



# Deliverable 1.2



## FOODSAFER

Report on selected indicators, together with their related data sources

## Deliverable D1.2.: Report on selected indicators, together with their related data sources



Work package number and title	WP1: Impact analysis of Food System Stressors and Future Proof Risk Management
Lead-beneficiary	IRIS – IRIS Technology
Work package Leader	WU – Wageningen University
Contributors to deliverable	IRIS
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[foodsaferr.eu](https://foodsaferr.eu) – #FoodSafeR



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## 1. Introduction

The FoodSafeR project aims to develop an innovative and holistic proactive food safety warning and management system, with identification of emerging risks a central focus. In order to create this system, it is necessary to first identify anticipated changes in the European food safety arena.

This deliverable report D1.2 relates to the work performed under Task 1.2 (Identification of indicators and data for food safety risk emergence), which aims to identify the indicators and corresponding data sources for food safety risk emergence, related to the trends, drivers and sub-drivers of changes in the food production system and its environment that might be related to food safety. The drivers and sub-drivers have been previously identified in Task 1.1 (Analysis of drivers and key influencing factors for food safety risk emergence).

The results of Task 1.2 will serve as input to the requirements definition and development in WP4 of the open digital hub. Our approach is to create a list of "INDICATORS" which will be used as keywords to search within a list of "DATABASES or WEBSITES". In this report, some databases related to specific indicators have been determined already. In the next phase of the project, we will have a dedicated section on the platform (being developed in WP4) that will display graphics and information about all the "fixed terms" or "INDICATORS" from WP1. If these terms appear in any database or website from WP1 (and depending on their accessibility credentials, which will need to be studied for each specific case), they will be shown on the platform, as part of WP4.

Below, a summary of Task 1.2 is given. The first three points refer to the content of this Deliverable report D1.2, whereas points 4 to 7 refer IT functionality which will be developed in WP4 for the open digital hub.

### **WP1 – Task 1.2:**

- For each of the prioritized stressors for the emergence of food safety hazards and related risks identified in Task 1.1, one or more indicators will be identified and/or established.
- Available data and datasets on these indicators will be searched for from open-source databases.
- T1.2 will be supplied with the necessary input from T1.1 on drivers and barriers.

### **WP4**

- This data will be linked to the open digital hub (WP4), such that the platform dashboard displays the real-time values of the indicators, based on underlying data.
- Risk managers can follow the trends in the indicators, reflecting potential relevant changes in our food system and its environment that may lead to the emergence of food safety hazards and related risks.
- Alerts will be given in case indicators tend to move out of the 'normal' range of values.
- Machine learning techniques will be used to crawl available databases, and search for unknown data and for underlying relationships, mainly to identify changes in the stressors and information on their impact on toxicity of the hazards. This will support the prioritization of the indicators and emerging hazards, as well as to identify data gaps.



Hence, within the scope of WP1 and the current deliverable, the focus will be on identifying indicators and associated data sources.

## 2. Materials and Methods

The drivers and sub-drivers developed in Task 1.1 (Analysis of drivers and key influencing factors for food safety risk emergence) have been used as starting point for identification of indicators. For one (sub)driver, one or more indicators can be identified. Indicators were first identified – per (sub) driver using literature and open available sources. From these, a gross list of indicators was established.

Next, a Living Lab 3 workshop was held with project partners to verify the identified indicators, and add missing indicators, if any. Also databases related to each indicators were identified, where possible.

### 2.1 Workshop “Indicators for drivers of emerging food safety hazards”

FoodSafeR Living Lab 3 was designed to **identify indicators for drivers of emerging food safety hazards**, which built on the workshop in 2023 where trends, drivers and barriers of food safety risks were identified. These drivers for hazards and risks which were already assembled and analysed in the FoodSafeR project were introduced in the first part of the Living Lab. In this Living Lab 3 we **focused on indicators**, measurable factors that point to or are related to the occurrence of hazards or risks.

#### 2.1.1 Short definition of drivers and indicators

##### Drivers

- are developments fostering change which affect or shape the future.
- are shaping how a society, organisation, industry, research area, technology, etc. develops (EFSA, 2010)
- can directly influence the food system and also extend beyond the food system into other aspects of society

##### Indicators

- A **measurable factor** (with a unit e.g. temperature in Celsius)
- indicates or is directly or indirectly **related to the possibility of the occurrence** of a (re)-emerging hazard or risk or in this project a driver (e.g. ‘storage and transport conditions’),
- provides **information on the nature** of the hazard or driver and source of risk,
- ideally it is **reliable, sensitive and quantifiable**, but can either be **qualitative** or **quantitative** in nature



### 2.1.2 Introduction to the task

**Aim:** finding indicator(s) to monitor subdrivers of emerging food safety hazards.

The guiding questions during the Living Lab were as follows:

- (1) Which **measurable “indicators”** can be used to monitor the subdriver?
- (2) Is the indicator linked to any **database** you are familiar with? If yes, which databases are they? If no, is there anything related to the indicator? Are they accessible/open source?
- (3) In case several indicators were mentioned: Which **indicator** do you consider as the **most relevant one for the subdriver**?

### 2.1.3 Methodology

LL3 was organized online to support a participatory approach in the analysis of indicators for drivers and key influencing factors for food safety risk emergence. The FoodSafeR consortium and scientific advisory board were invited to join the Living Lab via Zoom. 70 people participated in the Living Lab and discussed in 5 breakout rooms potential indicators of 2 (and in one group 3) drivers on a Mural Whiteboard. A list of participants can be found in the Appendix. The distribution of drivers across the 5 groups is the following:

1. Distribution / Environmental contamination
2. Management of (natural) resources / Demographic development
3. Technologies in food production / Health & Wellbeing
4. Legislation, policies & governance / Technologies in food processing
5. Consumer behaviour / Bioprocesses / Geopolitical instability

The drivers were shortly presented to all participants in the beginning of the Living Lab. When the participants were sent into the breakout rooms, a moderator presented the 2-3 drivers relevant for the group discussion in more detail. The moderators facilitated the two discussion sessions among the 7-8 participants in each of the breakout rooms.

## 3. Results

### 3.1 Workshop

The results of the workshop are sorted according to the STEEP factors as given in Figure 1. Each section starts with a description of the driver and according subdrivers (*in grey – because their definition was not the focus of the Living Lab*), followed by a screenshot of participant’s input on the Mural Whiteboard and ends with a list of indicators (in black) for each subdriver (indicators concerning a similar topic were grouped together).

NOTE: References to data or databases are marked in **BLUE**, text marked in **BOLD** shows if the indicators or databases were marked as **most relevant** by participants



Figure 1: Overview of drivers and sub-drivers

### 3.1.1 Social Drivers

#### (a) Consumer behaviour

The behaviour of individual consumers can influence nutritional habits/individual diets. (Changed eating habits can lead to potential exposure or development of new hazards).

- **Dietary choice:** What food consumers choose based on nutrition and preference; e.g., vegetarian, fast food, red meat
- **Consumer knowledge:** The individual and common knowledge of consumers in relation to food (including education & training); e.g., cooking at home, hygiene practices
- **Consumer awareness/attitude:** Change of attitude drives choices; e.g., animal welfare, natural equals safe, herbal tea is good for you
- **Public awareness:** The awareness on foods, diets and related hazards via governmental communication, news, social media, NGOs; e.g., high fibre, low salt, bird flu, antimicrobial resistance





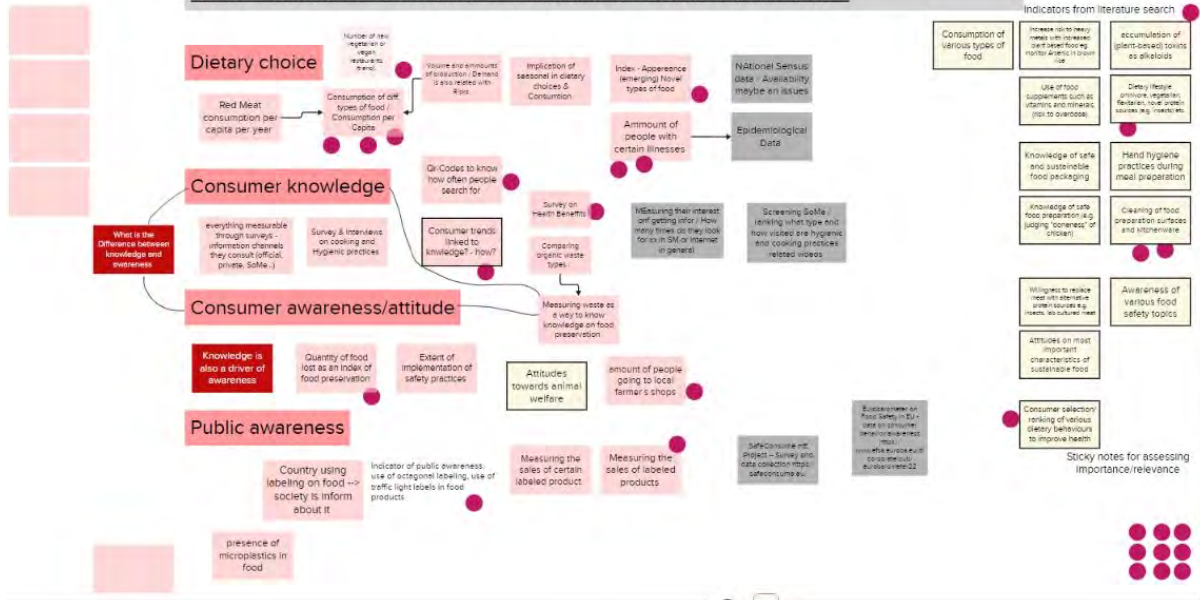
Sticky notes for indicators

## Consumer behaviour

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## Which measurable "indicators" can be used to monitor the subdriver?



## Dietary Choice indicators

- Red meat consumption per capita per year
- **Consumption of diff. types of food / Consumption per Capita/ Consumption of various types of food**
- **Dietary lifestyle: omnivore, vegetarian, flexitarian, novel protein sources (e.g. insects) etc.**
- **Number of new vegetarian or vegan restaurants (trend).**
- **Volume and amounts of production / Demand is also related with Risks**
- **National Sensus data / Availability may be an issue**
- Implication of seasonal in dietary choices & Consumption
- **Index - Appearance (emerging) Novel types of food**
- **Amount of people with certain Illnesses => Epidemiological Data**
- Increase risk to heavy metals with increased plant based food e.g. monitor Arsenic in brown rice
- Use of food supplements such as vitamins and minerals (risk to overdose)
- Accumulation of (plant-based) toxins as alkaloids

**Consumer knowledge indicators** everything measurable through surveys - information channels they consult (official, private, Social Media...)

