Introduction to
Institute For Global Food Security
School of Biological Sciences
Queen's University Belfast

Katrina Campbell
Professor in Food Security & Diagnostics

E-mail: katrina.campbell@qub.ac.uk

Queen's University Belfast

> Member of the Russell Group
> 3,500 staff
> 1000 active researchers
> 25,000 students

Institute for Global Food Security

Institute for Global Food Security Launched 14th March 2012
http://www.qub.ac.uk/igfs
Formerly Institute of Agri-Food And Land use
No1 UK REF Agriculture, Veterinary and Food Science

- 50 – 60 PIs
- 60 – 80 PDRAs
- 100 PhDs
- ~15 embedded support staff
- **A critical mass of 200 – 250 researchers**

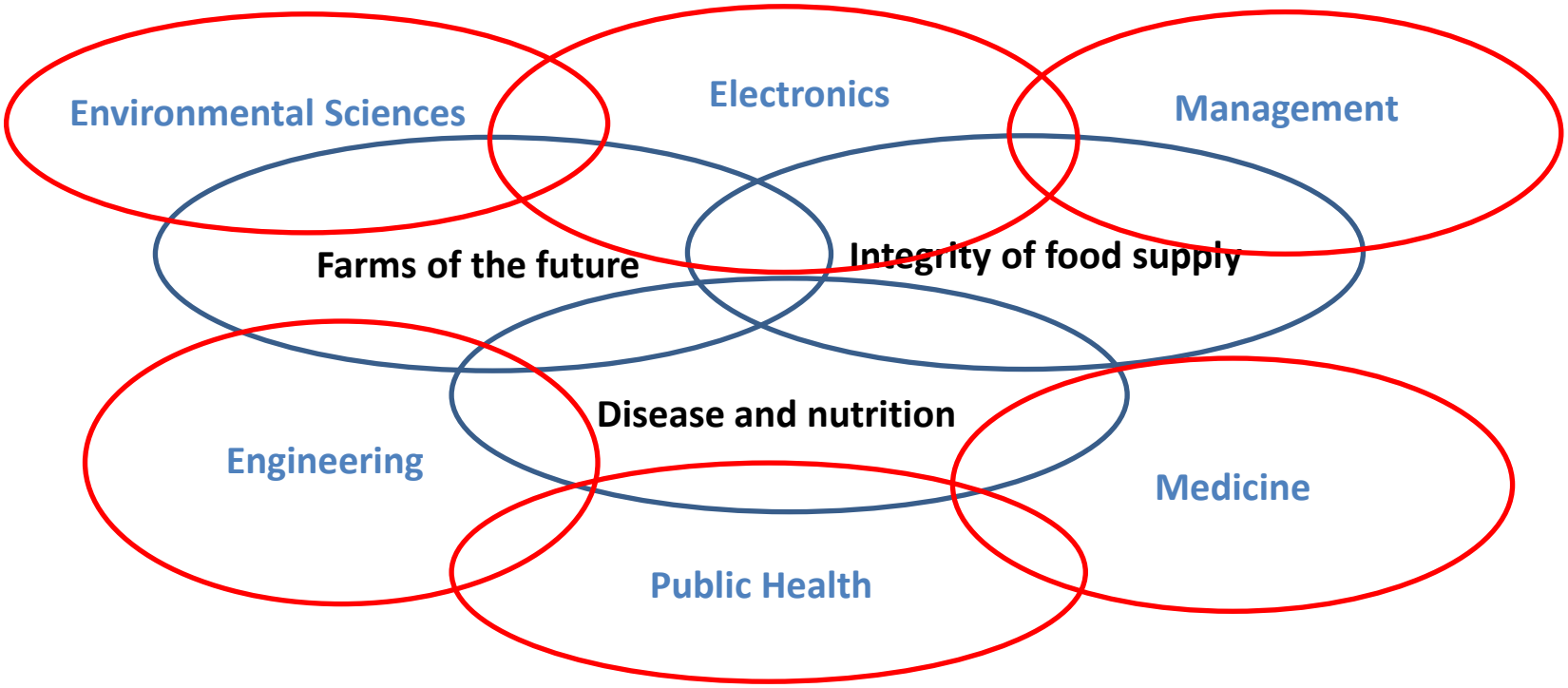
ASSET Centre - Centre for **AS**sured, **S**af**E** and **T**raceable food - Launched in January 2009

A food supply chain which is safe, transparent, rapidly traceable and sustainable

Innovative, state-of-the-art scientific techniques that will create a niche food forensic strength to develop a new dimension in animal and human health, food safety monitoring and traceability

ASSET aims to provide Industry and the consumer with Assured, Safe and Traceable food

Research Focus - Grand Challenges



UK | EU | US | Asia | Africa

Link with recognised centres of excellence and research leaders wherever they are located

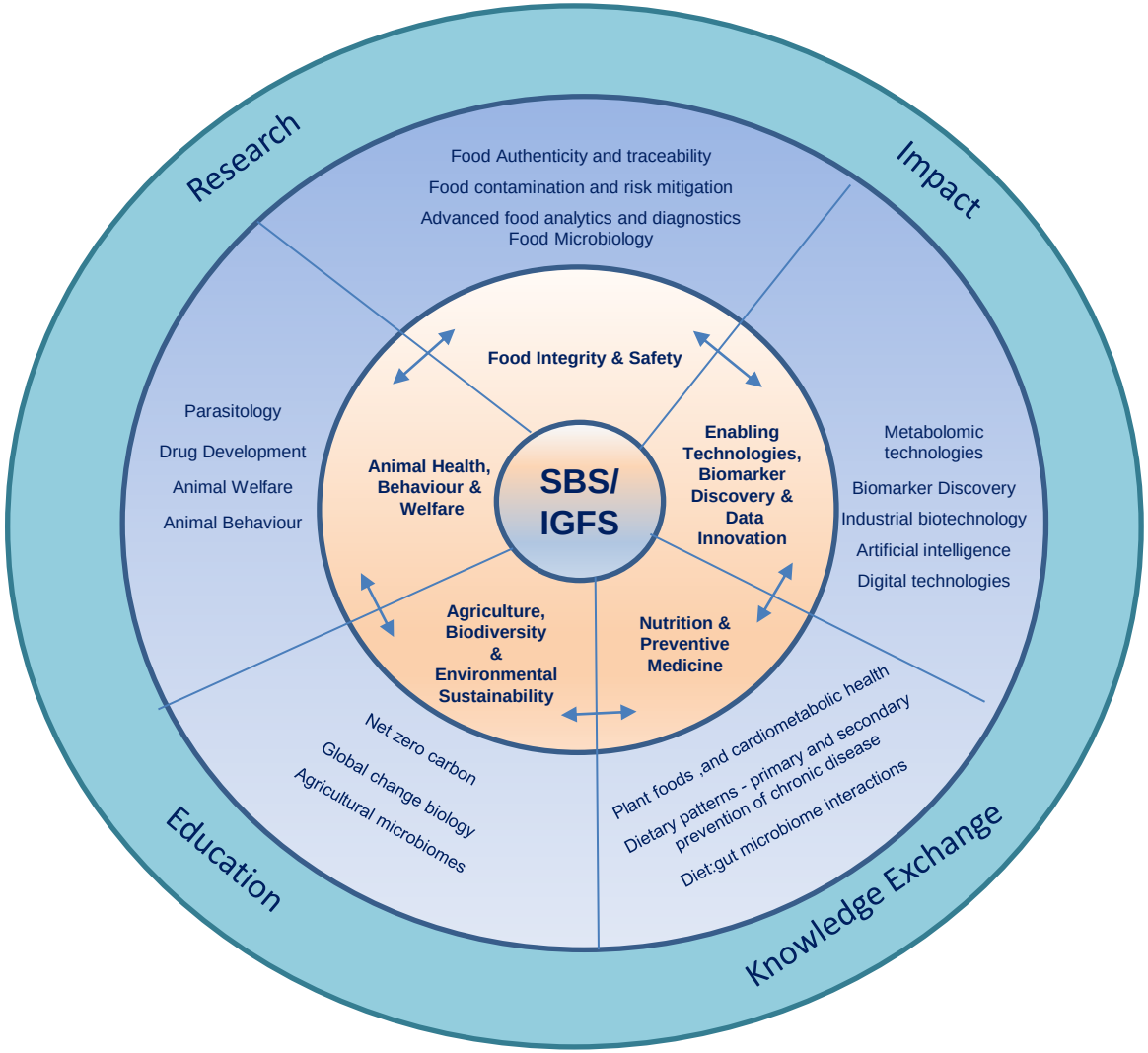
Interdisciplinary Research

Planetary Health

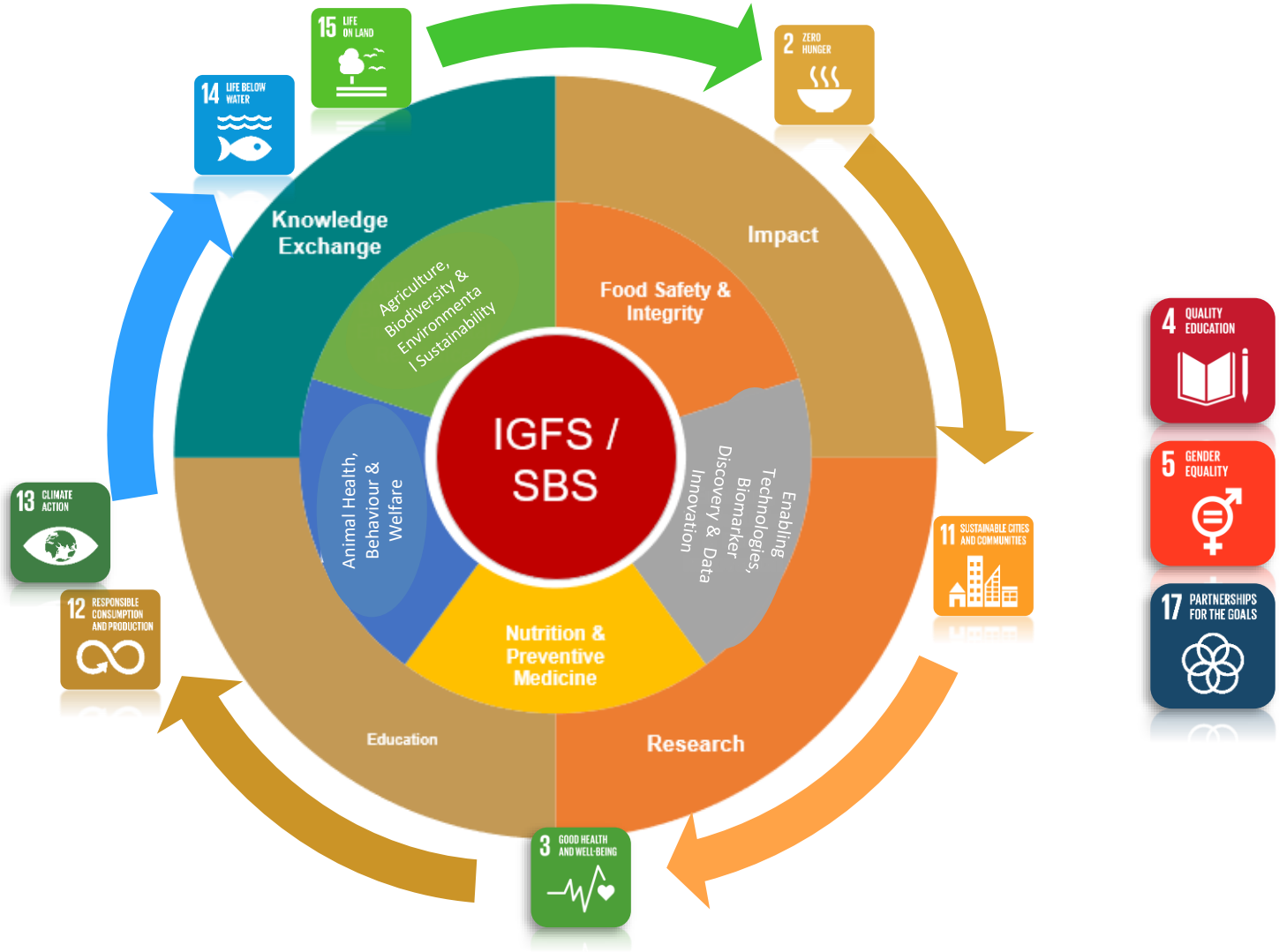
Transformative Food Systems

Nutrition and Human Health

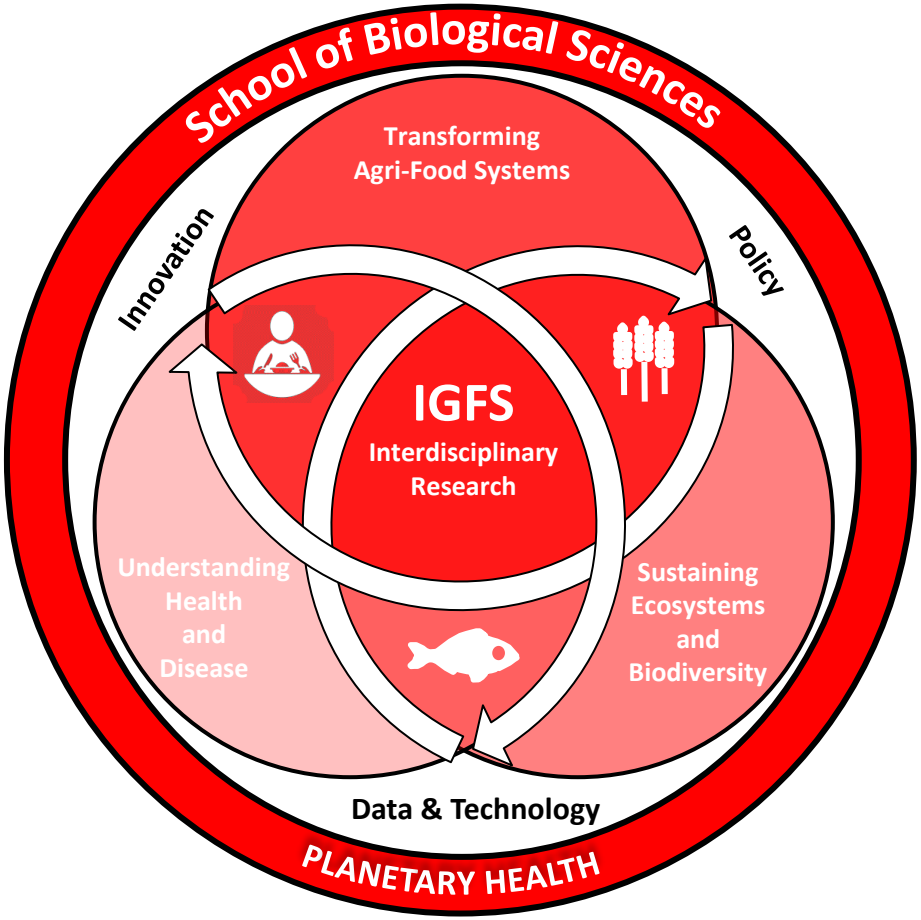
Strategic Research Themes



Strategic Research Themes & UN Goals



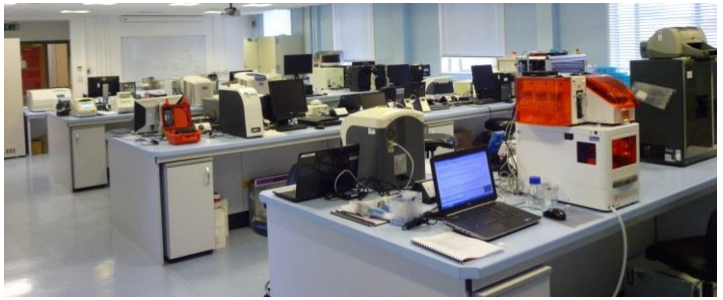
Strategic Research Themes



State of the Art Facilities

Food Analysis (Wet chemistry LAB): Sample preparation for food, feed and environmental sample analysis

