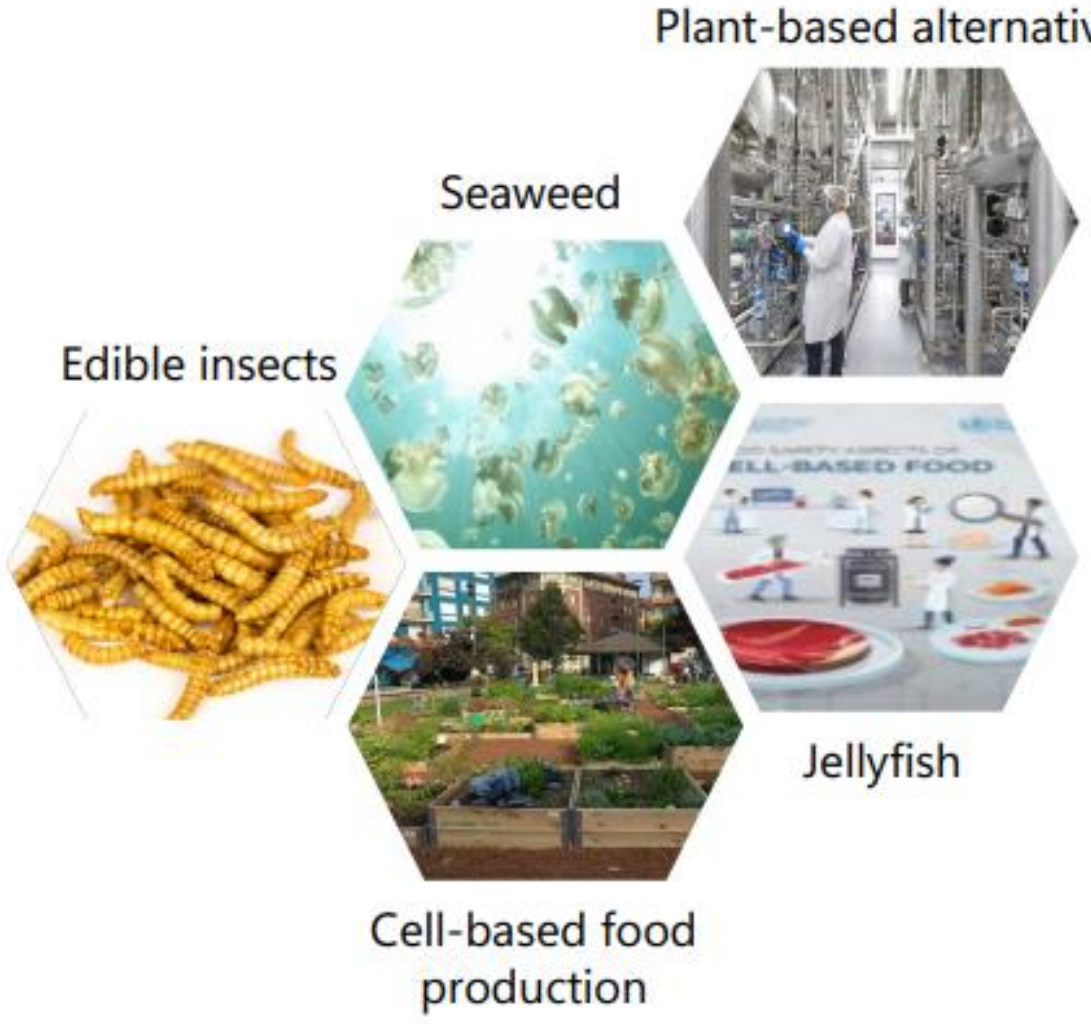
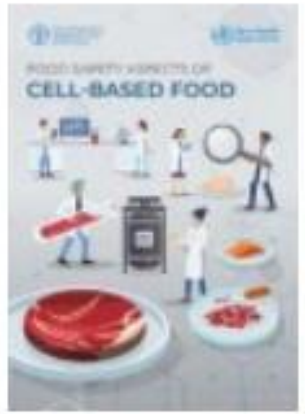
New food sources and food production systems



Food safety aspects

- ✓ Microbiological hazards
- ✓ Chemical hazards

Regulatory aspects



https://www.fao.org/documents/card/en/c/cc4855en

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Food safety considerations for agriculture *within* urban spaces

Multiple food safety implications to be considered.