- Knowledge of safe food preparation (e.g. judging "doneness" of chicken)  
Hand hygiene practices during meal preparation
- **Cleaning of food preparation surfaces and kitchenware**
- **Survey & Interviews on cooking and hygienic practices**
- **QR-Codes to know how often people search for something**



- Measuring their interest on getting information / How many times do they look for xx in Social Media or Internet in general
- **Consumer trends linked to knowledge? - how?**
- Knowledge of safe and sustainable food packaging
- **Survey on Health Benefits**
- Screening Social Media / ranking what type and how often visited are hygienic and cooking practices related videos
- Comparing organic waste types / (*see also Consumer awareness below*)

#### Consumer awareness / attitude indicators

- Knowledge is also a driver of awareness
- **Quantity of food lost as an index of food preservation**
- Measuring waste as a way to know knowledge on food preservation
- Attitudes towards animal welfare
- **amount of people going to local farmer's shops**
- Willingness to replace meat with alternative protein sources e.g. insects, lab cultured meat
- Attitudes on most important characteristics of sustainable food
- Extent of implementation of safety practices
- Awareness of various food safety topics

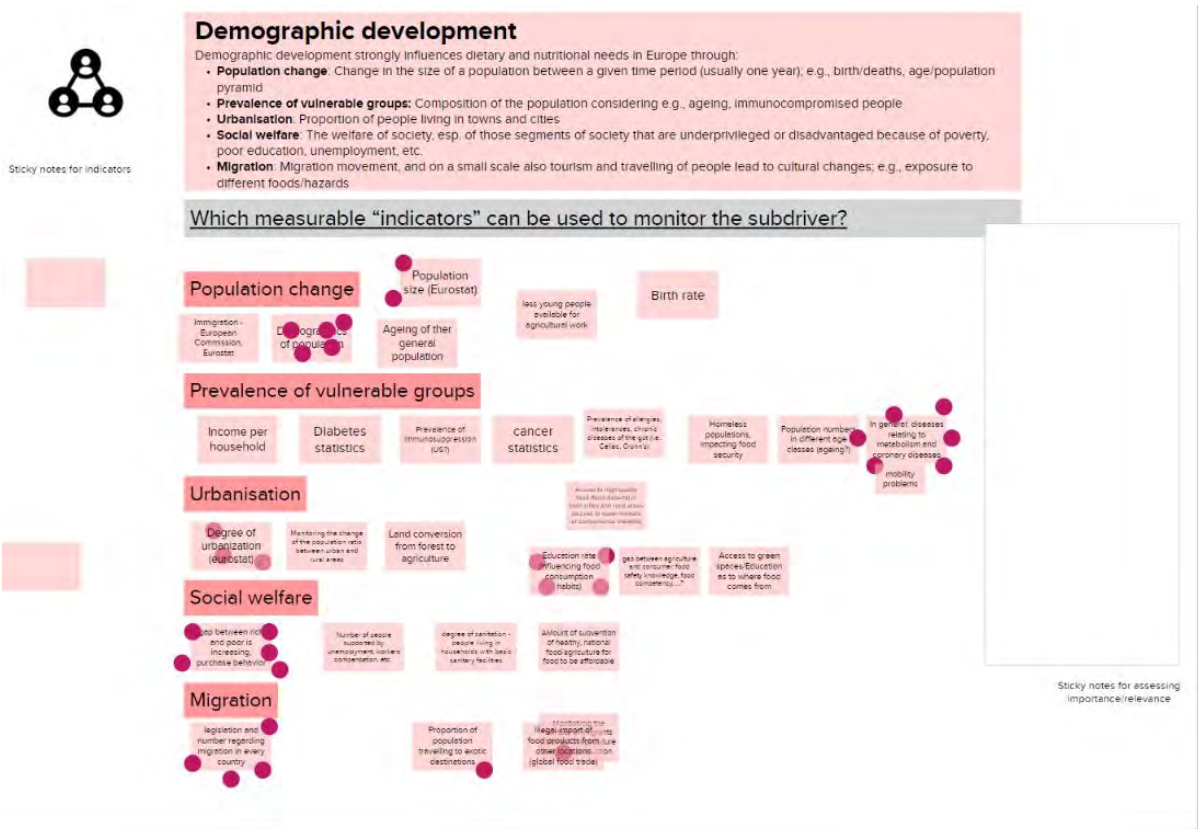
#### Public awareness indicators

- presence of microplastics in food
- Country using labelling on food --> society is informed about it  
Indicator of public awareness: use of octagonal labelling, use of traffic light labels in food products
- **Measuring the sales of certain labelled product**
- SafeConsume HE Project -- Survey and data collection <https://safeconsume.eu/>
- Eurobarometer on Food Safety in EU - data on consumer behavior/awareness <https://www.efsa.europa.eu/it/corporate/pub/eurobarometer22>
- **Consumer selection/ranking of various dietary behaviours to improve health**

#### (b) Demographic development

Demographic development strongly influences dietary and nutritional needs in Europe through:

- **Population change:** Change in the size of a population between a given time period (usually one year); e.g., birth/deaths, age/population pyramid
- **Prevalence of vulnerable groups:** Composition of the population considering e.g., ageing, immunocompromised people
- **Urbanisation:** Proportion of people living in towns and cities
- **Social welfare:** The welfare of society, esp. of those segments of society that are underprivileged or disadvantaged because of poverty, poor education, unemployment, etc.
- **Migration:** Migration movement, and on a small scale also tourism and travelling of people lead to cultural changes; e.g., exposure to different foods/hazards



### Population change indicators

- Immigration - European Commission, **Eurostat**
- **Demographics of population**
- Ageing of the general population
- **Population size (Eurostat)**
- less young people available for agricultural work
- Birth rate
- e.g. <https://data.oecd.org/pop/population.htm><sup>1</sup>
- <https://population.un.org/wpp/><sup>1</sup>

### Prevalence of vulnerable groups indicators

- Income per household
- Diabetes statistics
- Prevalence of immunosuppression (US?)
- **cancer statistics**
- Prevalence of allergies, intolerances, chronic diseases of the gut (i.e. Celiac, Crohn's)
- Homeless populations, impacting food security
- Population numbers in different age classes (ageing?)
- **In general: diseases related to metabolism and coronary diseases**

<sup>1</sup> Added from desktop research



- mobility problems

### Urbanisation indicators

- **Degree of urbanization (eurostat)**
  - Monitoring the change of the population ratio between urban and rural areas
  - Land conversion from forest to agriculture
  - **Education rate (influencing food consumption habits)**
  - Access to high quality food (food deserts) in both cities and rural areas (access to supermarkets or convenience markets)
  - Gap between agriculture and consumer: food safety knowledge, food competency, ...?
  - Access to green spaces/Education as to where food comes from

### Social welfare indicators

- **Gap between rich and poor is increasing, purchase behavior**
- Number of people supported by unemployment, workers compensation, etc.
- Degree of sanitation - people living in households with basic sanitary facilities
- Amount of subvention of healthy, national food/agriculture for food to be affordable

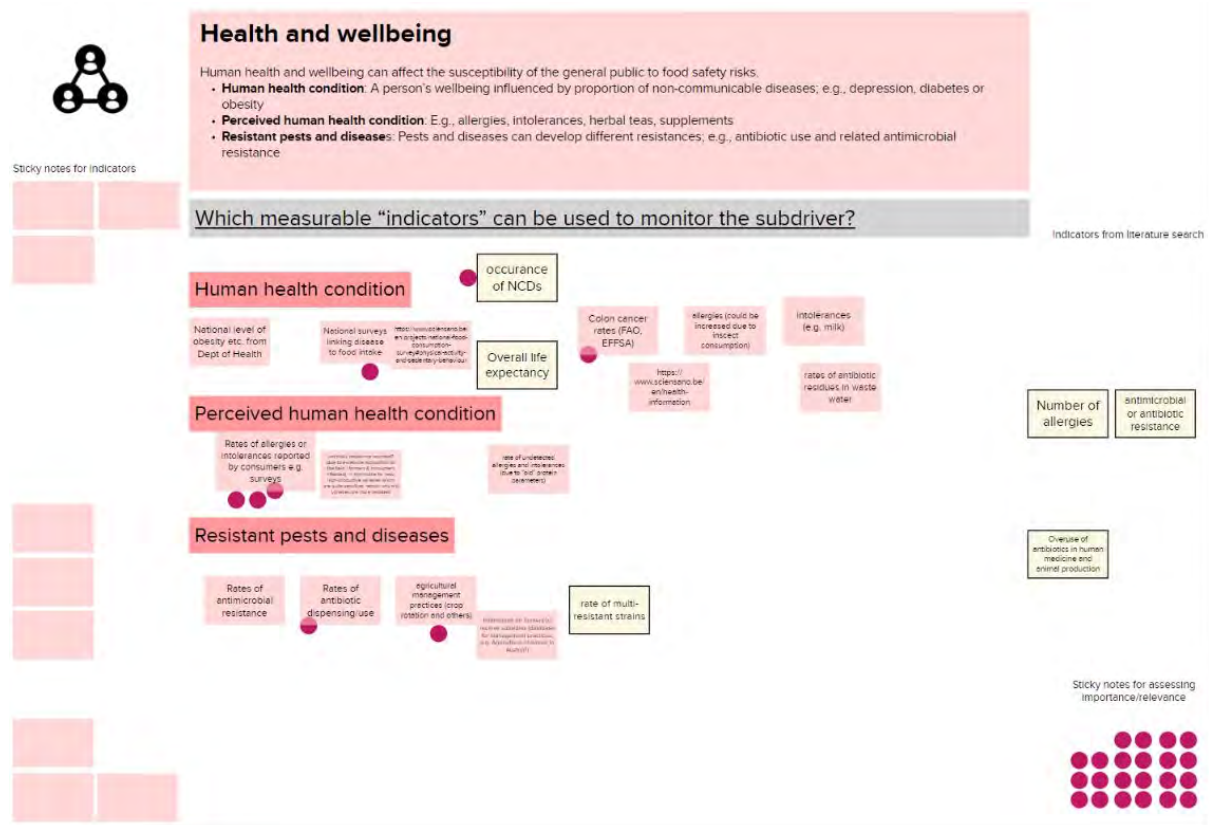
### Migration indicators

- **Legislation and number regarding migration in every country**
- Proportion of population travelling to exotic destinations
- Illegal import of food products from other locations (global food trade)
- Monitoring the number of immigrants involved in agriculture and food production

### (c) Health and wellbeing (of human beings)

Human health and wellbeing can affect the susceptibility of the general public to food safety risks.