ASSET LAB: Highly innovative rapid diagnostics including biosensor (SPR, acoustic wave, microarrays, lateral flow, flow cytometry, electrochemistry) and spectroscopic (IR and RAMAN) technologies



Advanced ASSET LAB: Suites of HPLCs, UPLC coupled to mass spectrometers including QTof, Xevo-TQ, Xevo-TQS, PDA, REIMS, Isotope ratio, ICP-MS for chemical analysis

Pathogen LABs: Category 2 and Category 3 Pathogen labs

Core Technologies

Building on existing core technologies:

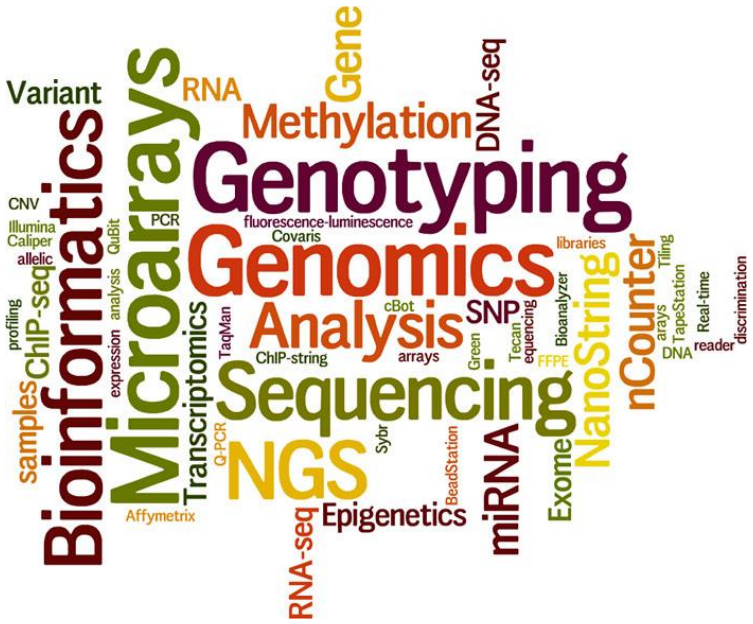
Biological Services Unit,

Advanced Imaging,

Advanced Mass Spectroscopy,

Functional Genomics

Informatics Unit



MSc & PhD Programmes

1. Advanced Food Safety
2. Molecular Biology and Biotechnology
3. Parasitology
4. Bioinformatics

PhD Research in many areas ……

Partnerships

- Institutional
- Industrial
- One to one

eit Food

Connectivity across Europe

EIT Food is a European Knowledge and Innovation Community (KIC) set up to transform our food ecosystem.
By connecting consumers with businesses, start-ups, researchers and students from around Europe, EIT Food supports innovative and economically sustainable initiatives which improve our health, our access to quality food, and our environment.
https://www.eitfood.eu/

Key drivers:

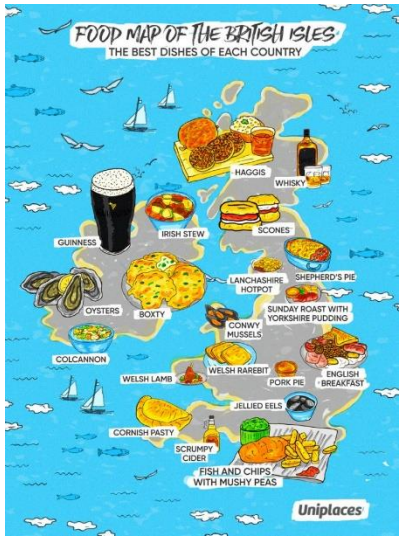
- Consumer Trust
- Public health
- Talent
- Connectivity & Transparency
- Venturing & Growth
- Sustainability

An Introduction to Food Security, Safety & Sustainability

Katrina Campbell
Prof in Food Security & Diagnostics
Institute for Global Food Security

katrina.campbell@qub.ac.uk

16th May 2022



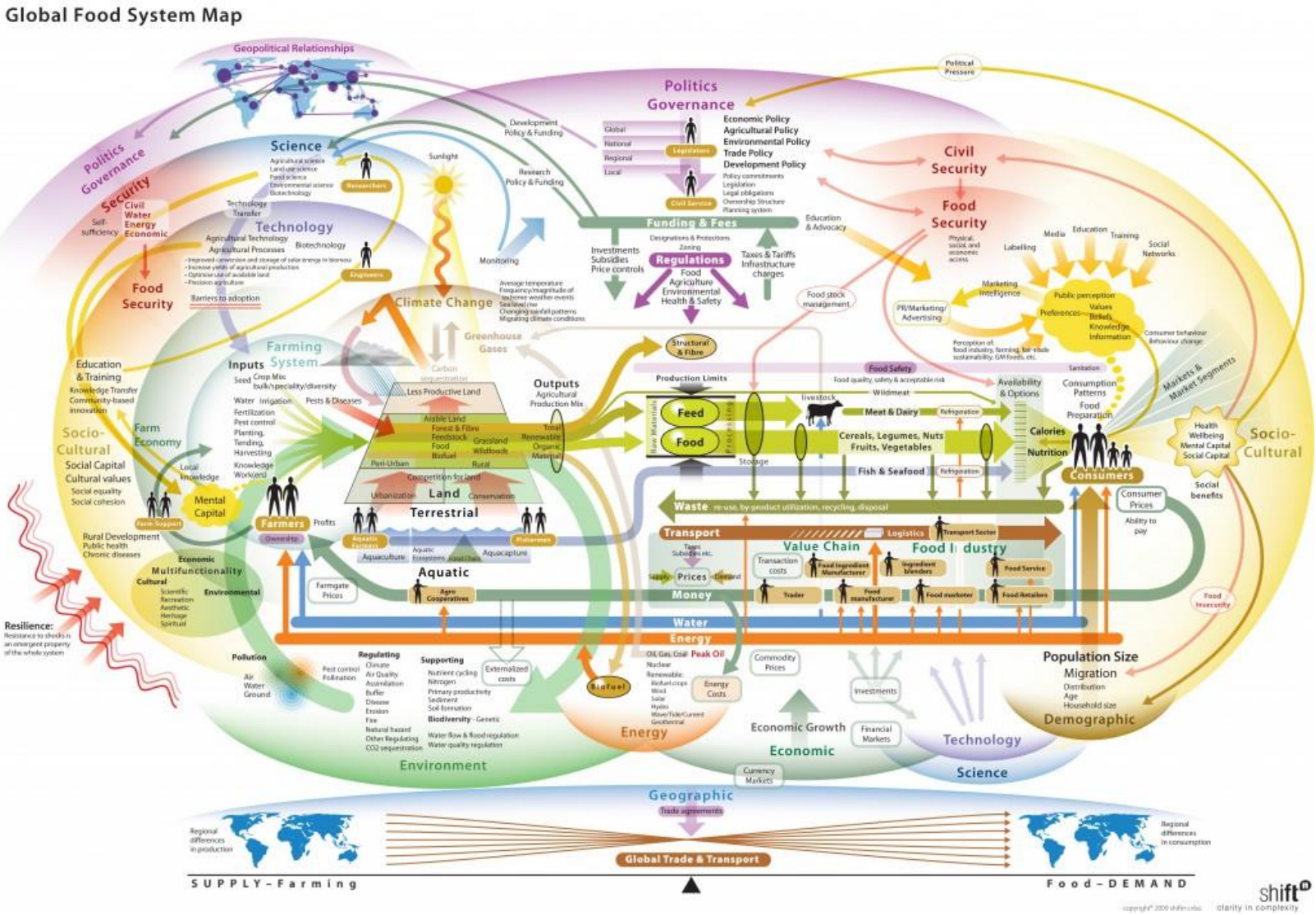
Food - agriculture & aquaculture

"Food and agriculture worldwide is fundamental for the preservation and advancement of human life on this planet"

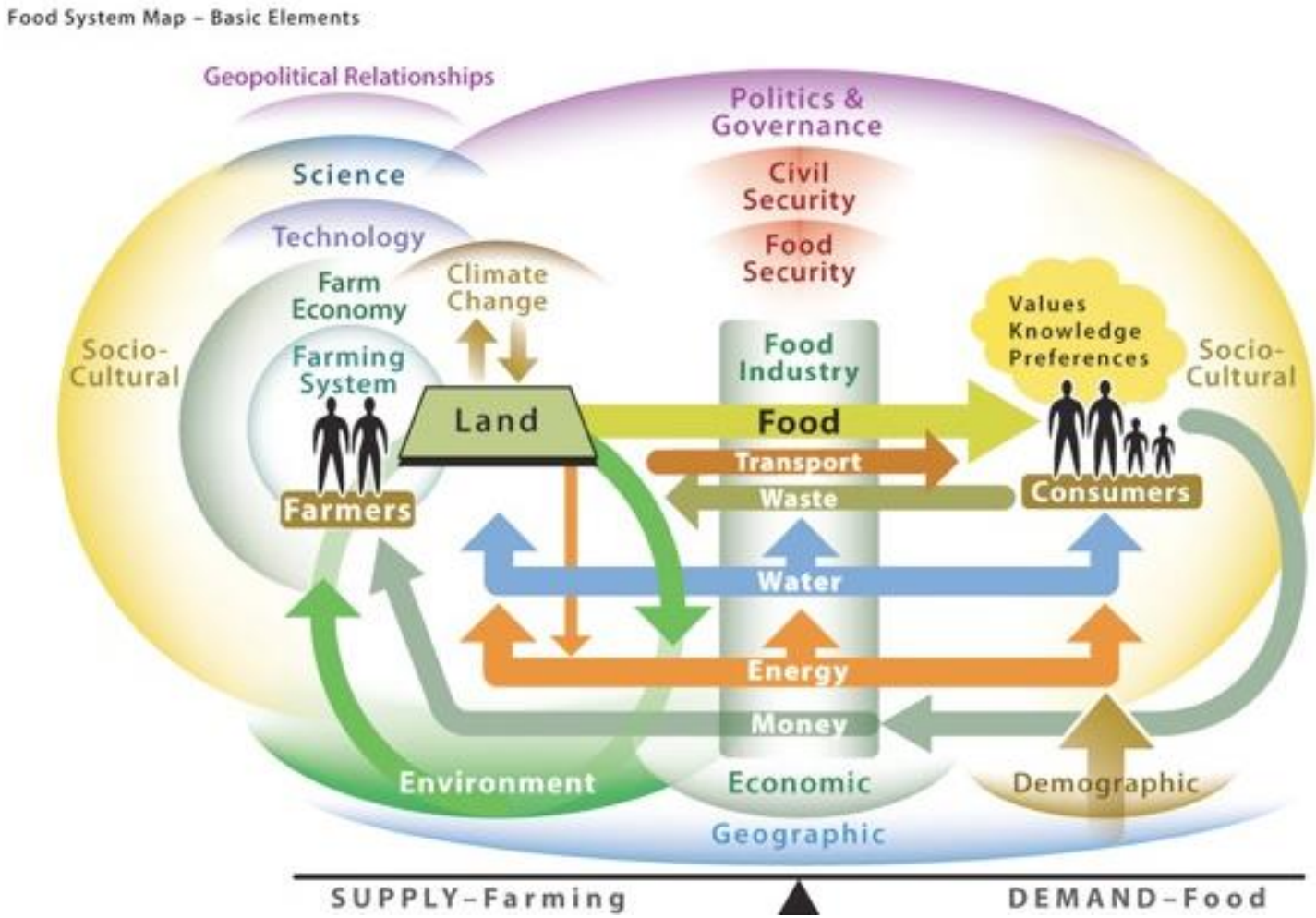
(Food and Agriculture Organization, 2016)

> "When we think about threats to the environment, we tend to picture cars and smokestacks, not dinner. But the truth is, our need for food poses one of the biggest dangers to the planet."
>
> Richardson (2014)