Good governance (mechanisms, capacities, policies, financial support, relevant infrastructure and services) specific to urban food systems will be needed for safe and sustainable urban food systems.

Agriculture within urban areas can meet local food and nutrition security concerns and reduce food miles

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Exploring circular economy through plastic recycling

Adequate regulatory frameworks and underpinning risk assessments are needed

The concept of circular economy has been gaining a lot of attention globally as a way to overcome the linear way of of resources use

While circular economy for plastic food packaging seems feasible in theory, recycling and reuse of food packaging require careful food safety considerations.

https://www.pangea-si.com/chemicals-and-plastic-recycling/

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Microbiomes, a food safety perspective

Microbiota consists of all microorganisms - bacteria, viruses, protozoa and fungi - that reside inside our guts and around us. Microbiome is the collection of their genetic materials.

The growing understanding of the microbiome-environment-host interactions, and their influence on human exposure to different types of agents, open a new avenue to better understand hazards and health risks, and therefore microbiological and chemical assessments.

Understanding the relative role and underlying mechanisms of the microbiome in health and disease will enable the update of food safety risk assessments and the development of evidence-based methodologies and frameworks to evaluate microbiome-related data.

https://www.fao.org/3/ca6767en/CA6767EN.pdf

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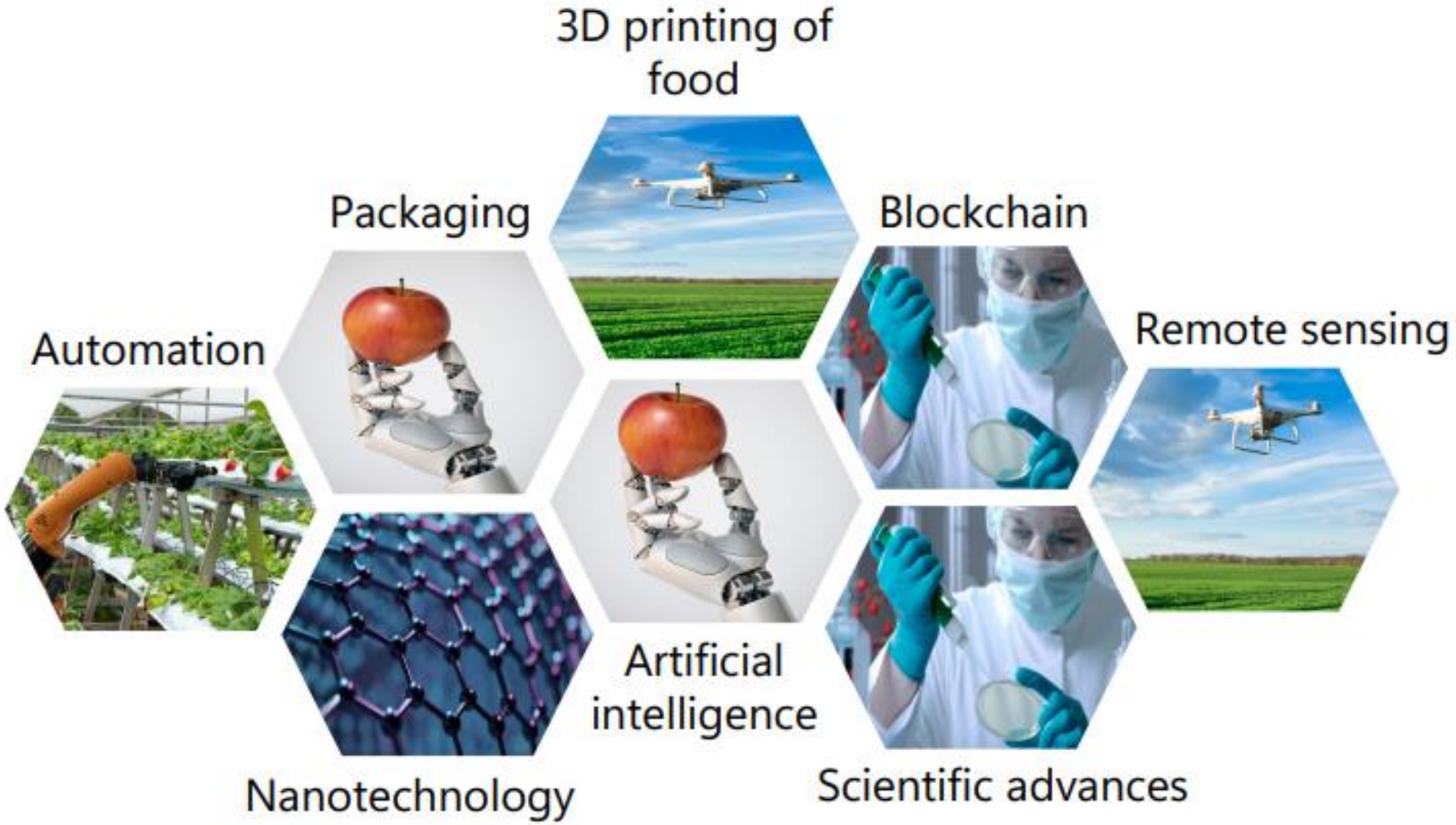
Technological innovations and scientific advances