- **Human health condition:** A person's wellbeing influenced by proportion of non-communicable diseases; e.g., depression, diabetes or obesity
- **Perceived human health condition:** E.g., allergies, intolerances, herbal teas, supplements
- **Resistant pests and diseases:** Pests and diseases can develop different resistances; e.g., antibiotic use and related antimicrobial resistance



## Human health condition indicators

- National level of obesity etc. from Dept of Health
- National surveys linking disease to food intake
- <https://www.sciensano.be/en/projects/national-food-consumption-survey#physical-activity-and-sedentary-behaviour>
- Occurrence of NCDs
- Overall life expectancy
- Colon cancer rates (FAO, EFFSA)
- <https://www.sciensano.be/en/health-information>
- Allergies (could be increased due to insect consumption)
- Rates of intolerances (e.g. milk) in population (*a rapid raise could be an indication for a food born cause*)
- Rates of antibiotic residues in waste water

## Perceived human health condition indicators

- Rates of allergies or intolerances reported by consumers e.g. surveys
- Antibiotic resistance reported (due to excessive application on the field / farmers & consumers affected) --> applicable for new, high-productive varieties which are quite sensitive; reason why old varieties are more resistant
- Rate of undetected allergies and intolerances (due to "old" protein parameters in ambulances to detect allergies)

## Resistant pests and diseases indicators



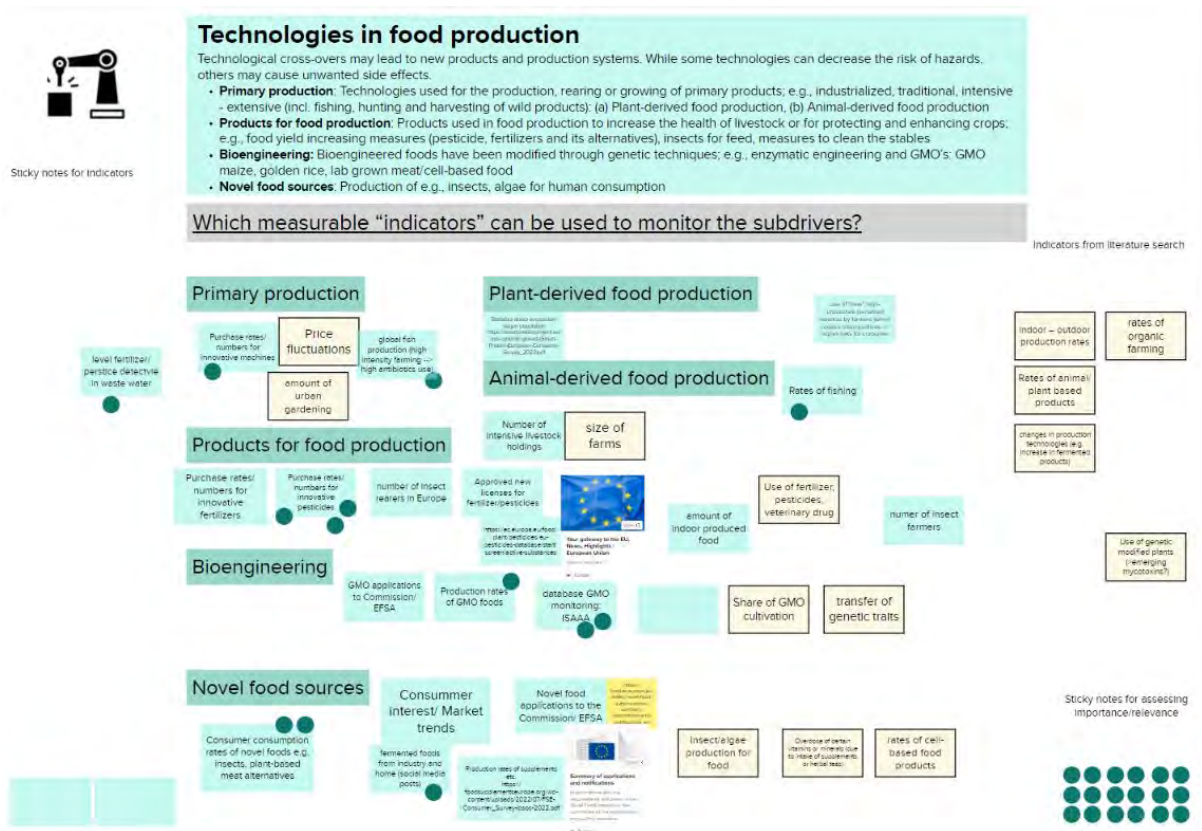
- Rates of antimicrobial resistance
- Rate of multi-resistant strains
- **Rates of antibiotic dispensing/use** / Overuse of antibiotics in human medicine and animal production
- **Record of agricultural management practices** (crop rotation and others can prevent high disease pressures) / Information on farmers to receive subsidies (**database for management practices**, e.g. Agricultural chamber in Austria?)

### 3.1.2 Technological Drivers

#### (a) Technologies in food production

Technological cross-overs may lead to new products and production systems. While some technologies can decrease the risk of hazards, others may cause unwanted side effects.

- **Primary production:** Technologies used for the production, rearing or growing of primary products; e.g., industrialized, traditional, intensive - extensive (incl. fishing, hunting and harvesting of wild products)
  - Plant-derived food production
  - Animal-derived food production
- **Products for food production:** Products used in food production to increase the health of livestock or for protecting and enhancing crops; e.g., food yield increasing measures (pesticide, fertilizers and its alternatives), insects for feed, measures to clean the stables
- **Bioengineering:** Bioengineered foods have been modified through genetic techniques; e.g., enzymatic engineering and GMO's: GMO maize, golden rice, lab grown meat
- **Novel food sources:** Production of e.g., insects, algae for human consumption



### Primary production indicators

- Level fertilizer/perstice detective in waste water (water quality databases?)
- Purchase rates/numbers for innovative machines
- Amount of urban gardening
- Price fluctuations
- Global fish production (high intensity farming --> high antibiotics use)
- Indoor – outdoor production rates
- Rates of animal/plant based products
- Rates of organic farming

### Plant-derived food production

- Statistics about vegetarian/vegan population
- [https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-European-Consumer-Survey\\_2023.pdf](https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-European-Consumer-Survey_2023.pdf)
- Use of "new", high-productive (sensitive) varieties by farmers (which require more pesticides --> higher risks for consumer)

### Animal-derived food production

- Number of intensive livestock holdings
- Size of farms
- Rates of fishing

### Products for food production indicators

- Use of fertilizer, pesticides, veterinary drug
- Purchase rates/numbers for innovative fertilizers
- **Purchase rates/numbers for innovative pesticides**
- Approved new licenses for fertilizer/pesticides
- <https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/active-substances>
- Number of insect farmers
- Number of insect rearers in Europe
- Amount of indoor produced food

### Bioengineering indicators

- Share of GMO cultivation
- Use of genetic modified plants (>emerging mycotoxins?)
- GMO applications to Commission/ **EFSA**
- **Production rates of GMO foods**
- **Database GMO monitoring: ISAAA**
- Transfer of genetic traits

### Novel food sources indicators

- **Consumer consumption rates of novel foods e.g. insects, plant-based meat alternatives**
- Consumer interest/ Market trends
- Insect/algae production for food
- Rates of cell-based food products
- **Novel food applications to the Commission/ EFSA**  
Summary of applications and notifications [https://food.ec.europa.eu/safety/novel-food/authorisations/summary-applications-and-notifications\\_en](https://food.ec.europa.eu/safety/novel-food/authorisations/summary-applications-and-notifications_en)
- **Fermented foods from industry and home (social media posts)**
- **Overdose of certain vitamins or minerals (due to intake of supplements or herbal teas)**
- **Production rates of supplements etc.** [https://foodsupplementseurope.org/wp-content/uploads/2022/07/FSE-Consumer\\_Survey-Ipsos-2022.pdf](https://foodsupplementseurope.org/wp-content/uploads/2022/07/FSE-Consumer_Survey-Ipsos-2022.pdf)

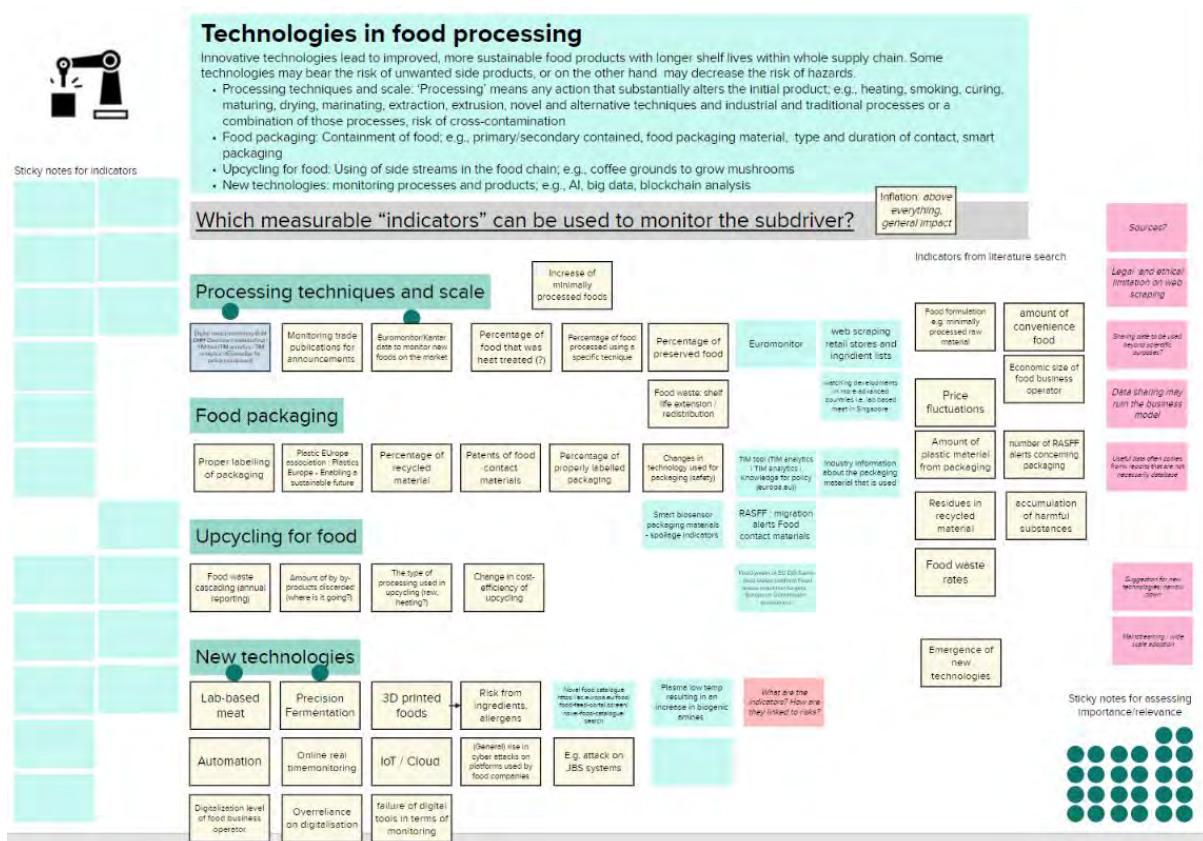
### (b) Technologies in food processing

Innovative technologies lead to improved, more sustainable food products with longer shelf lives within whole supply chain. Some technologies may bear the risk of unwanted side products, or on the other hand may decrease the risk of hazards.