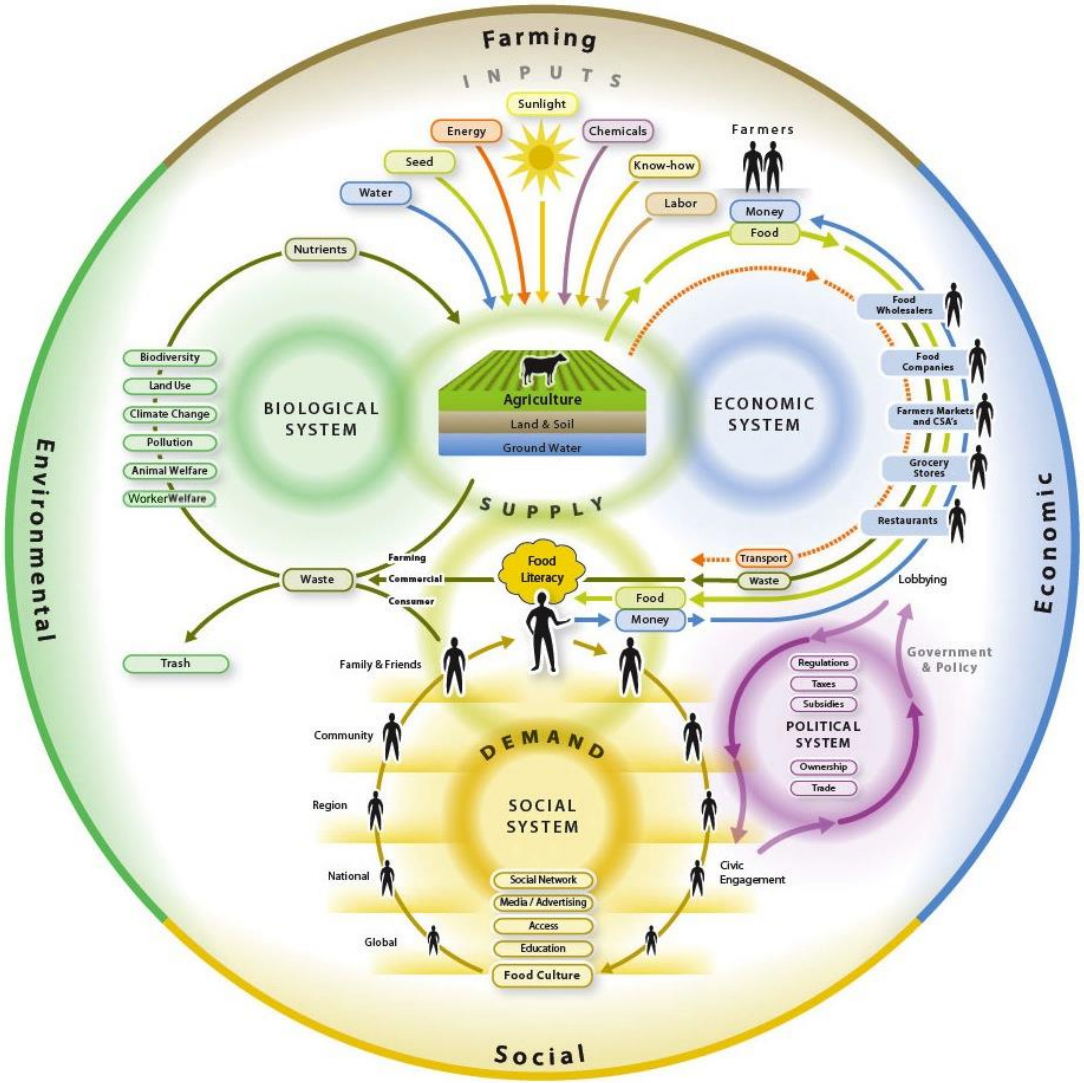
Global Food System



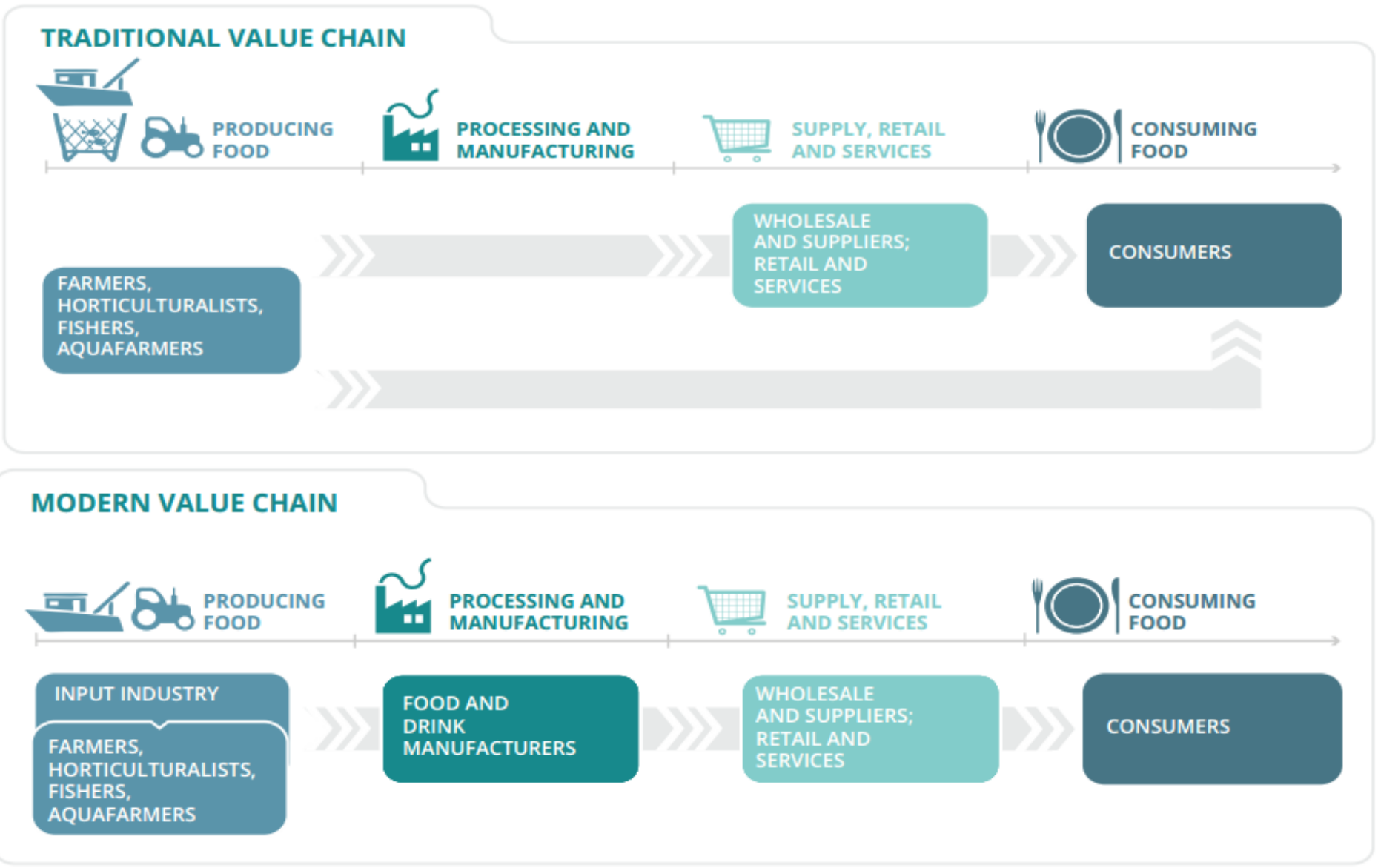
Supply vs Demand



Factors contributing to food systems

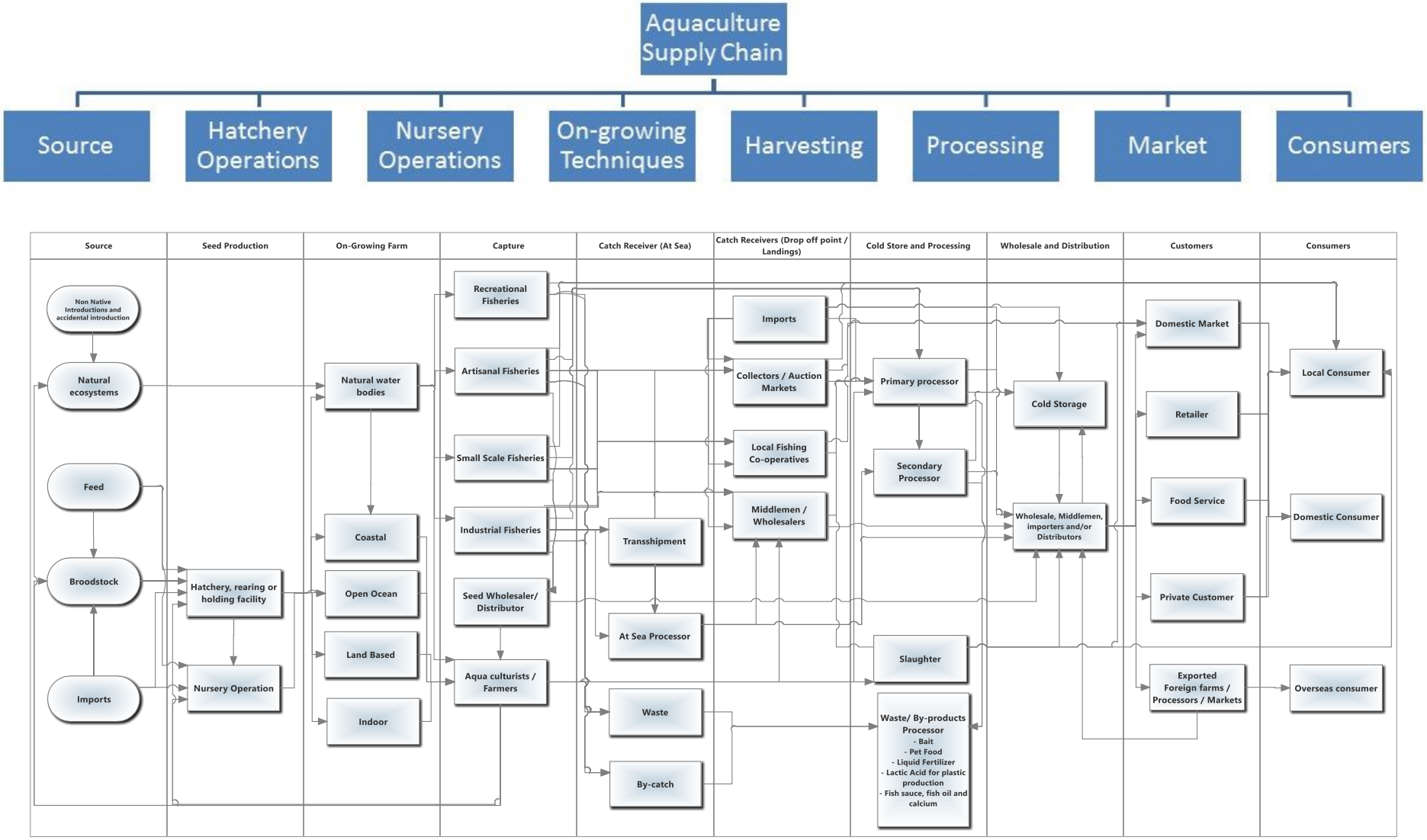


Supply Chain systems

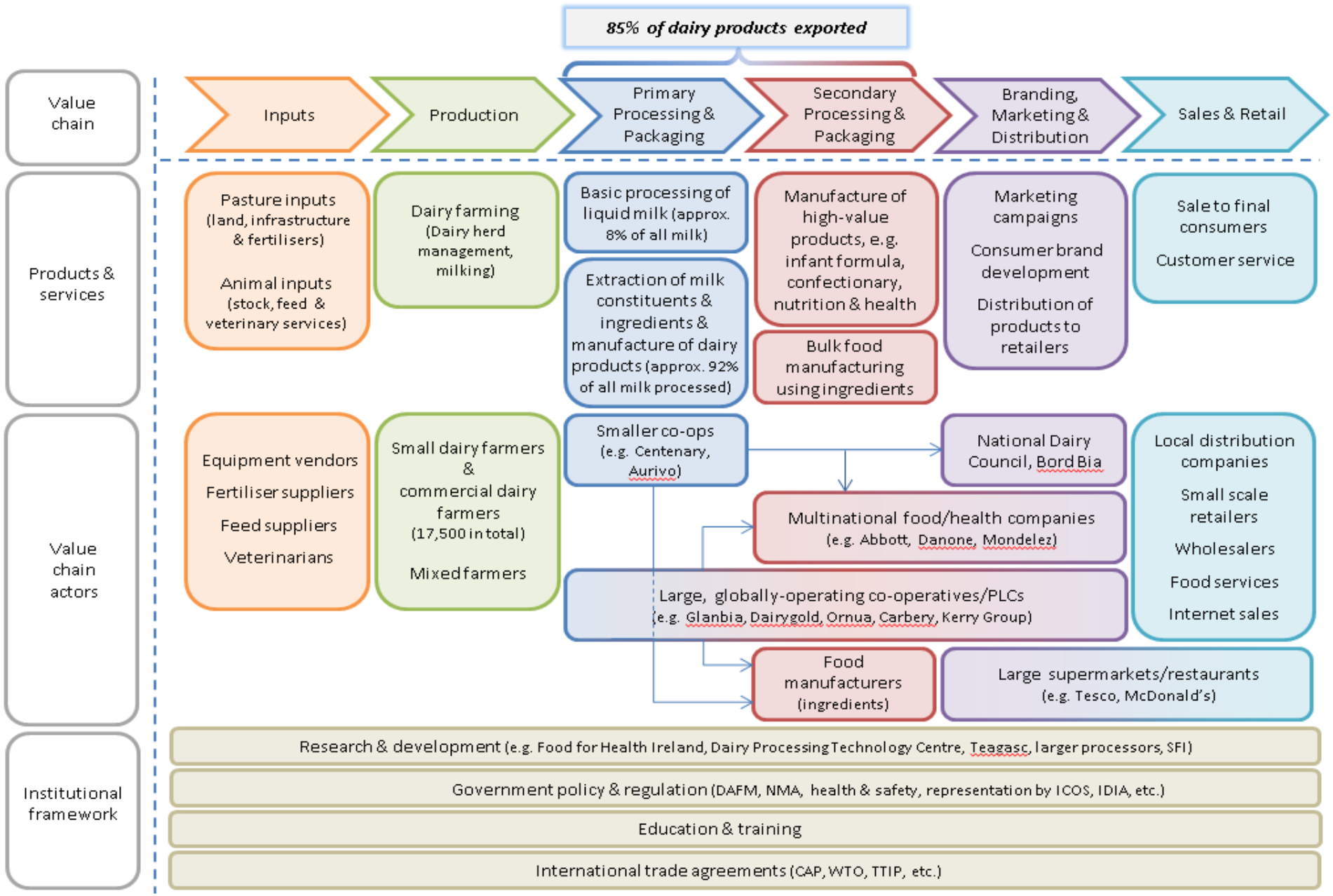


Source: EEA based on UNEP, 2016.