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Food fraud - reshaping the narrative

National food controls are built around the notion of trustworthiness of the agrifood system actors

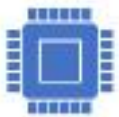
National and regional approaches can be developed using an appropriate combination of the regulatory strategies

Need to look beyond data as a solution and considering social variables as an equally valid element to address food fraud

Risk assessment

- Aiming to make more use of environmental data (satellite, remote sensing)
- Research to establish correlations
- Supports development of predictive models – only as good as the data are
- New risk assessment insights that can support risk management

New approaches to data analysis is required in the context of increasing data volumes, which include using tools based on machine learning and artificial intelligence



Technologies for data collection and processing are developing at a great pace and a good understanding how they can be used is essential

Data sources

- Sensor data (e.g., from spectroscopy and electronic noses)
- Image data (e.g., Satellite images, mobile phone images)
- Text data (e.g., online media, publications)
- Food inspection and control (e.g., whole-genome sequencing data)
- Food research (e.g., expert knowledge)

Smart food safety early warning systems

Corresponding technology:

- **Biosensors** and other types of sensors used in IoT and Big data(e.g., precision livestock farming).
- **Blockchain** for food traceability (difficult to mutate the data that once have been entered and the independent verification of data packages)
- **Portable and smartphone-based** food diagnostic technologies (e.g., for food fraud detection)
- **Text mining** and predictive machine learning techniques

Broader data focus: not only food safety data, but also data on economic, environmental, social, and technological factors

Example applications:

- A real-time food fraud early warning system based on media reports collected from overall the world using food fraud system (MedISys-FF)(Marvin et al., 2022).
- Automated food safety early warning system in the dairy supply chain using machine learning for real-time anomaly detection for food authorities and inspectors. (Liu et al., 2022)

Text mining in early warning system and identification of emerging issues

Data sources:

- mainstream news media
- government websites
- specialty blogs
- social media platforms

e.g., Twitter, Facebook and Instagram

Example application:

- Illegal stimulants in food supplements

The European Media Monitor and scientific literature served as data sources, word-embedding model applied (Gavai et al., 2021)

- lettuce food poisoning in the USA

Twitter as input for a text mining machine learning model (Tao et al., 2021)

Findings from FAO/WFSR survey (2022)