- **Processing techniques and scale:** 'Processing' means any action that substantially alters the initial product; e.g., heating, smoking, curing, maturing, drying, marinating, extraction, extrusion, novel and alternative techniques and industrial and traditional processes or a combination of those processes, risk of cross-contamination
- **Food packaging:** Containment of food; e.g., primary/secondary contained, food packaging material, type and duration of contact, smart packaging
- **Upcycling for food:** Using of side streams in the food chain; e.g., coffee grounds to grow mushrooms



➤ **New technologies:** Monitoring processes and products; e.g., AI, big data, blockchain analysis



**Notes and discussion points:**

**Inflation above everything, general impact**

- Sources?
- Legal and ethical limitation on web scraping
- Sharing data to be used beyond scientific purposes?
- Data sharing may ruin the business models
- Useful data often comes from reports that are not necessarily databases
- Suggestion for new technologies: narrow down
- Mainstreaming / wide scale adoption

**Processing techniques and scale indicators**

- Digital media monitoring EUM EMM Overview (newsbrief.eu) / TIM tool (TIM analytics | TIM analytics | Knowledge for policy (europa.eu))
- Monitoring trade publications for announcements
- Euromonitor/Kantar data to monitor new foods on the market
- Percentage of food that was heat treated (?)
- Increase of minimally processed foods
- Percentage of food processed using a specific technique
- Percentage of preserved food
- Food waste: shelf life extension / redistribution
- Euromonitor

- Web scraping retail stores and ingredient lists
- Watching developments in more advanced countries i.e. lab based meat in Singapore
- Food formulation e.g. minimally processed raw material
- Price fluctuations
- Amount of convenience food
- Economic size of food business operator

### Food packaging indicators

- Proper labelling of packaging
- Plastic Europe association: Plastics Europe • Enabling a sustainable future
- Percentage of recycled material
- Residues in recycled material
- Patents of food contact materials
- Industry information about the packaging material that is used
- Amount of plastic material from packaging
- Percentage of properly labelled packaging
- Changes in technology used for packaging (safety)
- Smart biosensor packaging materials - spoilage indicators
- TIM tool (TIM analytics | TIM analytics | Knowledge for policy (europa.eu))
- RASFF: migration alerts Food contact materials  
number of RASFF alerts concerning packaging
- Accumulation of harmful substances

### Upcycling for food indicators

- Amount of by by-products discarded (where is it going?)
- The type of processing used in upcycling (raw, heating?)
- Change in cost-efficiency of upcycling
- Food waste cascading (annual reporting)
- Food waste at EU DG Sante: food waste platform Food waste reduction targets - European Commission (europa.eu)
- Food waste rates

### New technologies indicators

- **Lab-based meat**
  - Precision Fermentation
  - 3D printed foods
  - Risk from ingredients, allergens
  - Plasma low temp resulting in an increase in biogenic amines
  - Novel food catalogue <https://ec.europa.eu/food/food-feed-portal/screen/novel-food-catalogue/search>
- Automation
- Online real time-monitoring
- IoT / Cloud
- (General) rise in cyber attacks on platforms used by food companies
- E.g. attack on JBS systems



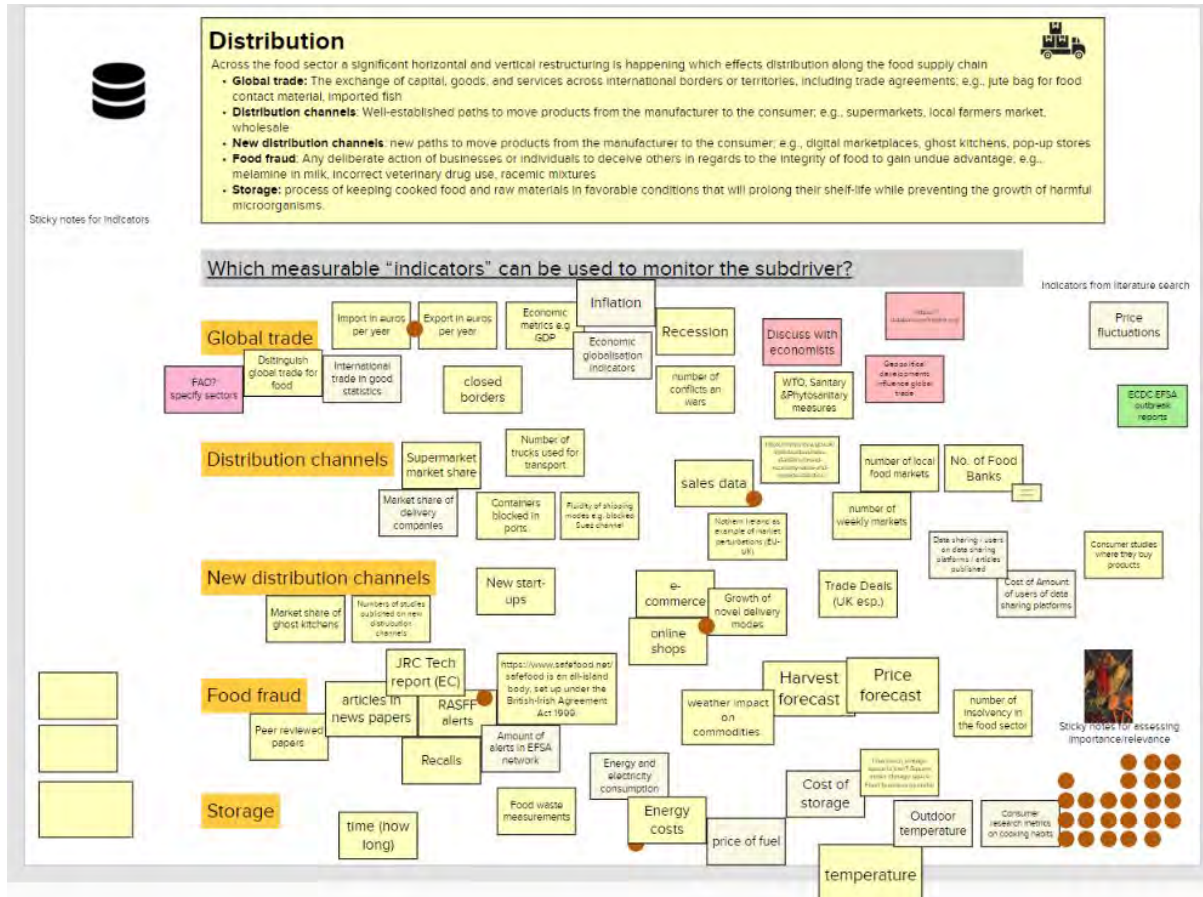
- Digitalization level of food business operator
- Overreliance on digitalisation
- Failure of digital tools in terms of monitoring
- Emergence of new technologies

### 3.1.3 Economic Drivers

#### (a) Distribution

Across the food sector, a significant horizontal and vertical restructuring is happening which effects distribution along the food supply chain.

- **Global trade:** The exchange of capital, goods, and services across international borders or territories, including trade agreements; e.g., jute bag for food contact material, imported fish
- **Distribution channels:** Well-established paths to move products from the manufacturer to the consumer; e.g., supermarkets, local farmers' market, wholesale
- **New distribution channels:** New paths to move products from the manufacturer to the consumer; e.g., digital marketplaces, ghost kitchens, pop-up stores
- **Food fraud:** Any deliberate action of businesses or individuals to deceive others in regards to the integrity of food to gain undue advantage; e.g., melamine in milk, incorrect veterinary drug use, racemic mixtures
- **Storage:** process of keeping cooked food and raw materials in favorable conditions that will prolong their shelf-life while preventing the growth of harmful microorganisms



## Global trade indicators

- International trade in good statistics - Distinguish global trade for food
  - Import in euros per year
  - Export in euros per year
  - **FAO? specify sectors**
  - Economic metrics e.g. GDP
- Inflation
- Recession
- Economic globalisation indicators
- Number of conflicts and wars
- **WTO, Sanitary & Phytosanitary measures**
- Closed borders
- **Discuss with economists for databases**
- Geopolitical developments influence global trade
- **<https://databank.worldbank.org/>**
- Price fluctuations
- **ECDC EFSA outbreak reports**
- **Economic Intelligence unit platform for trade/commodity/economy data**

## Distribution channels indicators

- Market share of delivery companies
- Supermarket market share



- Containers blocked in ports
- Fluidity of shipping modes e.g. blocked Suez channel
- Number of trucks used for transport
- **Sales data**
- Northern Ireland as example of market perturbations (EU-UK)
- <https://www.nisra.gov.uk/statistics/business-statistics/broad-economy-sales-and-exports-statistics>
- Number of weekly markets
- Number of local food markets
- No. of Food Banks (support systems)
- Data sharing / users on data sharing platforms / articles published
- Cost of Amount of users of data sharing platforms
- **Consumer studies** where they buy products

#### **New distribution channels indicators**

- Market share of ghost kitchens
- Numbers of studies published on new distribution channels
- New start-ups
- **Online shops**
- e-commerce
- **Growth of novel delivery modes**
- Trade Deals (UK esp.)

#### **Food fraud indicators**

- Peer reviewed papers
- Articles in news papers
- **JRC Tech report (EC)**
- Recalls
- **RASFF alerts**
- Amount of alerts in EFSA network
- <https://www.safefood.net/> safefood is an all-island body, set up under the British-Irish Agreement Act 1999.
- Weather impact on commodities
- Harvest forecast
- Price forecast
- Number of insolvency in the food sector
- **Food Fraud Database** <https://www.foodchainid.com/products/food-fraud-database/>
- Link to EU Agri Food Fraud Network page with enforcement actions, reports and publications: [https://food.ec.europa.eu/safety/eu-agri-food-fraud-network\\_en](https://food.ec.europa.eu/safety/eu-agri-food-fraud-network_en)

#### **Storage indicators**

- Time (how long)
- Food waste measurements
- Energy and electricity consumption
- **Energy costs**

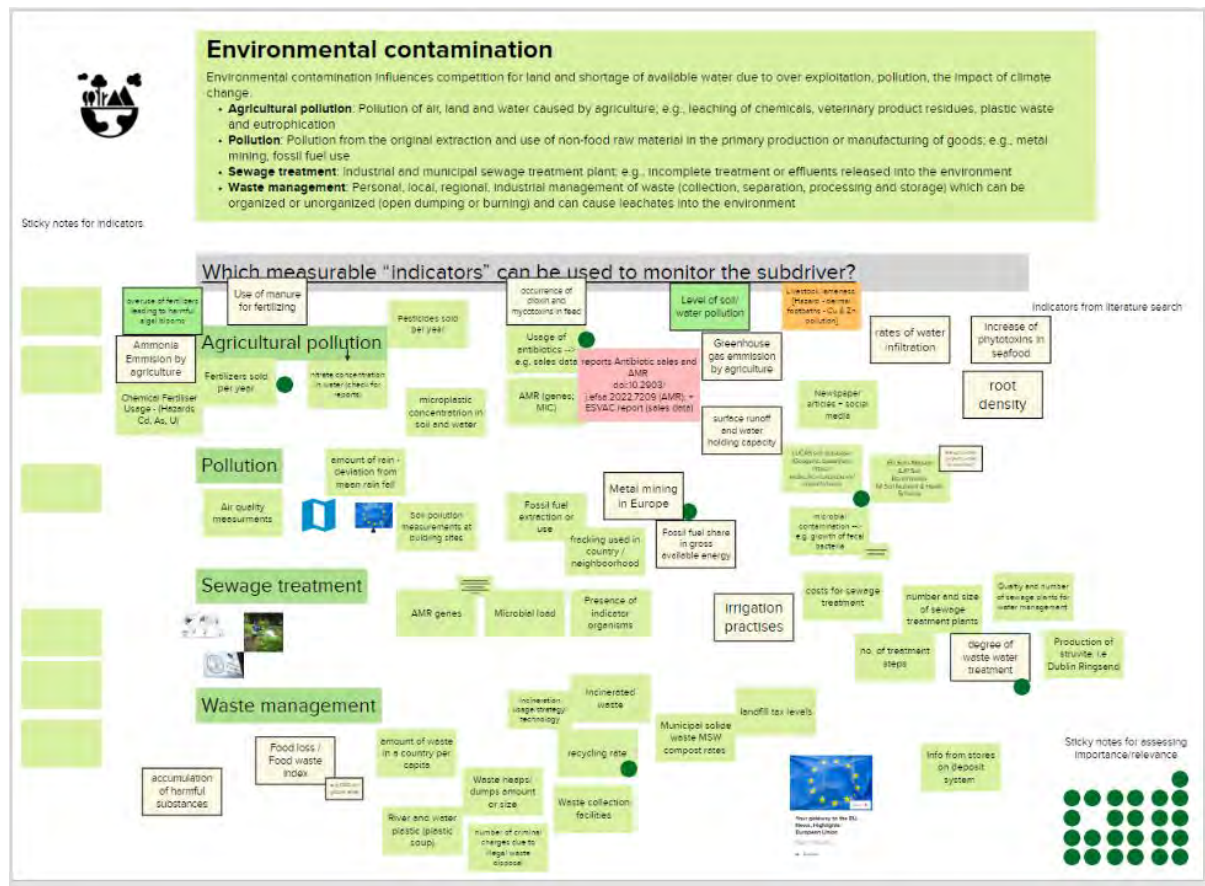
- Price of fuel
- Cost of storage
- Temperature & Outdoor temperature
- **How much storage space is there?** Square meter storage space Food business operator
- Consumer research metrics on cooking habits

### 3.1.4 Environmental Drivers

#### (a) Environmental contamination

Environmental contamination influences competition for land and shortage of available water due to over-exploitation, pollution, the impact of climate change.