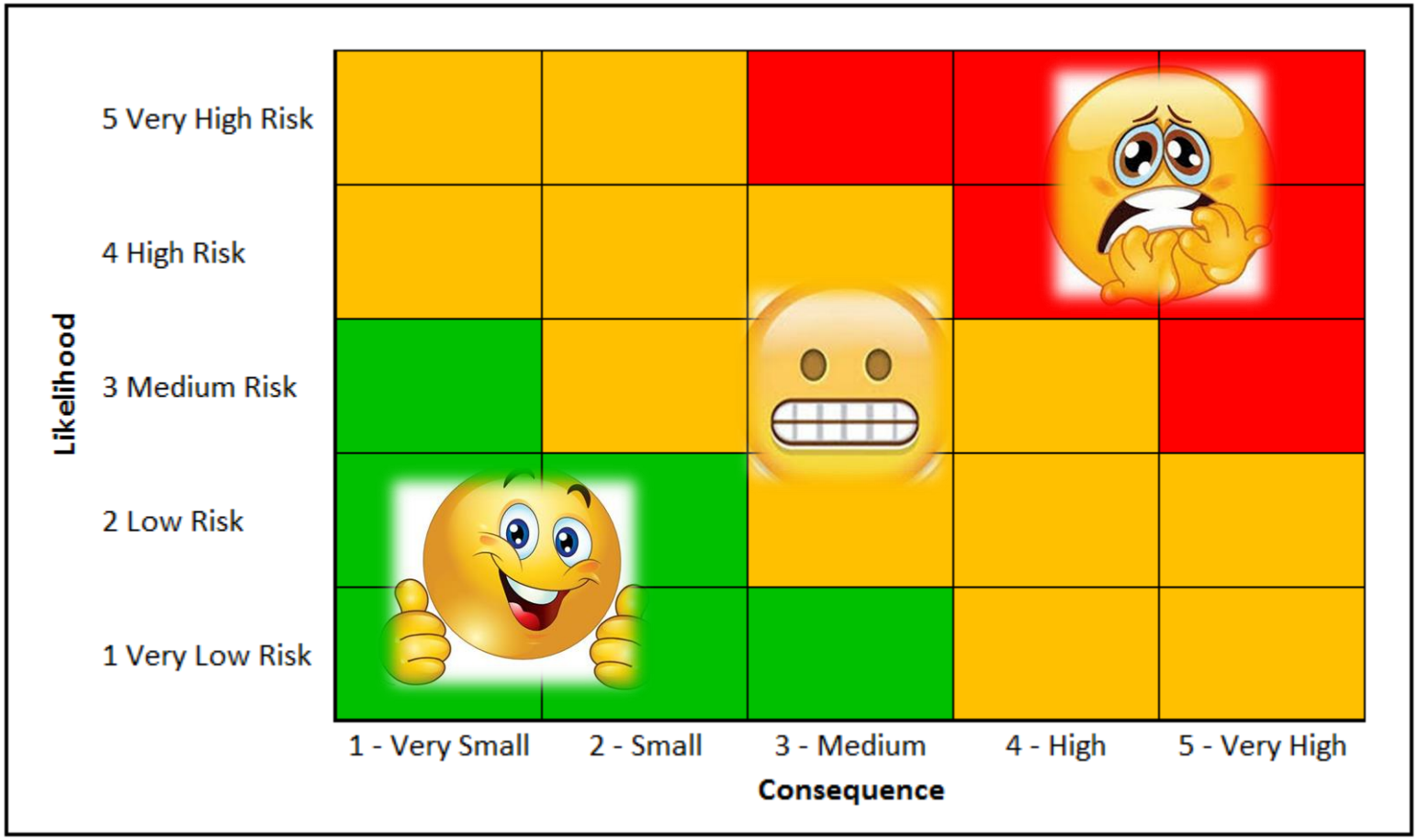
The Finfish Supply Chain (Fox et al., 2018)



Map of the Dairy Chain (Heery et al., 2015)

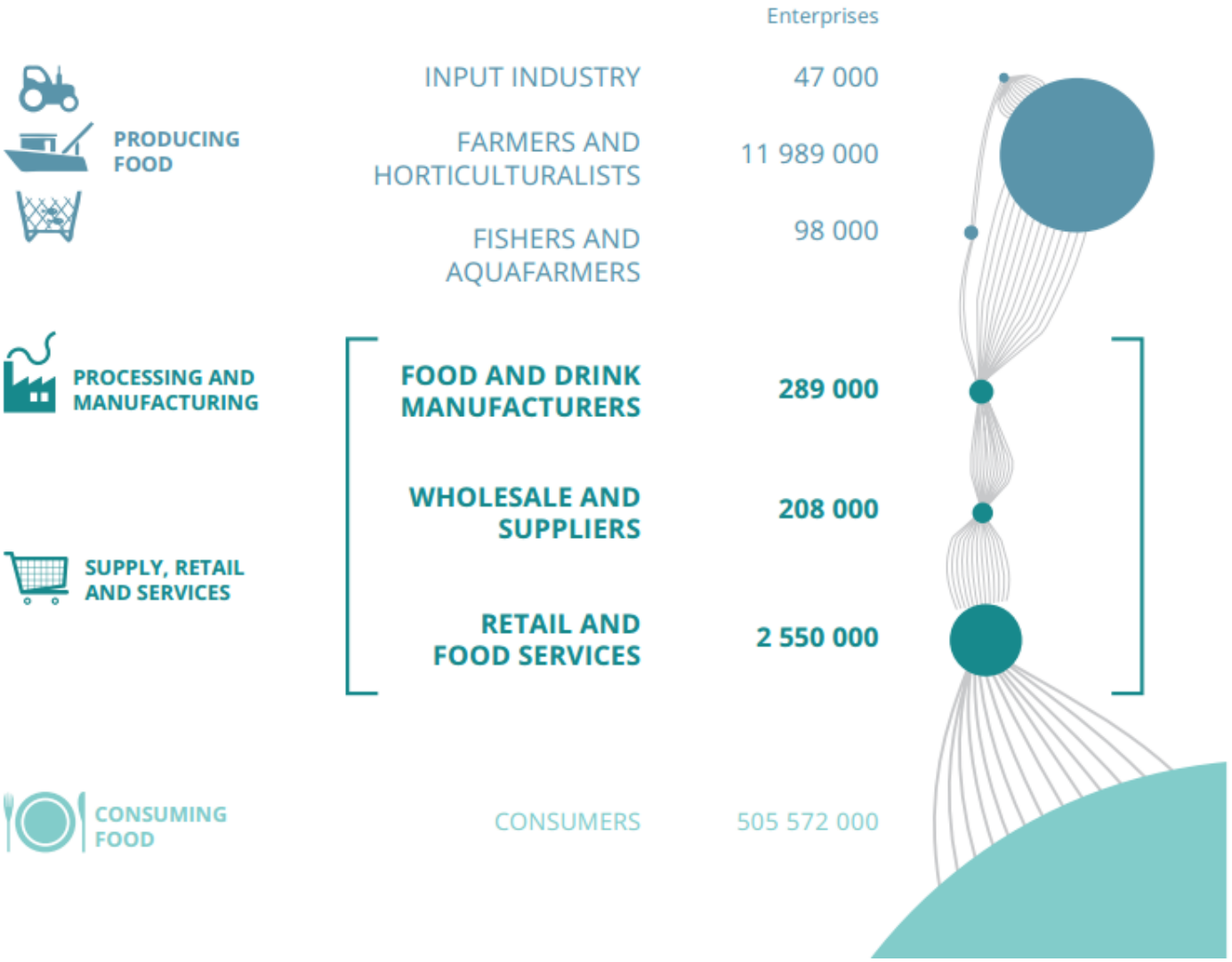


The Risk Matrix

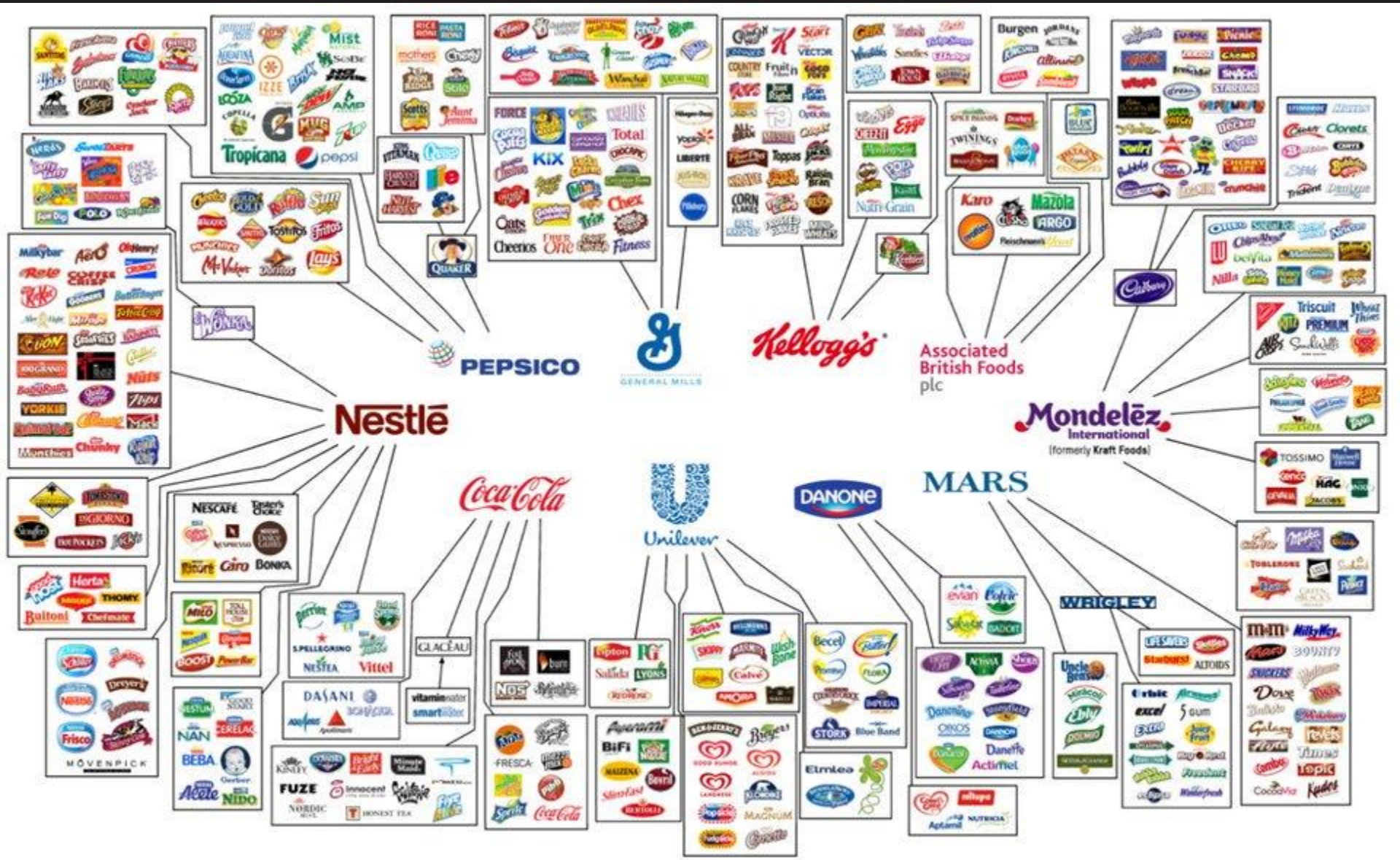


Can this be improved?

Europe's food supply chain by the number of enterprises in each food system activity

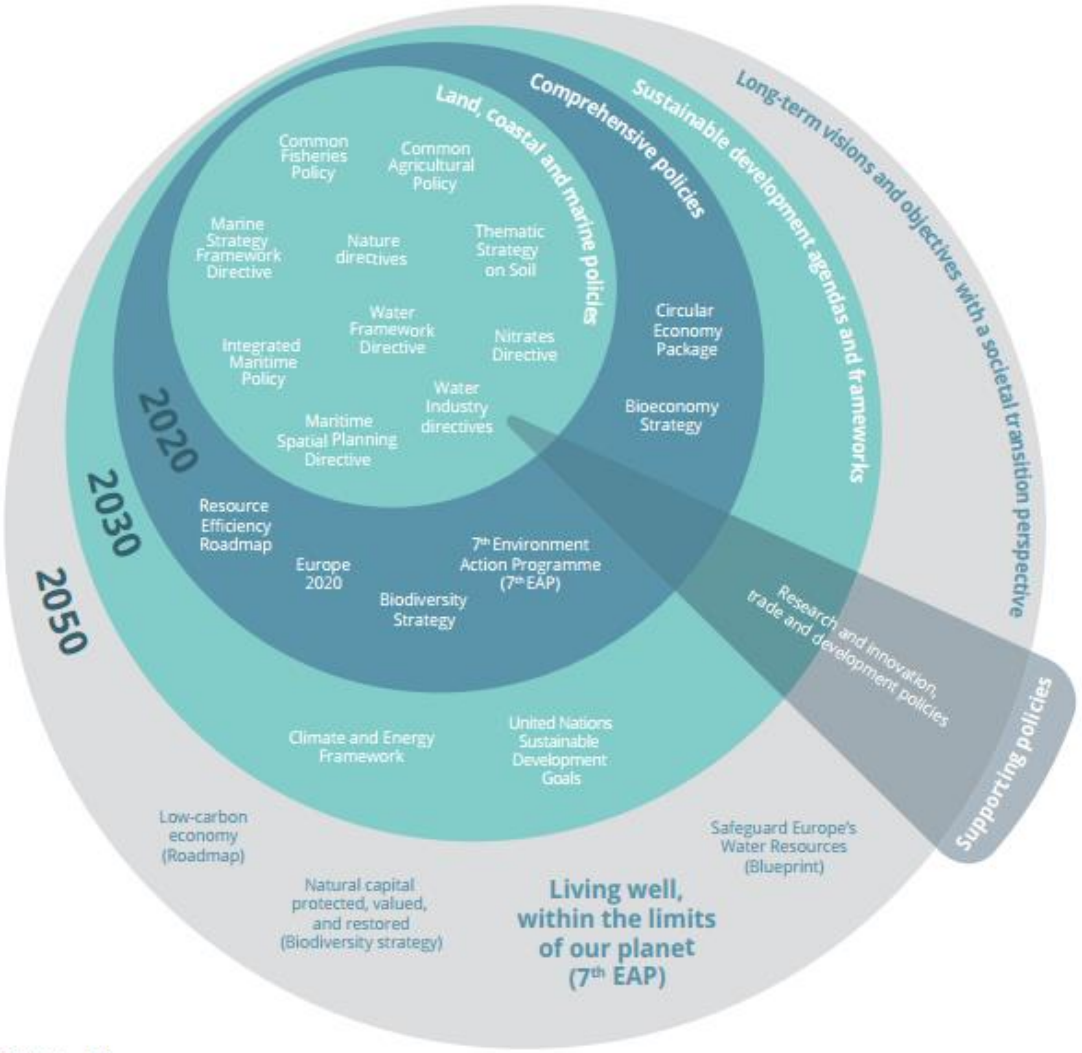


Big Brand Domination



Future supply chains - AMAZONATION

Big picture Policies to food systems



Source: EEA.