- Identification of **early warning signals and emerging risk signals of food safety** in food and feed is considered as **important**, but not always identified as a prioritized activity in many organizations. **Awareness need to be further enhanced**
- **Lack of software tools** for identifying food safety **early warning signals**, especially for **emerging risks** of food safety in food and feed.
- **Enabling policy environment**, **technical skills and capacities** (e.g., human, financial, infrastructure) are **insufficient** at their current level to build or improve emerging risks identifying tools.
- There is general **a low level** of **automated data collection**
- **Machine Learning and AI** are **not implemented** in many organizations. Nevertheless, their **importance** are acknowledged

Gap analysis

❖Technical challenges

- Lack of Internet access
- Lack of technologies (e.g., monitoring system; large computational infrastructure; High tech, e.g., robotics, sensors, drones)
- Limited access to the data

❖Social-economic challenges

- Lack of coordination between agencies
- Lack of skilled personnel
- Lack of good financial conditions
- Lack of supporting policy

Gaps for different technologies

- Big Data (Insufficient data quality and quantity; scalability, data storage, data integrity, data transformation, data governance, privacy and legal issues)
- Internet of Things (IoT) (Lack of standardized communication protocols; difficult in data interpretation; inadequate hardware and software security)
- Artificial Intelligence technology (Lack of sufficient digital labeled data in the food safety domain; issues of transparency and interpretability; long training time as well as hardware restrictions)
- Automated food safety early warning systems (The system presented in the literature is still a proof of principle; expert interventions are still needed for the regular maintenance; a holistic approach is needed including the creation of suitable ontologies)

Machine learning algorithms

- ***Bayesian network*** is the most frequently used algorithm for analyzing ***structured data*** and has advantage in incorporating multidimensional factors (e.g., social, environmental, economical) and expert opinions.

- ***Neural network*** is the main algorithm for analyzing ***unstructured data*** because of its advantage of handling both ***image and text data***.

Take action

- Be **aware**
- **Invest** and strengthen surveillance, strategic monitoring and food safety **management** plans - application/enforcement
- New approaches to analyse increasing data volumes using tools based on machine learning and artificial intelligence), promote data **sharing**
- **Engage** with stakeholders (local, national, global), harness expertise, resources
- Unified response to growing common challenges: integrated OH & cross-sectoral approach (environment, AG, health), **assess**/re-assess risk
- Advance knowledge though **research** (identifying the issues and improving solutions – they should not be re-inforcing the problem)
- **Increase awareness, accessibility and application of Codex texts** and web-based tools (Food Hygiene, Codes of practice for mycotoxins, Reducing of Salmonella and Campylobacter spp. In chicken meat, etc)
- Be **forward** thinking

Closing remarks

Foresight plays an important role in identifying emerging food safety challenges and opportunities that will continue to arise as the global context evolves with ongoing transformation of the agrifood systems

- ✓ The changing global contexts of the agrifood systems are highlighting the importance of acknowledging the growing interconnectedness, complexity and multidimensionality of food safety
- ✓ An overview of some of emerging areas of interest, as identified through the FAO food safety foresight programme can be read in our Foresight publication.

Foresight will enable emerging issues to be looked at through a food systems lens by encouraging a holistic way of evaluating both opportunities and challenges that can have varying impacts on food safety, and through it on agrifood systems.

- ✓ Foresight provides an avenue to explore emerging opportunities and challenges in their totality, including all variables influencing them, allowing food safety authorities to develop a multisectoral view of the changing dynamics within and for food safety
- ✓ Foresight can help bridge science and policy by utilizing the former to inform a range of food chain-related decisions that enhance the latter.

Closing remarks

FAO is well-placed to collect, analyse, and disseminate information on various emerging issues from numerous area, and it can also provide support to countries in implementing their own foresight activities

- ✓ Limited resources, user capabilities, technical skills, and financial support are among the factors that can affect the capacity of countries to engage in foresight exercises.
- ✓ FAO's global perspectives on emerging issues in food and agriculture coupled with extensive cross-border reach and the capacity to deliver global public goods make us well-placed to collect and distribute information that is impartial and trusted.
- ✓ Effective foresight approaches rely on information gathered from a wide range of sources and this endeavour will not be possible without collaborations with our various partners, both in-house and outside. Continue to seek partnerships.

Food Safety is Everyone's Business

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Thank you

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