- **Agricultural pollution:** Pollution of air, land and water caused by agriculture; e.g., leaching of chemicals, veterinary product residues, plastic waste and eutrophication
- **Pollution:** Pollution from the original extraction and use of non-food raw material in the primary production or manufacturing of goods; e.g., metal mining, fossil fuel use
- **Sewage treatment:** Sewage treatment plant, both industrial and municipal; e.g., incomplete treatment or effluents released into the environment
- **Waste management:** Personal, local, regional, industrial management of waste (collection, separation, processing and storage) which can be organized or unorganized (open dumping or burning) and can cause leachates into the environment



## Agricultural pollution indicators

- Chemical **Fertilizer** Usage - (Hazards Cd, As, U)
- Ammonia Emission by agriculture
- Overuse of fertilizers leading to harmful algal blooms
- Use of manure for fertilizing
- Nitrate concentration in water (check for reports)
- **Pesticides sold per year**
- **Fertilizers sold per year**
- Microplastic concentration in soil and water
- Occurrence of dioxin and mycotoxins in feed
- **Usage of antibiotics --> e.g. sales data**
- AMR (genes; MIC)
- Reports Antibiotic sales and AMR doi:10.2903/j.efs.2022.7209 (AMR); + ESVAC report (sales data)
- Level of soil/water pollution
- Greenhouse gas emission by agriculture
- Surface runoff and water holding capacity
- Livestock lameness [Hazard - dermal footbaths – indicator for Cu & Zn pollution]
- **Newspaper articles + social media**
- Rates of water infiltration
- Root density
- Increase of phytotoxins in seafood

## Pollution indicators

- Air quality measurements  
Air quality database 2022 <https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database/2022>
- Amount of rain - deviation from mean rain fall
- **Your gateway to the EU, News, Highlights | European Union**  
<https://data.jrc.ec.europa.eu/collection/EDGAR>
- Soil pollution measurements at building sites
- Fossil fuel extraction or use
- Fracking used in country /neighbourhood
- Metal mining in Europe
- **Fossil fuel share in gross available energy**
- **LUCAS soil database (Geogenic baselines)** <https://esdac.jrc.ec.europa.eu/projects/lucas>
- **EU Soils Mission EJP Soil Benchmarks NI Soil Nutrient & Health Scheme** - link up to other projects under Soil mission?
- **Microbial contamination →e.g. growth of fecal bacteria, check national databases?**

## Sewage treatment indicators

- **HydroWASTE** <https://www.hydrosheds.org/products/hydrowaste>



- Home | Food and Agriculture Organization of the United Nations <https://www.fao.org/aquastat/en/overview/methodology/wastewater>
- Global wastewater database <https://www.iwmi.cgiar.org/2014/06/global-wastewater-database/>
- AMR genes
- Microbial load
- Presence of indicator organisms
- Recent publications on these indicators, might be something being available publicly in the future
- Irrigation practises
- **Degree of waste water treatment**
- Costs for sewage treatment
- No. of treatment steps
- Number and size of sewage treatment plants
- Quality and number of sewage plants for water management
- Production of struvite. i.e Dublin Ringsend

#### Waste management indicators

- Accumulation of harmful substances
- Food loss / Food waste index - e.g FAO on global level
- Amount of waste in a country per capita
- Waste heaps/dumps amount or size
- River and water plastic (plastic soup) – reports on amount?
- Number of criminal charges due to illegal waste disposal
- **Recycling rate**
- Incineration usage/strategy/technology
- Incinerated waste
- Waste collection facilities
- Municipal solid waste MSW compost rates
- Landfill tax levels
- Your gateway to the EU, News, Highlights | European Union <https://ec.europa.eu/eurostat/web/waste/data/database>
- Info from stores on deposit system

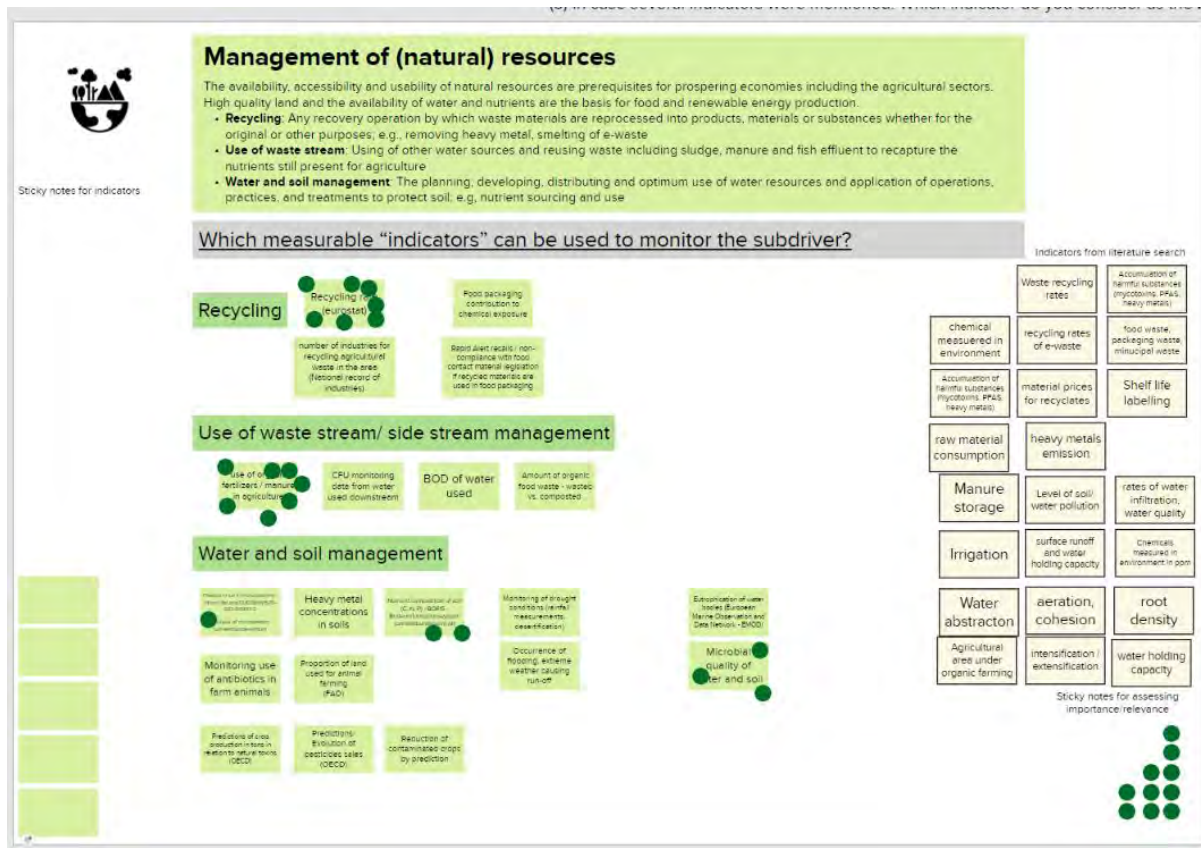
#### (b) Management of (natural) resources

The availability, accessibility and usability of natural resources are prerequisites for prospering economies including the agricultural sectors. High quality land and the availability of water and nutrients are the basis for food and renewable energy production.

- **Recycling:** Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes; e.g., removing heavy metal, smelting of e-waste
- **Use of waste stream:** Using of other water sources and reusing waste including sludge, manure and fish effluent to recapture the nutrients still present for agriculture



- **Water and soil management:** The planning, developing, distributing and optimum use of water resources and application of operations, practices, and treatments to protect soil; e.g, nutrient sourcing and use



### Recycling indicators

- Number of industries for recycling agricultural waste in the area (**National record of industries**)
- Waste recycling rates
- Recycling rates of e-waste
- **Recycling rate (eurostat)**
- Food waste, packaging waste, municipal waste
- **Rapid Alert recalls / non-compliance with food contact material legislation if recycled materials are used in food packaging**
- Food packaging contribution to chemical exposure
- Accumulation of harmful substances (mycotoxins, PFAS, heavy metals)
- Chemicals measured in environment
- Material prices for recyclates
- Shelf life labelling

### Use of waste stream indicators

- **Use of organic fertilizers / manure in agriculture**
- CFU monitoring data from water used downstream
- BOD of water used
- Rates of water infiltration, water quality

- Level of soil/water pollution
- Amount of organic food waste - wasted vs. composted
- Raw material consumption
- Manure storage
- Heavy metals emission

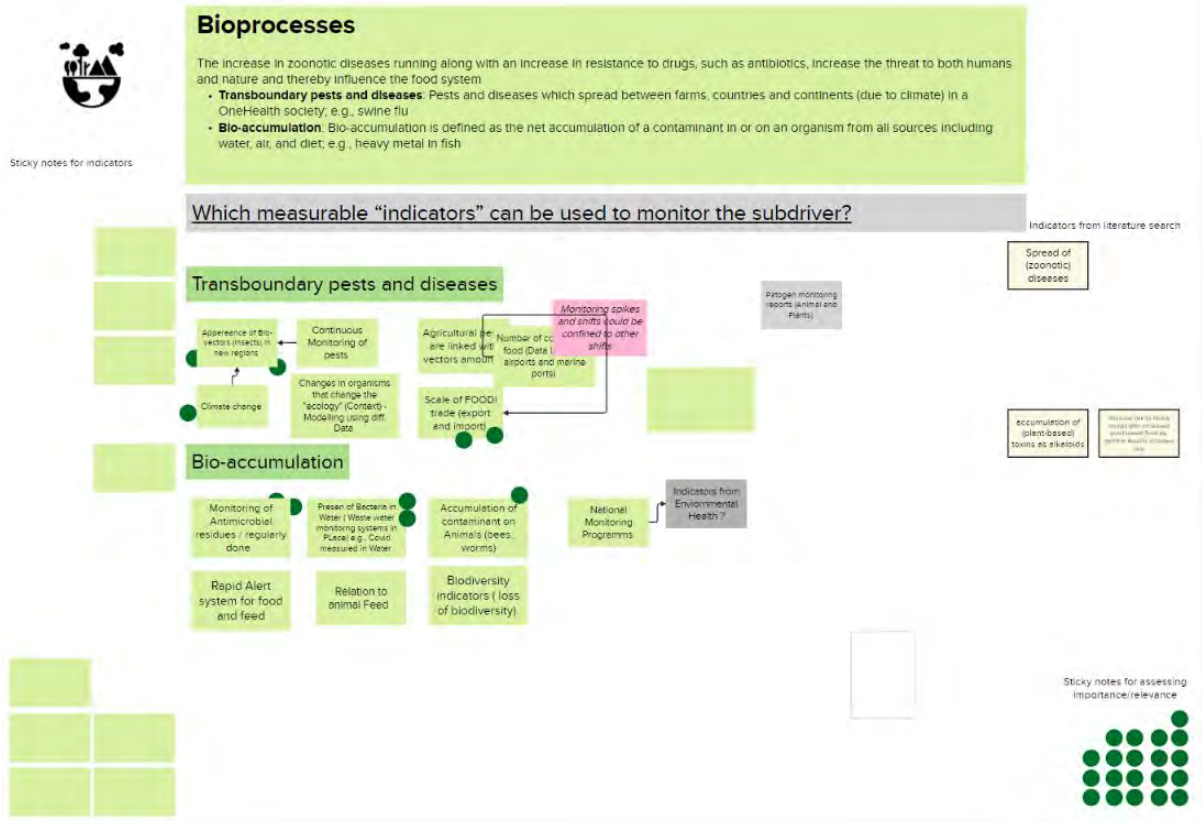
### Water and soil management indicators