- Land, coastal and marine policies
- Comprehensive policies
- Sustainable development agenda & frameworks
- Long term visions and objectives with a societal transition perspective
- Research & innovation, trade and development policies

- 2050 - 7th European Action Programme (EAP) – Living well within the limits of our planet

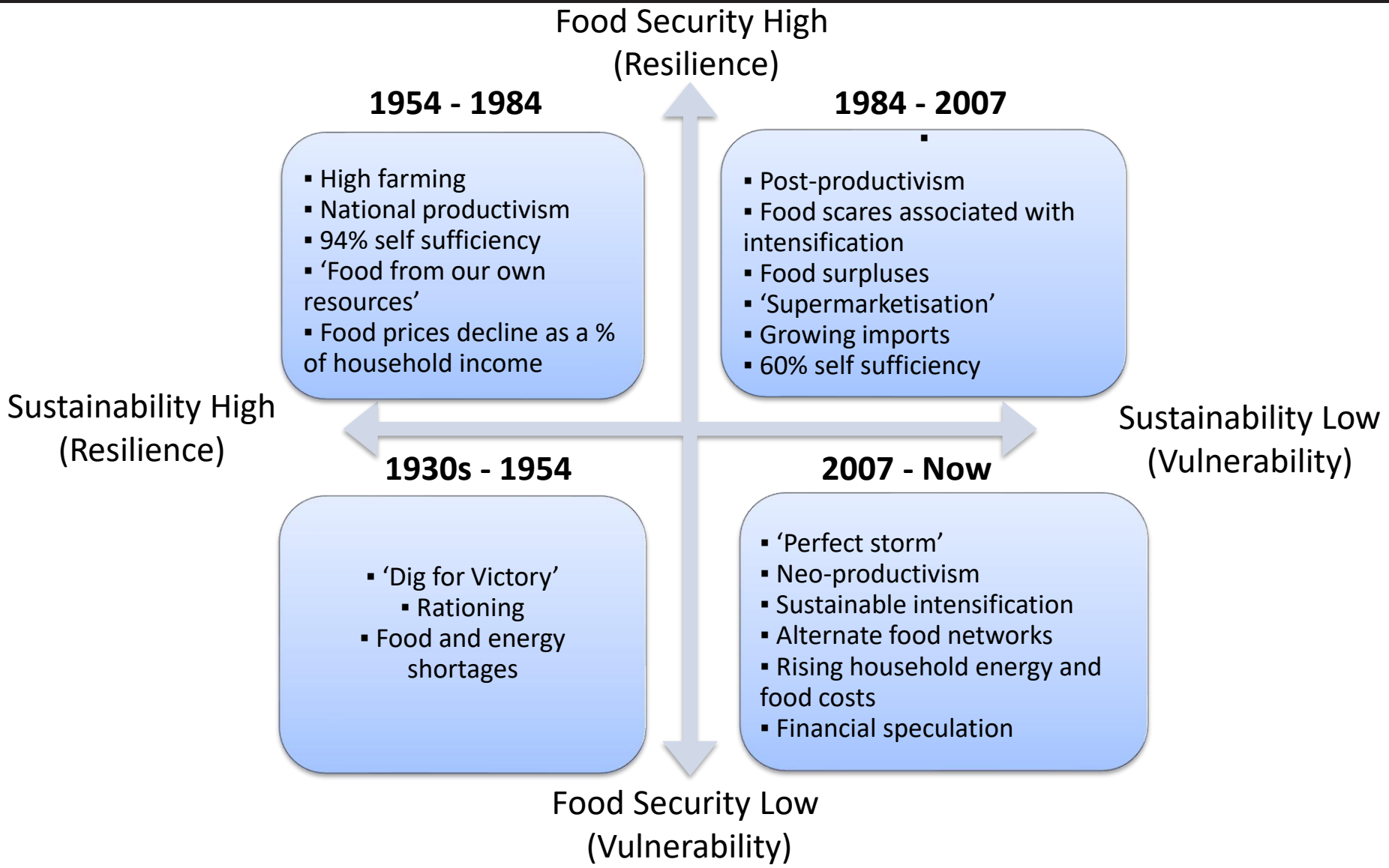
Food Security

The World Food Summit of 1996 defined food security as "**when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life".**

New caveat is

"produced by ethical and respectful means"

Food Security & Sustainability in the UK



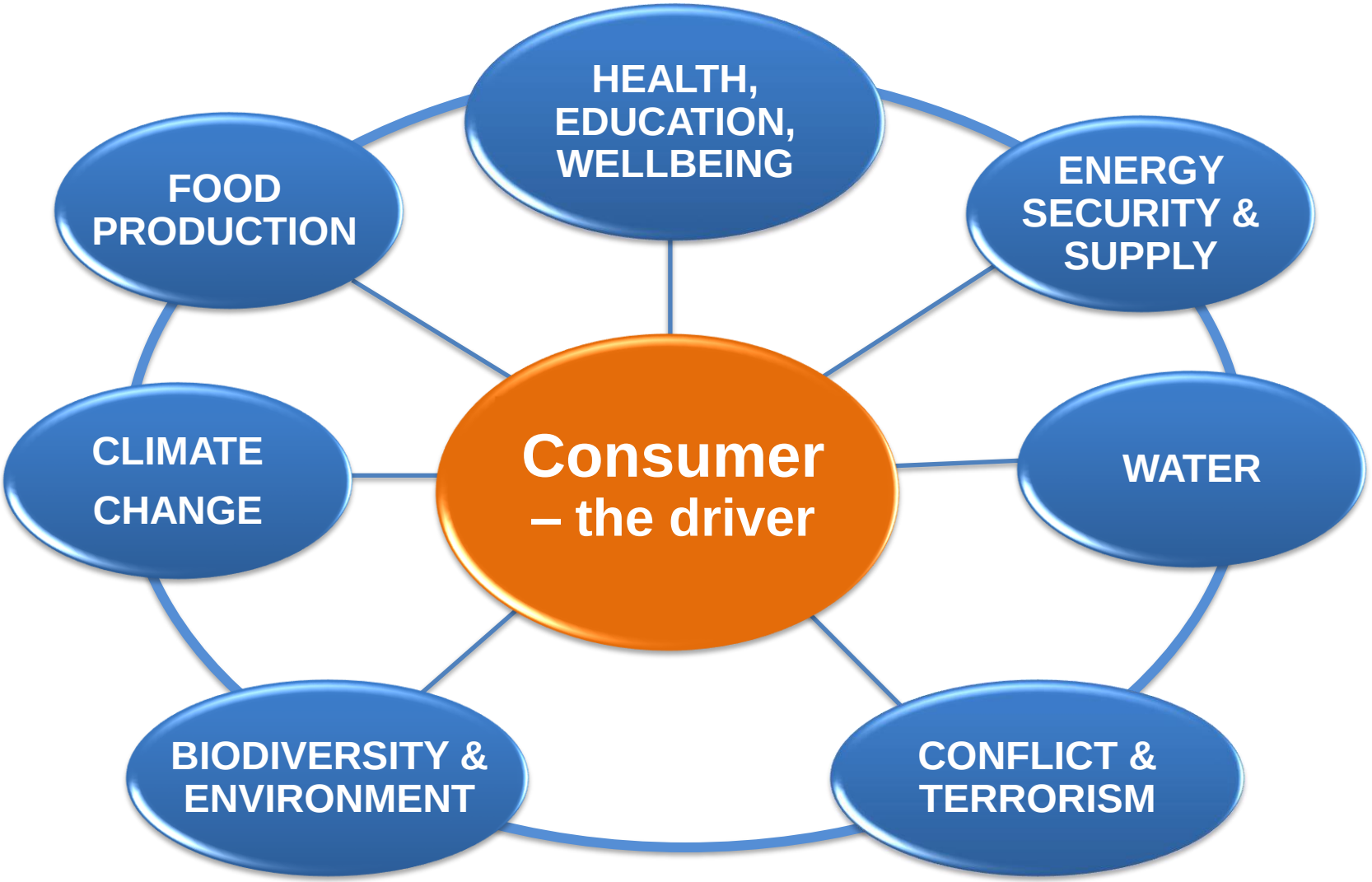
Food Security

Worldwide, people's health and well-being are affected by food
E.g. some modern diets that are rich in fat, sugar, salt and meat.

- ~ 800 million people are hungry
- >2 billion suffer from micronutrient deficiencies, which affect their growth and development

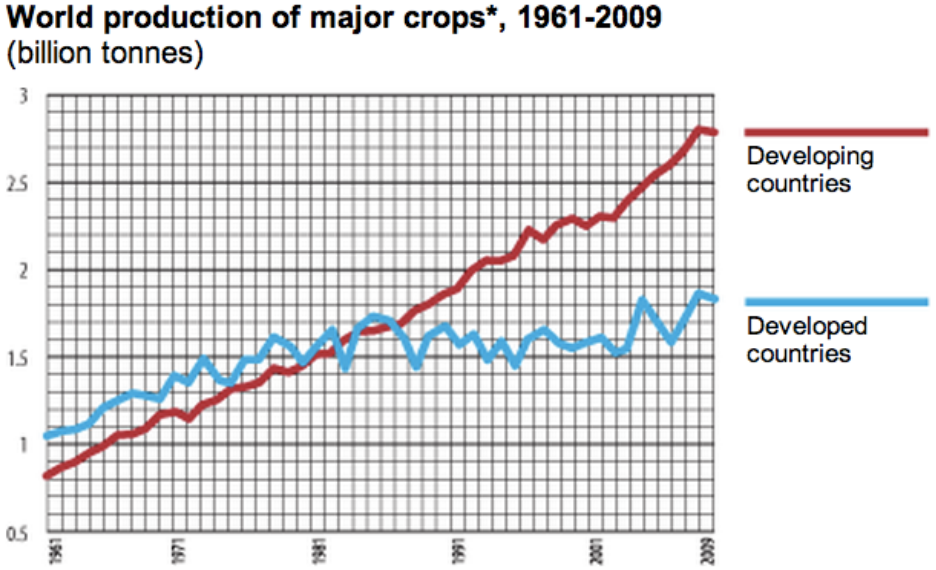
- ~2 billion people are overweight
  >600 million of those are obese
- Slave labour in particular child labour in the food production is high
  - 16 million people were in forced labour in 2016.
  - >1 in 10 worked in agriculture or fishing
  - 15% manufacturing
  - Approx. 25% children

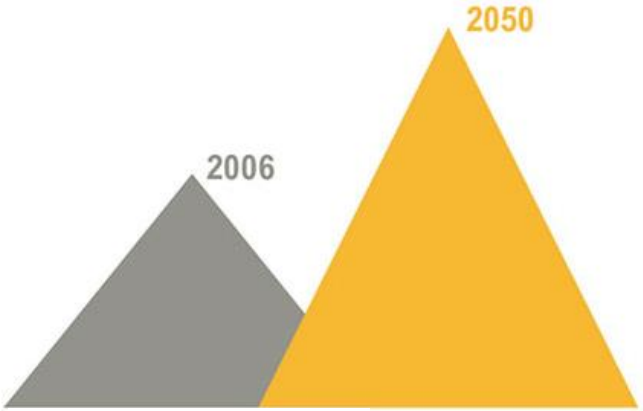
21st Century Challenges



21st Century Challenges – Food Production

To feed 9 billion people by 2050, food supplies need to increase by 60% globally and 100% in developing countries