- **Plastics in soils (microplastics) <https://doi.org/10.1038/s41579-023-00967-2> Analysis of microplastics (umweltbundesamt.at)**
- Monitoring use of antibiotics in farm animals
- **Predictions of crop production in tons in relation to natural toxins (OECD)**
- Heavy metal concentrations in soils
- Reduction of contaminated crops by prediction
- **Proportion of land used for animal farming (FAO)**
- **Predictions/Evolution of pesticides sales (OECD)**
- **Nutrient composition of soil (C, N, P) - BORIS - Bodeninformationssystem (umweltbundesamt.at)**
- Monitoring of drought conditions (rainfall measurements, desertification)
- Occurrence of flooding, extreme weather causing run-off
- **Eutrophication of water bodies (European Marine Observation and Data Network - EMOD)**
- **Microbial quality of water and soil**
- Agricultural area under organic farming
- Irrigation
- Water abstraction
- Surface runoff and water holding capacity
- Aeration, cohesion
- Intensification / extensification
- Water holding capacity
- Root density
- Chemicals measured in environment in ppm

### (c) Bioprocesses

The increase in zoonotic diseases running along with an increase in resistance to drugs, such as antibiotics, increase the threat to both humans and nature and thereby influence the food system.

- **Transboundary pests and diseases:** Pests and diseases which spread between farms, countries and continents (due to climate) in a OneHealth society; e.g., swine flu
- **Bio-accumulation:** Bio-accumulation is defined as the net accumulation of a contaminant in or on an organism from all sources including water, air, and diet; e.g., heavy metal in fish



## Transboundary pests and diseases indicators

- **Appearance of Bio-vectors (insects) in new regions** <= Climate change
- Continuous Monitoring of pests
- Changes in organisms that change the "ecology" (Context) - **Modelling using diff. Data**
- Agricultural pests are linked with vectors amounts
- **Number of confiscated food (Data bases of airports and marine ports)**
- **Scale of FOODI trade (export and import)**
- Monitoring spikes and shifts could be confined to other shifts
- **Pathogen monitoring reports (Animal and Plants)**
- Spread of (zoonotic) diseases

## Bio-accumulation indicators

- **Monitoring of Antimicrobial residues / regularly done**
- **Rapid Alert system for food and feed**
- **Presence of Bacteria in Water (Waste water monitoring systems in PLace) e.g., Covid measured in Water**
- Relation to animal Feed
- **Accumulation of contaminant in animals (bees, worms)**
- Biodiversity indicators (loss of biodiversity)
- National Monitoring Programms => Indicators from Environmental Health?
- Accumulation of (plant-based) toxins as alkaloids

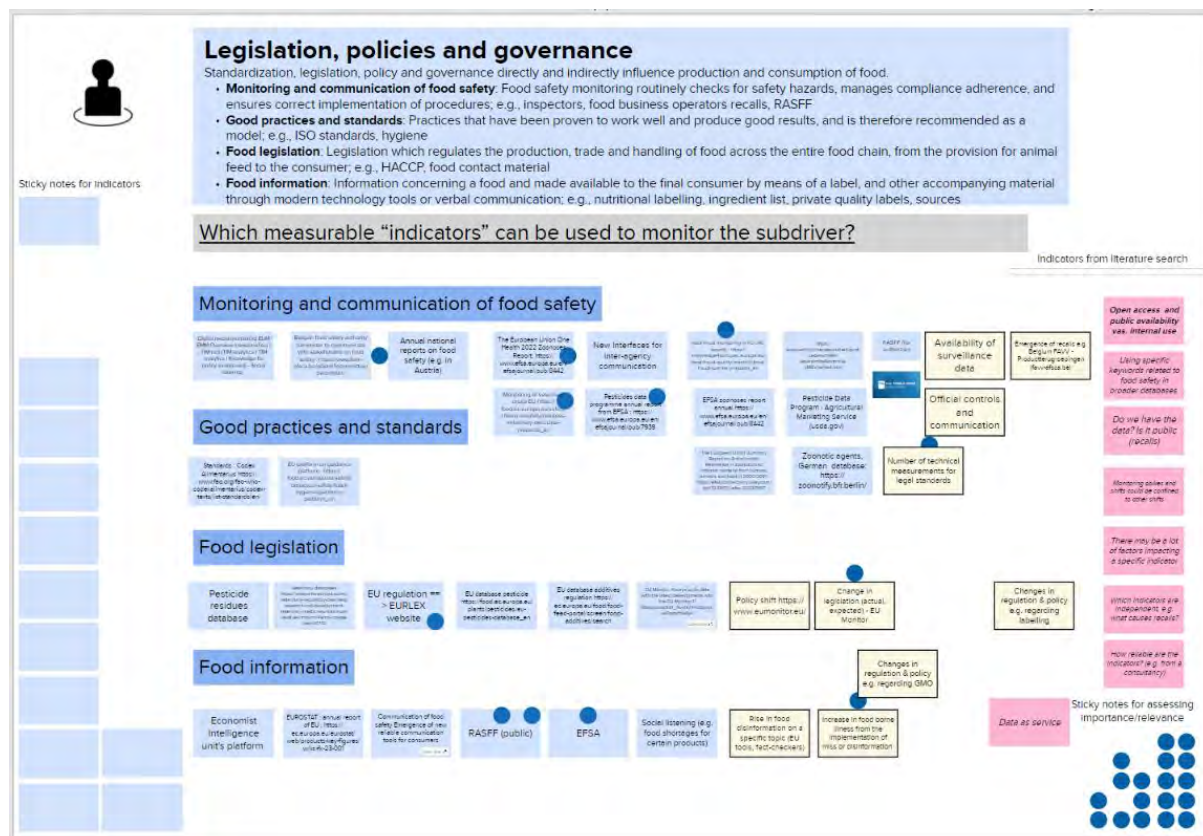
- Increase risk to heavy metals with increased plant based food eg. monitor Arsenic in brown rice

### 3.1.5 Political Drivers

#### (a) Legislation, policies and governance

Standardization, legislation, policy and governance directly and indirectly influence production and consumption of food.

- **Monitoring and communication of food safety:** Food safety monitoring is the mechanism that routinely checks for safety hazards, manages compliance adherence, and ensures procedures are being correctly implemented and communicated openly; e.g., inspectors, food business operators recalls, RASFF
- **Good practices and standards:** Practices that have been proven to work well and produce good results, and is therefore recommended as a model; e.g., ISO standards, hygiene
- **Food legislation:** Legislation which regulates the production, trade and handling of food across the entire food chain, from the provision for animal feed to the consumer; e.g., HACCP, food contact material
- **Food information:** Information concerning a food and made available to the final consumer by means of a label, and other accompanying material through modern technology tools or verbal communication; e.g., nutritional labelling, ingredient list, private labels of quality, source, etc.



Notes and discussion points:



- Open access and public availability vs. internal use
- Using specific keywords related to food safety in broader databases
- Do we have the data? Is it public (recalls)
- Monitoring spikes and shifts could be confined to other shifts
- There may be a lot of factors impacting a specific indicator
- Which indicators are independent, e.g. what causes recalls?
- How reliable are the indicators? (e.g. from a consultancy)
- Data as service

### Monitoring and communication of food safety indicators

- Digital media monitoring EUM EMM Overview (newsbrief.eu) / TIM tool (TIM analytics | TIM analytics | Knowledge for policy (europa.eu)) - Social listening
- Belgian food safety authority barometer to communicate with stakeholders on food safety : <https://www.favv-afscab.be/scientificcommittee/barometer/>
- Annual national reports on food safety (e.g. in Austria)
- The European Union One Health 2022 Zoonoses Report; <https://www.efsa.europa.eu/en/efsajournal/pub/8442>
- Monitoring of veterinary drugs EU [https://food.ec.europa.eu/safety/chemical-safety/residues-veterinary-medicinal-products\\_en](https://food.ec.europa.eu/safety/chemical-safety/residues-veterinary-medicinal-products_en)
- Pesticides data programme annual report from EFSA : <https://www.efsa.europa.eu/en/efsajournal/pub/7939>
- New Interfaces for inter-agency communication
- food fraud monitoring in EU JRC reports : [https://knowledge4policy.ec.europa.eu/food-fraud-quality/monthly-food-fraud-summary-reports\\_en](https://knowledge4policy.ec.europa.eu/food-fraud-quality/monthly-food-fraud-summary-reports_en)
- EFSA zoonoses report annual <https://www.efsa.europa.eu/en/efsajournal/pub/8442>
- <https://www.verbrauchergesundheit.gv.at/Lebensmittel/lebensmittelkontrolle/LMSI/cherheit.html>
- Pesticide Data Program | Agricultural Marketing Service (usda.gov)
- RASFF (for authorities)
- FDA Total Diet Study (TDS) <https://www.fda.gov/food/reference-databases-and-monitoring-programs-food/fda-total-diet-study-tds>
- Availability of surveillance data
- Official controls and communication
- Emergence of recalls e.g. Belgium FAVV - Productterugroepingen (favv-afscab.be)
- The European Union Summary Report on Antimicrobial Resistance in zoonotic and indicator bacteria from humans, animals and food in 2020/2021: <https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2023.7867>
- Zoonotic agents, German database: <https://zoonotify.bfr.berlin/>
- Number of technical measurements for legal standards

### Good practices and standards indicators

- Standards : Codex Alimentarius <https://www.fao.org/fao-who-codexalimentarius/codex-texts/list-standards/en/>



- EU platform on guidance platform : [https://food.ec.europa.eu/safety/biological-safety/food-hygiene/guidance-platform\\_en](https://food.ec.europa.eu/safety/biological-safety/food-hygiene/guidance-platform_en)

### Food legislation indicators

- Pesticide residues database
- Veterinary databases
- <https://www.ema.europa.eu/en/veterinary-regulatory-overview/research-and-development-veterinary-medicines/maximum-residue-limits-mrl#ema-inpage-item-10712>
- **EU regulation ==> EURLEX website**
- EU database pesticide [https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database\\_en](https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en)
- EU database additives regulation <https://ec.europa.eu/food/food-feed-portal/screen/food-additives/search>
- EU Monitor: Always up to date with the latest developments with the EU Monitor/1/j9tvgajcovz8izf\_j9vvik7m1c3gyxp/vk0qgtdhw4yx  
<https://www.eumonitor.nl/9353000>
- Change in legislation (actual, expected) - EU Monitor **Policy shift**  
<https://www.eumonitor.eu/>
- Changes in regulation policy e.g. regarding labelling