60% Required increase in food calories to feed 9.6 billion people by 2050

FAO Save and Grow, 2011

Impact of Climate Change on Human Health

Injuries, fatalities, mental health impacts

Asthma, cardiovascular disease

Severe Weather

Air Pollution

Heat-related illness and death, cardiovascular failure

Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus

Extreme Heat

Changes in Vector Ecology

Forced migration, civil conflict, mental health impacts

Respiratory allergies, asthma

Environ-mental Degradation

Increasing Allergens

Water and Food Supply Impacts

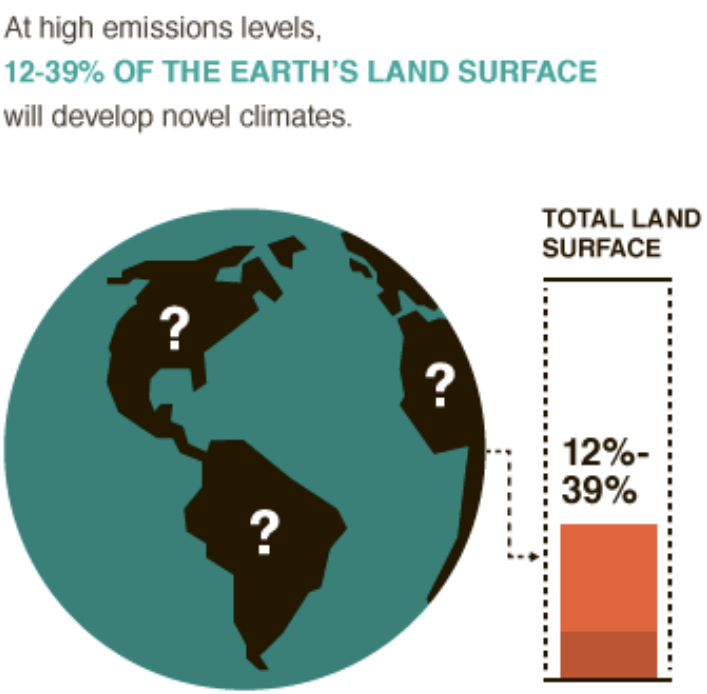
Water Quality Impacts

Malnutrition, diarrheal disease

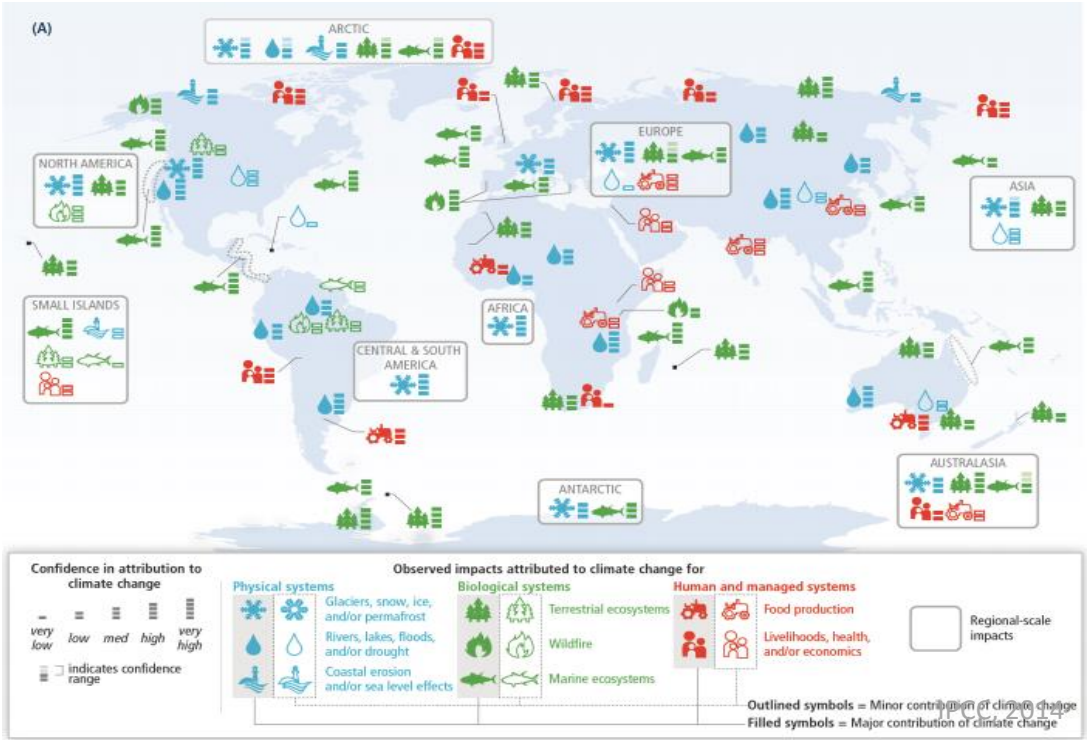
Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms

21st Century Challenge – Climate Change

Climate change may reduce agricultural production 2% each decade while demand increases 14%. Up to 40% of the world will develop unfamiliar climates.



CCAFS, 2014



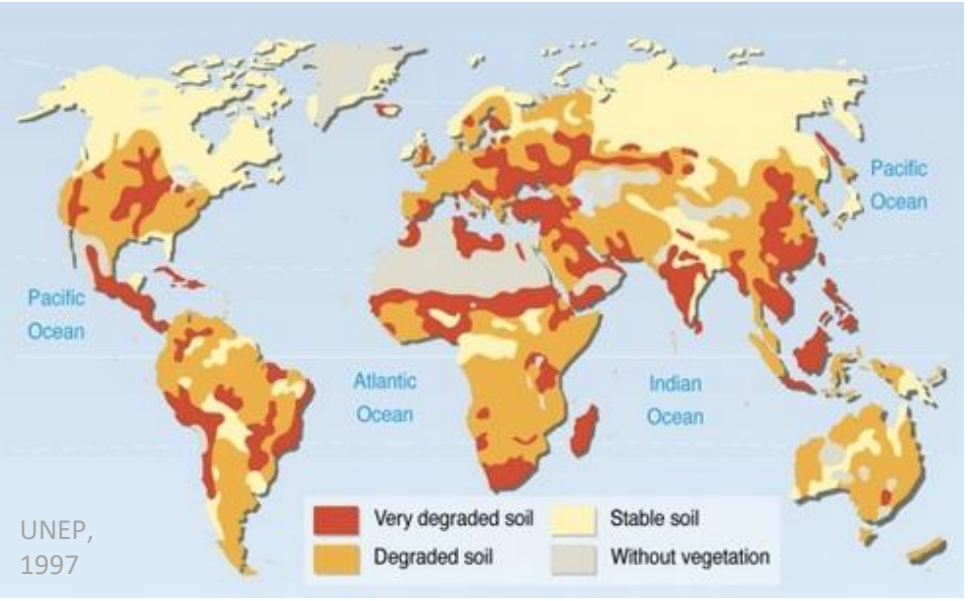
IPCC, 2014

Climate Change & Water Scarcity

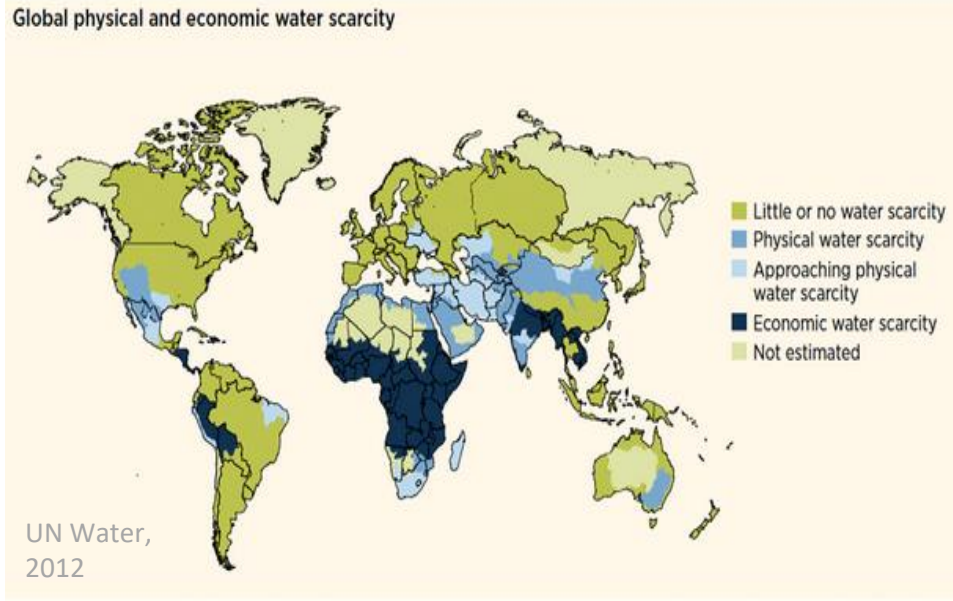
- How can Europe's food supply and primary production adapt to more extreme weather events?
- How can the sustainability of primary production be improved without expanding social and environmental footprints overseas?
- How can water resources be better managed to improve water-use efficiency for food production?
- How can efficiency be improved and greenhouse gas emissions reduced with respect to water and energy inputs in food processing (e.g. reduction of heating then cooling or wetting then subsequent drying steps across the food chains?

21st Century Challenge - Vulnerability

Most increased food production will take place on marginal and fragile lands, where yields are extremely variable



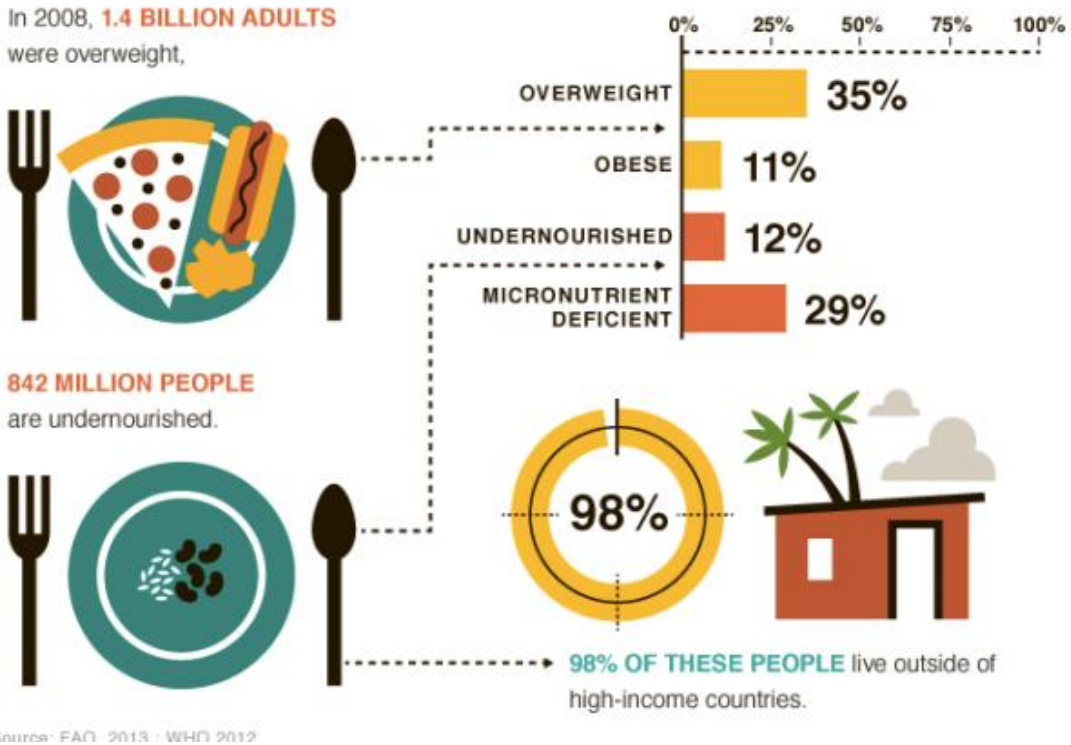
UNEP, 1997



UN Water, 2012

21st Century Challenge - Malnutrition

Once considered a high-income problem, overweight and obesity are on the rise in low and middle-income countries, especially in urban settings. At the same time, 1 billion people suffer from “hidden hunger.”

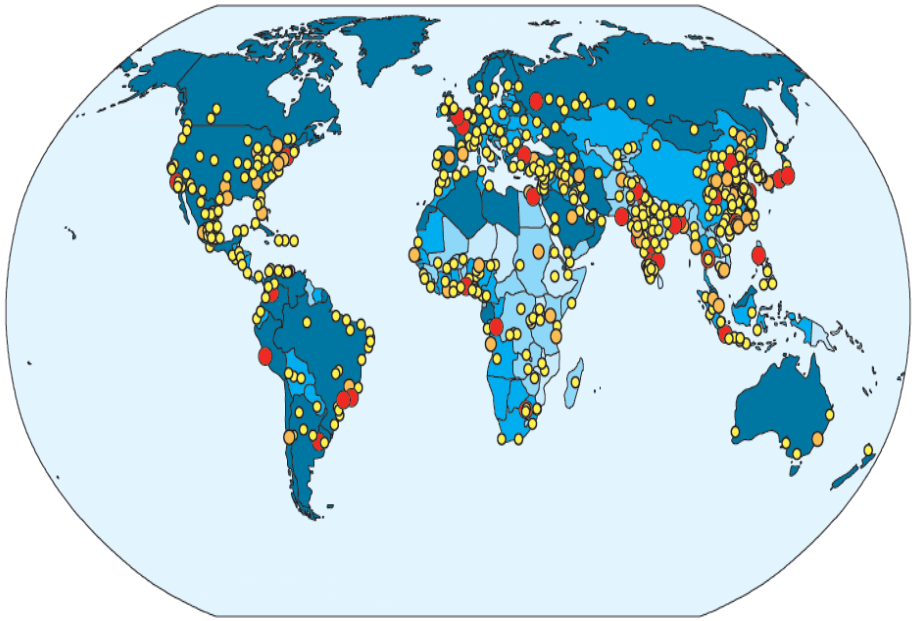


Food Security & Sustainable Nutrition

- What factors influence the allocation of food within European households, and what are the implications for health?
- How can the fat, sugar, preservative and salt content of foods be reduced while ensuring that palatability is maintained, waste is minimised, and food remains safe and does not spoil?
- How will novel, emerging and re-emerging pathogens be prevented, detected and controlled rapidly and accurately to enhance food security?
- Which EU groups (e.g. socioeconomic, regional) are, or are likely to become, food insecure in the near future, and why?
- How do we define a healthy and sustainable diet and what is the role of governments, businesses and civil society in driving healthy and sustainable food behaviours?

Pressures on natural resources are increasing

Population growth and urbanisation



Climate change

Supermarketisation

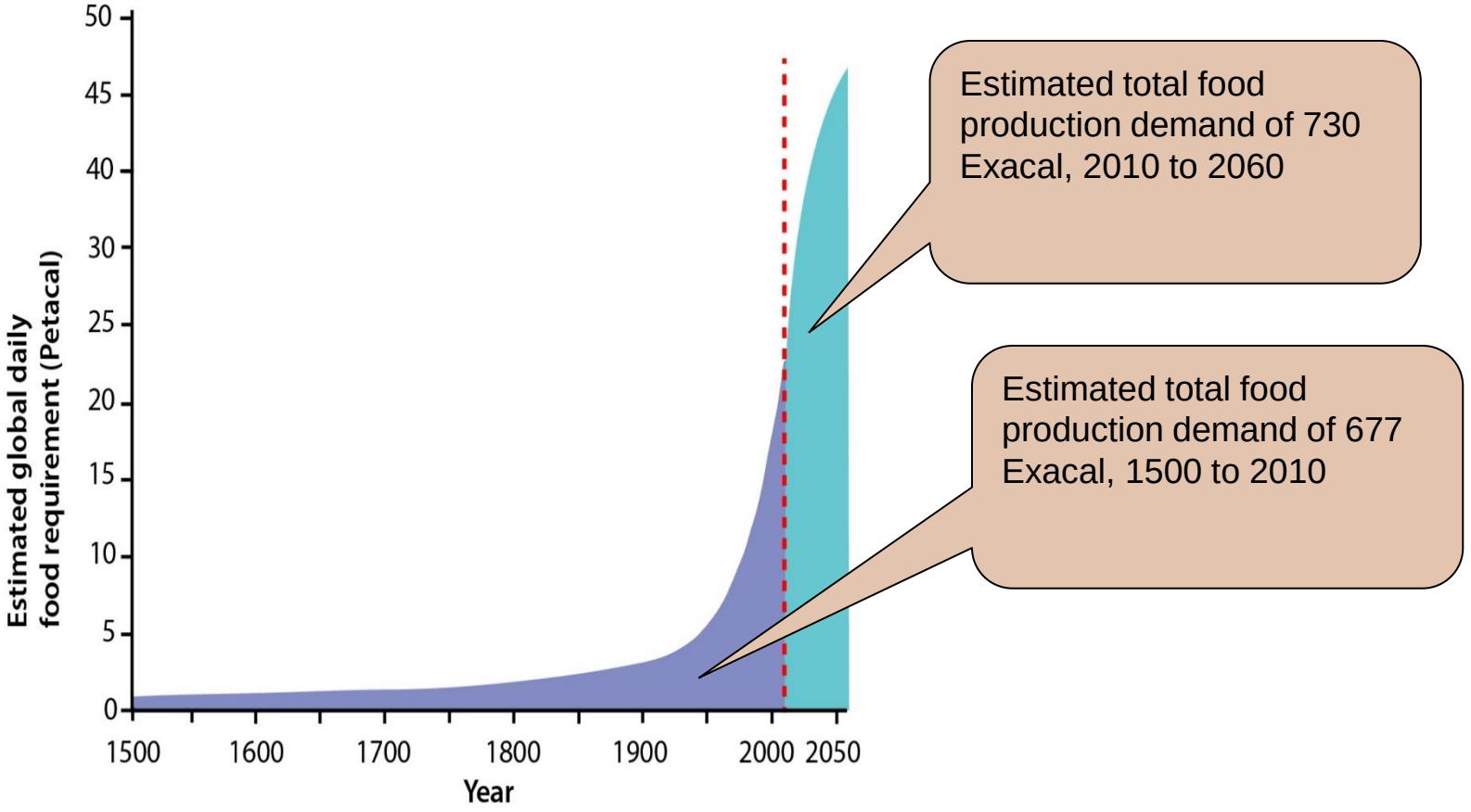
Dietary changes

Demographic Change

- Will aspiring consumers in emerging economies follow the same food consumption model as in the West?
- Will China import more food and thus also water, nutrients and energy from other countries? How can it transform its own agriculture to produce enough food in a sustainable and safe manner?
- How can emerging economies direct more of their economic growth towards rural development and eradicating widespread poverty and malnutrition?

Challenge

produce as much food in the next 50 years as in the last 500 years



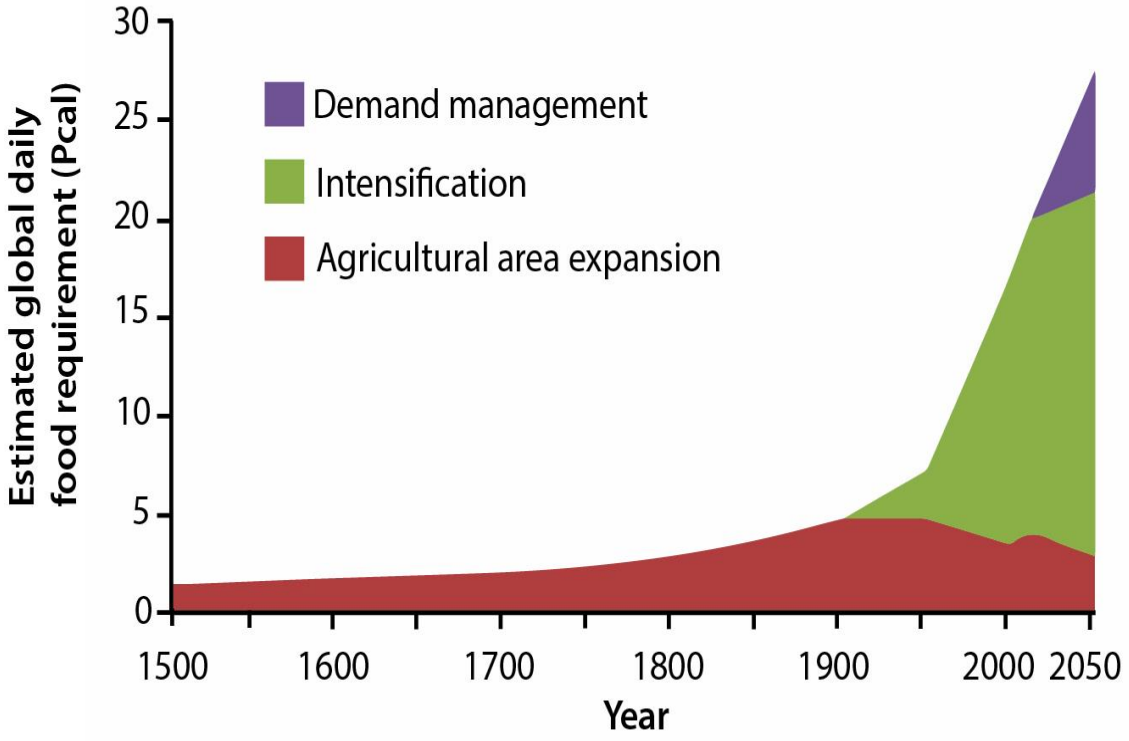
Source: CSIRO.Au

Challenge

Cereal production will have to increase by almost a billion tonnes from 2.1 billion today

Meat production will have to grow by more than 200 million tonnes to reach a total of 470 million tonnes in 2050.

How will food demand be met ?

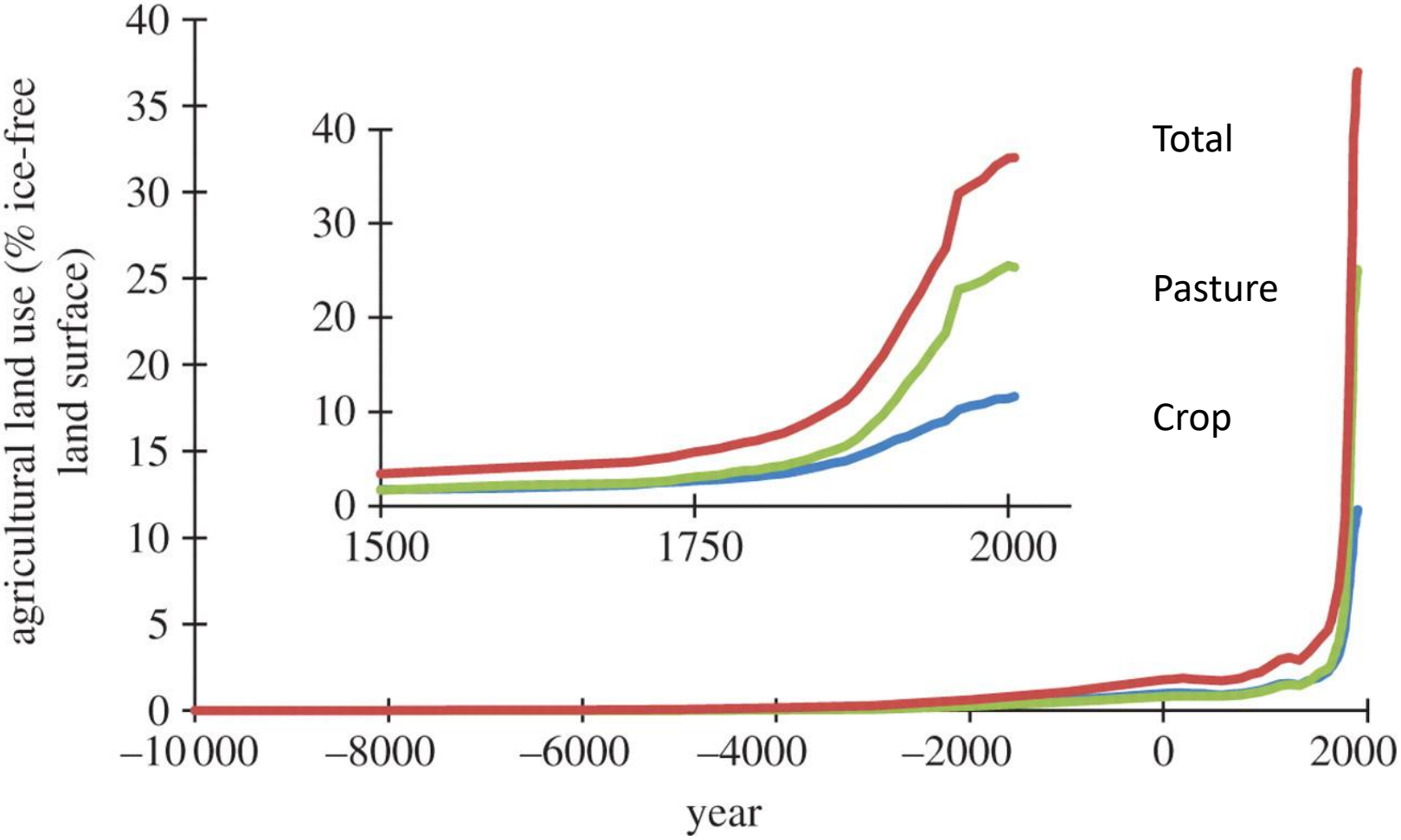


Need to "produce more responsibily" and manage "demand"

Smith (2014)

Changes in land use

Singarayer & Davies-Barnard (2012)



Land Use & Biodiversity

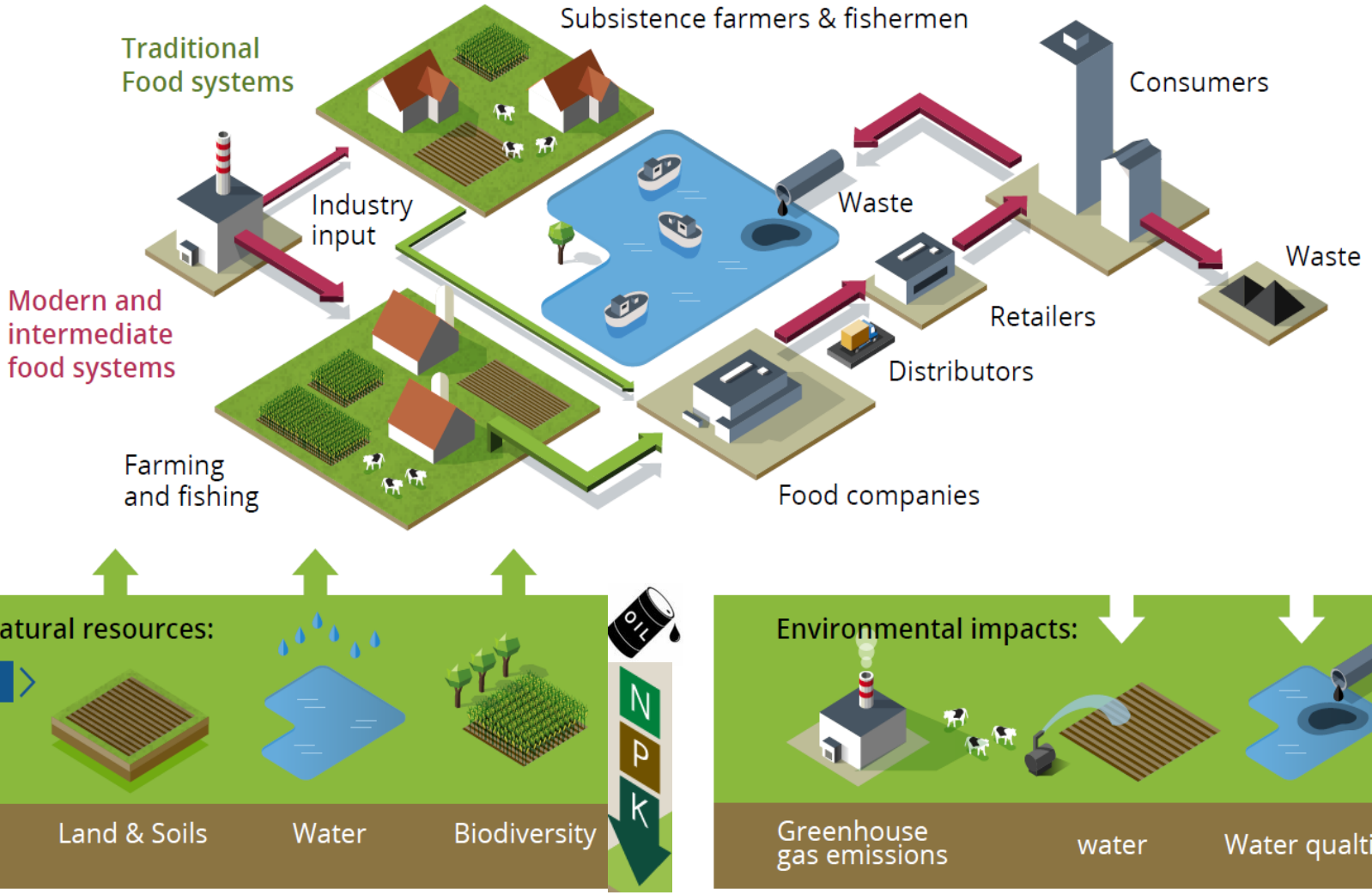
- How might we make farming more profitable and more sustainable in our generation?
- How can we transform the food system to ensure that healthy proteins, an essential nutrient for human health, are available to a global population estimated to reach from 7.5 to 9 billion people by 2050?
- How can we ensure proteins are produced within environmental limits and in a way that contributes rather than degrades key ecosystems?
- How can biotechnology best contribute to future food and nutritional security and serve the needs of the poor?
- How should EU soils be managed for optimum productivity and environmental protection in field vegetable, arable and grassland livestock systems in the long term

Smart systems for sustainable development goals

Smart systems for sustainable development goals

These are food systems in which the environmental basis to deliver food security for current and future generations is not compromised

Interconnected resources



Towards sustainable and efficient food systems

Consumer Side

Reduced food waste *Balanced diets* *Packaging*

4 tips for eating sustainably - Harvard T.H. Chan School of Public Health
https://www.youtube.com/watch?v=cYCPqoosYXI

Consumer behaviour

- What food information system would allow EU consumers to make an informed choice about each product's impact on different aspects of sustainability (environmental, economic, health and social)?