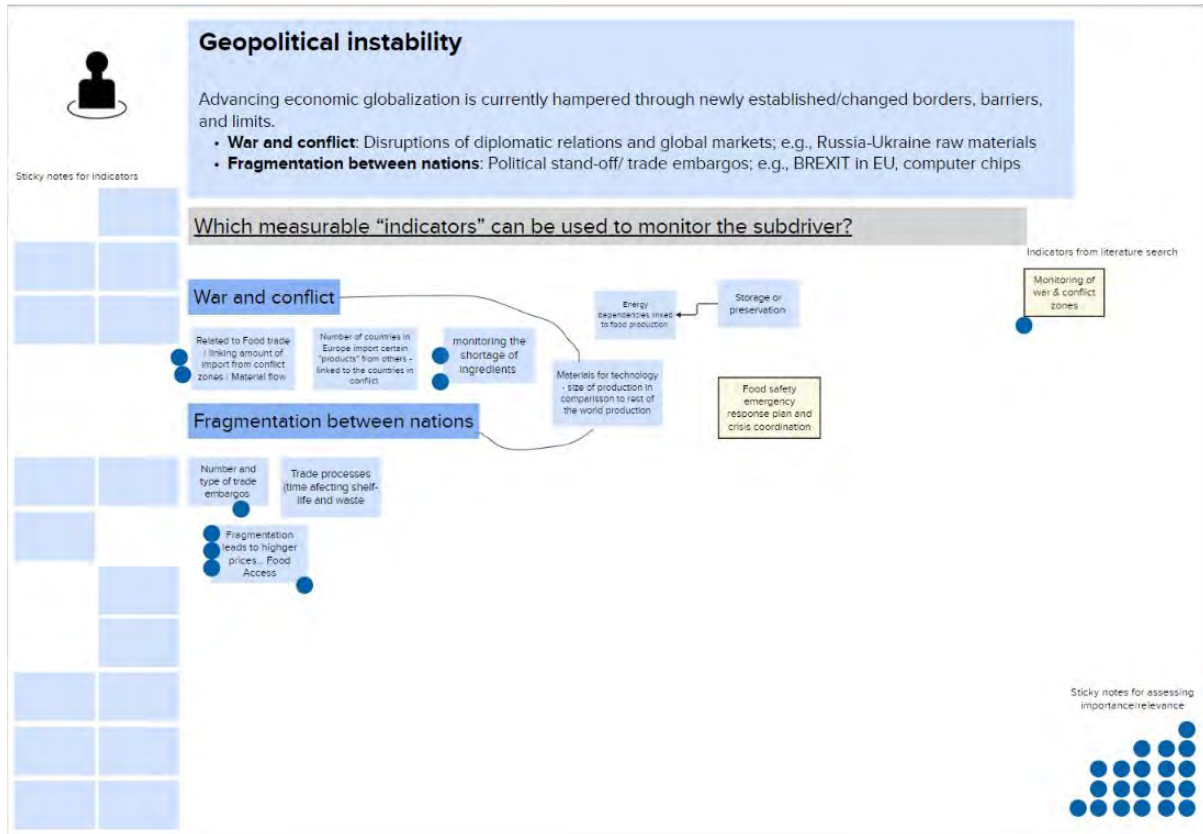
### Food information indicators

- Economist Intelligence unit's platform
- EUROSTAT : annual report of EU : <https://ec.europa.eu/eurostat/web/products-key-figures/w/ks-fk-23-001>
- Communication of food safety Emergence of new reliable communication tools for consumers <https://www.fda.gov/consumers/consumer-updates/food>
- **RASFF (public)**
- **EFSA**
- Social listening (e.g. food shortages for certain products)
- Rise in food disinformation on a specific topic (EU tools, fact-checkers)
- Increase in food borne illness from the implementation of miss or disinformation
- Changes in regulation & policy e.g. regarding GMO

### (b) Geopolitical instability

Advancing economic globalization is currently hampered through newly established/changed borders, barriers, and limits.

- **War and conflict:** Disruptions of diplomatic relations and global markets; e.g., Russia-Ukraine raw materials
- **Fragmentation between nations:** Political stand-off/ trade embargos; e.g., BREXIT in EU, computer chips



### War and conflict indicators

- **Related to Food trade / linking amount of import from conflict zones / Material flow**
- Number of countries in Europe import certain "products" from others -linked to the countries in conflict
- **Monitoring the shortage of ingredients**
- Materials for technology - size of production in comparison to rest of the world production
- Energy dependencies linked to food production
- Storage or preservation
- Food safety emergency response plan and crisis coordination
- **Monitoring of war & conflict zones**

### Fragmentation between nations indicators

- **Number and type of trade embargos**
- **Fragmentation leads to higher prices... Food Access**
- Trade processes (time affecting shelf-life and waste)

### 3.2. Final list of indicators and corresponding data sources / databases

The key indicators and databases from the initial literature survey (sections 2 and 3) are first listed in Section 6.1, which is followed in Section 6.2 by the key indicators and databases identified from the LL3 workshop (Section 5).

As in Section 5, the indicators are grouped by driver/subdriver and ordered by STEEP classification.

#### 3.2.1. Indicator list chosen by the FOODSAFER WP1 partners prior de workshop

##### **SOCIAL DRIVERS**

##### **Consumer behaviour**

Indicator	Data source
Dietary lifestyle food safety	Surveys conducted in 2021 and 2023 - <a href="https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-European-Consumer-Survey_2023.pdf">https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-European-Consumer-Survey_2023.pdf</a>
Consumption various types food safety	FoodEx2 - <a href="https://www.efsa.europa.eu/en/microstrategy/foodex2-level-1">https://www.efsa.europa.eu/en/microstrategy/foodex2-level-1</a>
Consumption novel foods food safety	
Amount food waste preservation safety	Eurostat - <a href="https://ec.europa.eu/eurostat/databrowser/view/ENV_WASFW/bookmark/table?lang=en&amp;bookmarkId=6231196e-cf3c-4e0b-88ce-a7eb958f6e3e&amp;page=time:2021">https://ec.europa.eu/eurostat/databrowser/view/ENV_WASFW/bookmark/table?lang=en&amp;bookmarkId=6231196e-cf3c-4e0b-88ce-a7eb958f6e3e&amp;page=time:2021</a>
Searches for information food safety	Google Trends e.g. <a href="https://trends.google.com/trends/explore?geo=GB&amp;q=food%20safety&amp;hl=en">https://trends.google.com/trends/explore?geo=GB&amp;q=food%20safety&amp;hl=en</a>
new vegetarian/vegan restaurants safety	
Cleaning food preparation surfaces kitchenware	<a href="https://www.sciencedirect.com/science/article/pii/S0956713519306668">https://www.sciencedirect.com/science/article/pii/S0956713519306668</a>

##### **Demographic development**

Indicator	Data source
Degree of urbanisation food safety	<a href="https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS">https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS</a>
Population size food safety	<a href="https://data.oecd.org/pop/population.htm">https://data.oecd.org/pop/population.htm</a>
Immigration/Emigration food safety	<a href="https://www.migrationdataportal.org/international-data?i=stock_abs &amp;t=2020">https://www.migrationdataportal.org/international-data?i=stock_abs &amp;t=2020</a>





Education rate food safety habits	<a href="https://data.oecd.org/eduatt/population-with-tertiary-education.htm">https://data.oecd.org/eduatt/population-with-tertiary-education.htm</a>
Gap rich poor food safety	<a href="https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_income_distribution_and_income_inequality">https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_income_distribution_and_income_inequality</a>
vulnerable groups food safety	

### **Health and wellbeing (of human beings)**

<b>Indicator</b>	<b>Data source</b>
Colon cancer rates food safety	<a href="https://ec.europa.eu/eurostat/databrowser/view/hlth_cd_aro/default/table?lang=en">https://ec.europa.eu/eurostat/databrowser/view/hlth_cd_aro/default/table?lang=en</a>
Occurrence of NCDs food safety	<a href="https://vizhub.healthdata.org/gbd-results/">https://vizhub.healthdata.org/gbd-results/</a>
Life expectancy food safety	<a href="https://ec.europa.eu/eurostat/databrowser/view/demo_r_mlifexp/default/table?lang=en">https://ec.europa.eu/eurostat/databrowser/view/demo_r_mlifexp/default/table?lang=en</a>
allergies or intolerances food safety	<a href="https://onlinelibrary.wiley.com/doi/full/10.1111/all.15560">https://onlinelibrary.wiley.com/doi/full/10.1111/all.15560</a>
antibiotic dispensing/use food safety	<a href="https://www.ecdc.europa.eu/sites/default/files/documents/Antimicrobial-consumption-in-the-EU-Annual-Epidemiological-Report-2019.pdf">https://www.ecdc.europa.eu/sites/default/files/documents/Antimicrobial-consumption-in-the-EU-Annual-Epidemiological-Report-2019.pdf</a>
agricultural management practices food safety	

### **TECHNOLOGICAL DRIVERS**

#### **Technologies in food processing**

<b>Indicator</b>	<b>Data source</b>
RASFF alerts food packaging	RASFF
Emergence new technologies food safety	
minimally processed foods food safety, amount of convenience food	

#### **Technologies in food production**

<b>Indicator</b>	<b>Data source</b>
Share of GMO cultivation / genetic modified plants mycotoxins, traits	

cell-based food production food safety / cell-based food approved market entrance	
total crop production	<ul style="list-style-type: none"> <li>- EUROSTAT utilised agricultural area</li> <li>- EUROSTAT Harvested production</li> </ul>
Dairy food production food safety	EUROSTAT
Meat production food safety	EUROSTAT
Fishing & aquaculture production	EUROSTAT
indoor – outdoor production food safety ates	
Organic production food safety	<ul style="list-style-type: none"> <li>- EUROSTAT organic production of animal products</li> <li>- EUROSTAT area under organic farming</li> <li>- EUROSTAT organic production by crops</li> <li>- FAOSTAT</li> </ul>
dioxin and mycotoxins in feed	
Veterinary drug use food safety	EFSA reports
Water use agriculture food safety	

## ECONOMIC DRIVERS

### Distribution

Indicator	Data source
International trade in good statistics	EUROSTAT
Economic globalisation indicators food safety	EUROSTAT
Outdoor temperature food safety	IBM/weatherdata base
Amount published about data sharing	PUBMED/Scopus

## ENVIRONMENTAL DRIVERS

### Environmental contamination

Indicator	Data source
Ammonia Emission by agriculture	
Pesticides fertilizers sold food safety	
Microplastic concentration soil water safety	



Greenhouse gas emission agriculture	
Air quality measurements food safety	<a href="https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database/2022">https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database/2022</a>
Land use coverage area frame	<a href="https://esdac.jrc.ec.europa.eu/projects/lucas">https://esdac.jrc.ec.europa.eu/projects/lucas</a>
municipal wastewater irrigation food safety	<a href="https://www.fao.org/aquastat/en/overview/methodology/wastewater">https://www.fao.org/aquastat/en/overview/methodology/wastewater</a>
Food loss waste index safety	FAO

### Management of (natural) resources

Indicator	Data source
Waste collection facilities	
Landfill tax levels	
Waste recycling rates	
Material prices for recyclates	

### Bioprocesses indicators

Indicator	Data source
organic fertilizers manure agriculture safety	
Heavy metals soil food safety	
Nutrient composition of soil (C, N, P)	BORIS - Bodeninformationssystem (umweltbundesamt.at)
Microbial quality of water and soil	
Pest monitoring food safety	
Spread of zoonotic diseases food	



### 3.2.2 Indicator list selected from the LL3 workshop

## **SOCIAL DRIVERS**

### **(a) Consumer behavior:**

#### Dietary choice:

- Consumption per Capita food safety

#### Dietary lifestyle:

- Omnivore food safety
- Vegetarian food safety
- Flexitarian food safety
- Novel protein sources food safety
- new vegetarian food safety
- vegan restaurants food safety
- emerging Novel food safety
- people illnesses food safety
- National Census data food safety