- Which intervention (or combination of interventions) would be most effective in achieving changes in consumption decisions and which types of intervention (e.g. awareness raising campaigns, choice editing, education, legislation or regulatory) are most appropriate for specific contexts and decisions?

- What dietary choices would EU consumers make if their intake of meat and dairy products was reduced, and what impact would this have on health and sustainability?

Food Waste

- Under which circumstances are the various channels for using food waste (including anaerobic digestion, feeding it to animals, composting, land-spreading etc.) socially, environmentally and economically preferable?
- How can ways of influencing behaviour be most cost-effectively designed and targeted to reduce food waste in EU homes?
- How can waste of primary production be minimised by ensuring efficient conversion to secondary products?

The Grand Challenges

Towards sustainable and efficient food systems

Production side

Better land management

Sustainable intensification

Biological pest control

Coupling crop and livestock systems

The Grand Challenges

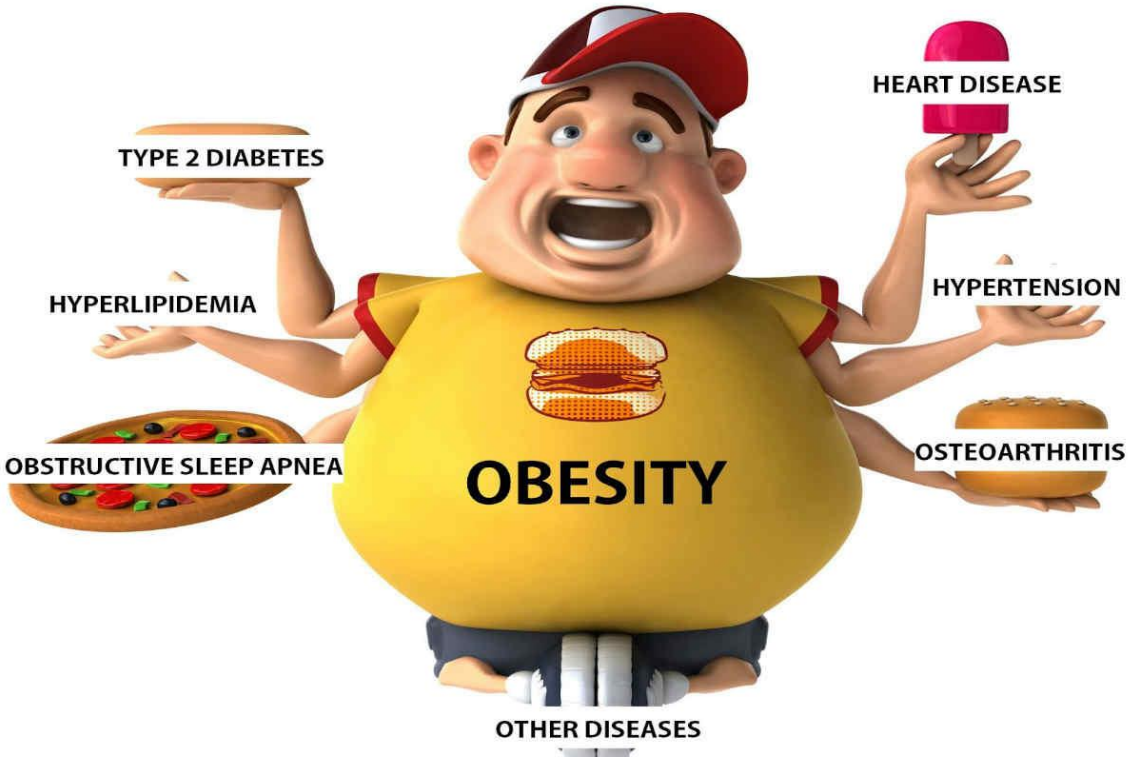
Nutritional Challenges in the 21st Century

Improved human health

Genetics
Knowledge

Improved
nutrition

Improved
health

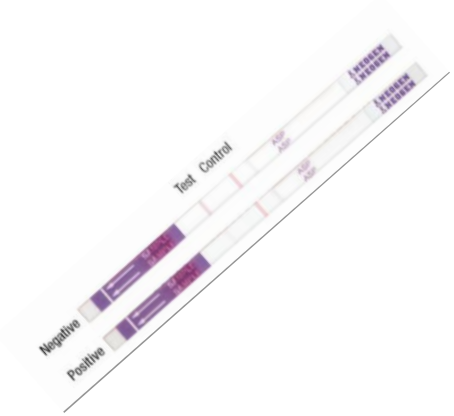


Connected Food & Health - Personalised Nutrition

Integrity of Global Food Supply

- Ensure the food we produce is safe, authentic and nutritious

Food Safety Minimising unintentional contamination	**Food Fraud** Deception, using food, for economic gain
Food Defence Minimising intentional contamination	**Food Security** Access to adequate supplies of safe food



- The systems used to produce our food are sustainable
- Our food is produced to the highest ethical standards
- We respect the environment and all those who work in our food industry

Ensure Food Sustainability

New science, technologies and tools right across the food supply chain - investment

A partnership approach between farmers, advisors, researchers and other stakeholders including consumers

We must work together locally, nationally and internationally

Ensure Food Sustainability

Ensuring Food Sustainability is a complex process but will require a step change within our production systems and re-evaluation of the circular economy to reuse waste”

Food Safety - Global Issues

- Globally 600 million, approx. 1 in 10 people in the world, fall ill after consuming contaminated food.
- Of these, 420 000 people die, including 125 000 children < 5 years.

Microbiological

Bacterial / Viral / Parasite

Chemical

Natural

Man made

Process

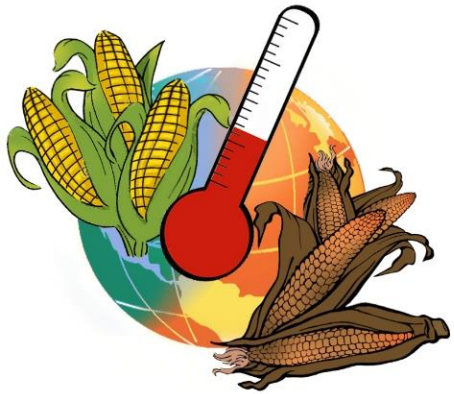
Heat Contact Adulterants

- As a prevention strategy legislation, regulations, education and food analysis are implemented.

Routes of Exposure

Food Concerns and Awareness

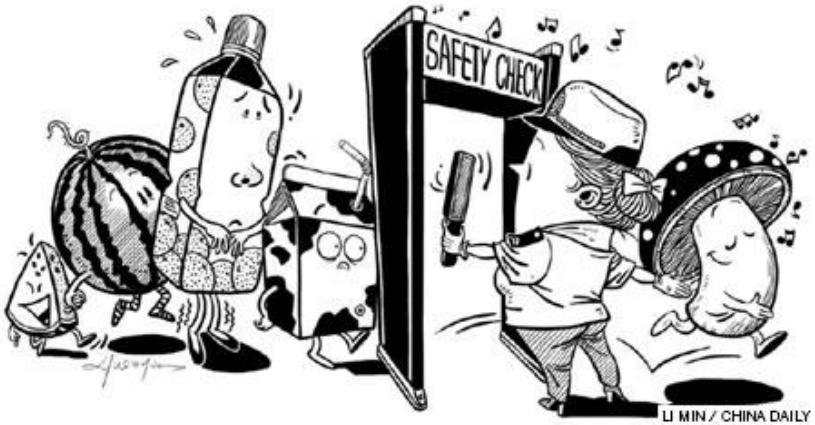
Under the current EU Food Hygiene legislation Producing safe and authentic food is the responsibility of Food Business Operators (FBOs)



Creates Uncertainty in the food supply chain
More Questions Asked

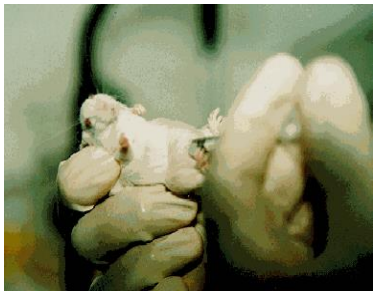
Food Analysis

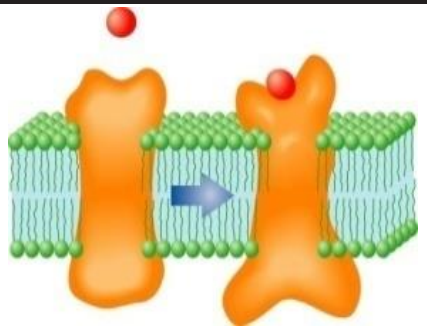
Uncertainty leads to increased surveillance and monitoring of our foods globally.



Choices in Methods of Analysis

1. Functional Assays
    a. Bioassay
    b. Cell based
    c. Receptor based
    d. Enzyme based





2. Analytical methods
    a. HPLC
    b. LC-MS
    c. GC-MS
    d. ICP-MS

ANALYTICAL METHODS TRADITIONAL CONFIRMATORY METHODS

Choices in Methods of Analysis

1. Functional Assays
   a. Bioassay
   b. Cell based
   c. Receptor based
   d. Enzyme based

- Level of contaminant measured relative to the response
- May detect new contaminants e.g. toxins
- Contaminant identification is not unequivocal
- Technology transfer of methods is difficult

2. Analytical methods
   a. HPLC
   b. LC-MS
   c. GC-MS
   d. ICP-MS

- Contaminants are identified and quantified for available analytical standards
- Toxicity equivalent factors may need applied
- Sample clean-up is extensive with oxidation steps being required for contaminants
- Data analysis is laborious
- LC-MS is unequivocal for identification

ANALYTICAL METHODS TRADITIONAL CONFIRMATORY METHODS

Rapid Evaporative Ionization Mass Spectrometry (REIMS)

theguardian | TheObserver

News | Sport | Comment | Culture | Business | Money | Life & style | Travel | Environment

Comment is free

We must be alert to the new age of food crime

Food fraud is a growing problem that will prove fatal unless we ask more questions about what we are served

Observer editorial
The Observer, Saturday 3 May 2014 20.42 BST
Jump to comments (53)

Lasy year's horsemeat scandal proved 'how vulnerable our food chains were to blatant fraud perpetrated on an industrial scale'. Photograph: Ina Fassbender/Reuters

For st... we'll have the pig's anus masquerading as cala... llowed by th... potentially fatal puffer fish pretending to be monkfish, all w... ed down wi... dulterated milk and some relabelled ... wine passed off as champagne. ... have a faux artisanal sourdough roll made with normal flour substituted for organic and road salt

Article history

Life and style
Food & drink

World news
Food safety

UK news
Crime

More from Comment is free on

Life and style
Food & drink

World news
Food safety

UK news
Crime

More on this story

UNIVERSITÀ DEGLI STUDI DI TORINO

Choices in Methods of Analysis

3. Spectroscopic methods
   a. Near IR
   b. Mid IR
   c. RAMAN
   d. SERS
   e. REIMS

- Fingerprinting techniques
- Non-destructive methods little to no sample prep
- Require chemometric models of known samples
- Sensitivity is questionable

4. RNA/DNA (Pathogen Monitoring)
   a. PCR
   b. qPCR
   c. NGS

- Fingerprinting techniques
- Destructive methods highly sepcialised
- Require libraries and databases of known sequences
- Sensitivity is questionable without enhancement

Spectroscopic techniques

"fingerprinting" technique giving unique spectra
Little or no sample preparation
Ideal technique for use with adulteration of food eg fats and oils
Multivariate techniques can be used to extrapolate the desired chemical information

HANDHELD RAMAN

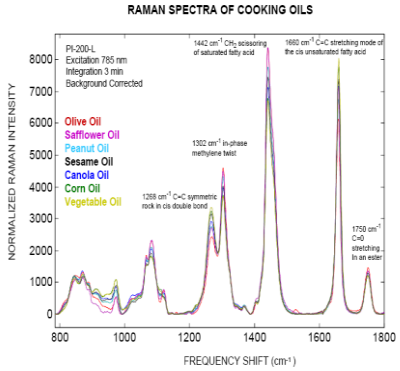


Image Detector Processor Data Answer

Choices in Methods of Analysis

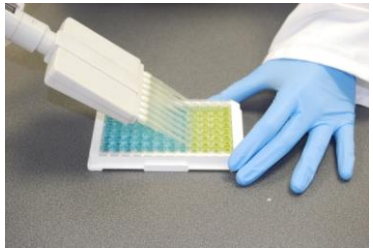
3. Spectroscopic methods
   a. Near IR
   b. Mid IR
   c. RAMAN
   d. SERS
   e. REIMS

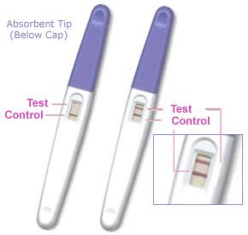
- Fingerprinting techniques
- Non-destructive methods little to no sample prep
- Require chemometric models of known samples
- Sensitivity is questionable

4. RNA/DNA (Pathogen Monitoring)
   a. PCR
   b. qPCR
   c. NGS

- Fingerprinting techniques
- Destructive methods highly specialised
- Require libraries and databases of known sequences
- Sensitivity is questionable without enhancement

5. Biochemical Assays
   a. ELISA
   b. Lateral flow devices
   c. Biosensor
   d. Nanosensor
   e. Aptasensors





Choices in Methods of Analysis

3. Spectroscopic methods
   a. Near IR
   b. Mid IR
   c. RAMAN
   d. SERS
   e. REIMS

- Fingerprinting techniques
- Non-destructive methods little to no sample prep
- Require chemometric models of known samples
- Sensitivity is questionable

4. RNA/DNA (Pathogen Monitoring)
   a. PCR
   b. qPCR
   c. NGS

- Fingerprinting techniques
- Destructive methods highly specialised
- Require libraries and databases of known sequences
- Sensitivity is questionable without enhancement

5. Biochemical Assays
   a. ELISA
   b. Lateral flow devices
   c. Biosensor
   d. Nanosensor
   e. Aptasensors

- Sensitivity and specificity determined by quality of binders
- Sample preparation and data analysis is fast
- Screening tools for HACCP management and rapid response

An Introduction to Global Food Security, Safety & Sustainability

Katrina Campbell
Prof in Food Security & Diagnostics
Institute for Global Food Security

katrina.campbell@qub.ac.uk