#### Consumer knowledge:

- Cleaning food preparation surfaces kitchenware
- QRhow often people search
- Consumer trends linked knowledge
- Survey Health Benefits food safety
- Survey cooking hygienic practices

#### Consumer awareness / attitude:

- food lost and food preservation
- people local farmer's shops safety

#### Public awareness:

- sales labelled product food safety
- Consumer selection/ranking of various dietary behaviours to improve health
- Data - SafeConsume HE Project -- Survey and data collection <https://safeconsume.eu/>  
Eurobarometer on Food Safety in EU - data on consumer behavior/awareness  
<https://www.efsa.europa.eu/it/corporate/pub/eurobarometer22>

### **(b) Demographic development**



#### Population change:

- Demographics of population food safety
- Population size food safety
- Data - Immigration - European Commission, Eurostat, <https://data.oecd.org/pop/population.htm> <https://population.un.org/wpp/>

#### Prevalence of vulnerable groups:

- metabolism coronary diseases food safety
- cancer food safety

#### Urbanisation:

- Degree urbanization Eurostat food safety
- Education rate food consumption habits

#### Social welfare:

- Gap rich poor food safety
- Purchase behavior food safety

#### Migration:

- Legislation migration food safety

### **(c) Health and wellbeing (of human beings)**

#### Human health condition:

- Occurrence NCDs food safety
- Colon cancer rates food safety (FAO, EFFSA)
- Data - FAO, EFFSA, Dept of Health , National surveys linking disease to food intake , <https://www.sciensano.be/en/projects/national-food-consumption-survey#physical-activity-and-sedentary-behaviour><https://www.sciensano.be/en/health-information>

#### Perceived human health condition:

- allergies intolerances surveys food safety

#### Resistant pests and diseases:

- antibiotic dispensing use food safety
- agricultural management practices food safety

## TECHNOLOGICAL DRIVERS

### (a) Technologies in food production

#### Primary production:

- fertilizer waste water food safety Purchase innovative machines food safety
- Global fish production food safety
- high intensity farming food safety
- high antibiotics use food safety

#### Plant-derived food production:

- vegetarian/vegan population food safety ,

#### Products for food production:

- Purchase innovative pesticides food safety
- Data - <https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/active-substances>

#### Bioengineering:

- Production GMO foods food safety

#### Novel food sources:

- consumption rates novel foods safety
- Fermented foods industry safety
- Fermented foods home safety
- Novel food applications to EFSA
- Summary of applications and notifications [https://food.ec.europa.eu/safety/novel-food/authorisations/summary-applications-and-notifications\\_en](https://food.ec.europa.eu/safety/novel-food/authorisations/summary-applications-and-notifications_en)
- Production rates food supplements safety

### (b) Technologies in food processing

#### Processing techniques and scale:

- Data - Digital media monitoring EUM EMM Overview ([newsbrief.eu](https://newsbrief.eu))
- TIM tool (TIM analytics | TIM analytics | Knowledge for policy (europa.eu))



- new foods market food safety
- retail stores food safety
- cultured meat food safety

#### Food packaging:

- Plastics Europe food safety
- Enabling a sustainable future, TIM tool (TIM analytics | TIM analytics | Knowledge for policy (europa.eu))
- RASFF: migration alerts Food contact materials, alerts packaging

#### Upcycling for food:

- Data - annual reporting , Food waste at EU DG Sante: food waste platform Food waste reduction targets - European Commission (europa.eu)

#### New technologies:

- Precision Fermentation food safety
- Data - Novel food catalogue <https://ec.europa.eu/food/food-feed-portal/screen/novel-food-catalogue/search>

## **ECONOMIC DRIVERS**

### **(a) Distribution**

#### Global trade:

- Imports in euros food safety
- Exports in euros food safety
- Data - FAO, WTO, Sanitary & Phytosanitary measures, <https://databank.worldbank.org/>, ECDC EFSA outbreak reports, Economicst Intelligence unit platform for trade/commodity/economy data

#### Distribution channels:

- Sales data food safety
- Data - <https://www.nisra.gov.uk/statistics/business-statistics/broad-economy-sales-and-exports-statistics> , Consumer studies

#### New distribution channels:

- Online shops food safety
- Novel delivery food safety



### Food fraud:

Data - JRC Tech report (EC) , RASFF alerts , <https://www.safefood.net/> safefood is an all-island body, set up under the British-Irish Agreement Act 1999 , Food Fraud Database <https://www.foodchainid.com/products/food-fraud-database/> , [https://food.ec.europa.eu/safety/eu-agri-food-fraud-network\\_en](https://food.ec.europa.eu/safety/eu-agri-food-fraud-network_en)

### Storage:

- Energy costs food safety
- Storage space food safety

## **ENVIRONMENTAL DRIVERS**

### **(a) Environmental contamination**

#### Agricultural pollution:

- Chemical Fertilizer Usage food safety
- Nitrate concentration water food safety
- Pesticides sold food safety
- Fertilizers sold food safety
- Usage antibiotics sales food safety Data - reports, sales data, social media, newspaper articles, Reports Antibiotic sales and AMR doi:10.2903/j.efsa.2022.7209 (AMR); + ESVAC report (sales data)

#### Pollution:

- Fossil fuel share food safety
- Microbial contamination food safety
- Data - Air quality database 2022 <https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database/2022>
- Your gateway to the EU, News, Highlights | European Union <https://data.jrc.ec.europa.eu/collection/EDGAR>

LUCAS soil database (Geogenic baselines) <https://esdac.jrc.ec.europa.eu/projects/lucas>

#### Sewage treatment:

- waste water treatment food safety
- sewage treatment plants food safety
- Quality sewage plants food safety Production of struvite food safety
- Data - HydroWASTE <https://www.hydrosheds.org/products/hydrowaste>





- Home | Food and Agriculture Organization of the United Nations <https://www.fao.org/aquastat/en/overview/methodology/wastewater>
- Global wastewater database <https://www.iwmi.cgiar.org/2014/06/global-wastewater-database/>

#### Waste management:

- Recycling rate food safety
- Data - FAO on global level , Your gateway to the EU, News, Highlights | European Union <https://ec.europa.eu/eurostat/web/waste/data/database>

### **(b) Management of (natural) resources**

#### Recycling:

- National record industries food safety
- Recycling rate food safety (eurostat) ,
- Rapid Alert recalls
- non-compliance food contact material legislation
- Use waste stream food safety
- organic fertilizers food safety agriculture
- Use manure agriculture food safety

#### Waste and soil management:

- Plastics soils microplastics food safety
- Proportion of land used for animal farming (FAO)
- Predictions pesticides sales food safety (OECD)
- Nutrient composition of soil (C, N, P) - BORIS - Bodeninformationssystem ([umweltbundesamt.at](http://umweltbundesamt.at))
- Eutrophication of water bodies (European Marine Observation and Data Network - EMOD)
- Microbial quality water soil safety
- Data - <https://doi.org/10.1038/s41579-023-00967-2> Analysis of microplastics ([umweltbundesamt.at](http://umweltbundesamt.at)) , FAO, OECD, BORIS, EMOD.

### **(b) Bioprocesses**

#### Transboundary pests and diseases:

- Bio-vectors Climate change food safety
- Number of confiscated food (Databases of airports and marine ports)
- Scale FOODI trade food safety



- Data - Modelling using diff. Data , Pathogen monitoring reports (Animal and Plants)

#### Bio-accumulation:

- Antimicrobial residues food safety
- Presence Bacteria Water food safety
- Accumulation contaminant bees food safety
- Accumulation contaminant worms food safety

### **POLITICAL DRIVERS**

#### **(a) Legislation, policies and governance**

##### Monitoring and communication of food safety:

- Data - Digital media monitoring EUM EMM Overview ([newsbrief.eu](https://newsbrief.eu)) / TIM tool (TIM analytics | TIM analytics | Knowledge for policy ([europa.eu](https://europa.eu))) - Social listening
- Belgian food safety authority barometer to communicate with stakeholders on food safety : <https://www.favv-afscab.be/scientificcommittee/barometer/>
- Annual national reports on food safety (e.g. in Austria)
- The European Union One Health 2022 Zoonoses Report; <https://www.efsa.europa.eu/en/efsajournal/pub/8442>
- Monitoring of veterinary drugs EU [https://food.ec.europa.eu/safety/chemical-safety/residues-veterinary-medicinal-products\\_en](https://food.ec.europa.eu/safety/chemical-safety/residues-veterinary-medicinal-products_en)
- Pesticides data programme annual report from EFSA: <https://www.efsa.europa.eu/en/efsajournal/pub/7939>
- food fraud monitoring in EU JRC reports : [https://knowledge4policy.ec.europa.eu/food-fraud-quality/monthly-food-fraud-summary-reports\\_en](https://knowledge4policy.ec.europa.eu/food-fraud-quality/monthly-food-fraud-summary-reports_en)
- EFSA zoonoses report annual <https://www.efsa.europa.eu/en/efsajournal/pub/8442>
- <https://www.verbrauchergesundheit.gv.at/Lebensmittel/lebensmittelkontrolle/LMSicherheit.html>
- Pesticide Data Program | Agricultural Marketing Service ([usda.gov](https://usda.gov))
- RASFF (for authorities)
- FDA Total Diet Study (TDS) <https://www.fda.gov/food/reference-databases-and-monitoring-programs-food/fda-total-diet-study-tds>
- Belgium FAVV - Productterugroepingen ([favv-afscab.be](https://favv-afscab.be))
- The European Union Summary Report on Antimicrobial Resistance in zoonotic and indicator bacteria from humans, animals and food in 2020/2021: <https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2023.7867>
- Zoonotic agents, German database: <https://zoonotify.bfr.berlin/>



### Good practises and standards:

- Data - Alimentarius <https://www.fao.org/fao-who-codexalimentarius/codex-texts/list-standards/en/>
- EU platform on guidance platform : [https://food.ec.europa.eu/safety/biological-safety/food-hygiene/guidance-platform\\_en](https://food.ec.europa.eu/safety/biological-safety/food-hygiene/guidance-platform_en)

### Food legislation:

- Data - <https://www.ema.europa.eu/en/veterinary-regulatory-overview/research-and-development-veterinary-medicines/maximum-residue-limits-mrl#ema-inpage-item-10712>
- EU regulation ==> EURLEX website
- EU database pesticide [https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database\\_en](https://food.ec.europa.eu/plants/pesticides/eu-pesticides-database_en)
- EU database additives regulation <https://ec.europa.eu/food/food-feed-portal/screen/food-additives/search>
- EU Monitor: Always up to date with the latest developments with the EU [Monitor/1/j9tvgajcovz8izf\\_j9vvik7m1c3gyxp/vk0qgtdhw4yx](https://www.eumonitor.nl/9353000)  
<https://www.eumonitor.nl/9353000>
- Policy shift <https://www.eumonitor.eu/>

### Food information:

- Data - EUROSTAT : annual report of EU : <https://ec.europa.eu/eurostat/web/products-key-figures/w/ks-fk-23-001>
- Communication of food safety Emergence of new reliable communication tools for consumers <https://www.fda.gov/consumers/consumer-updates/food>
- RASFF (public) , EFSA

## **(b) geopolitical instability**

### War and conflict:

- Food trade warfood safety
- import conflict zones food safety
- Shortage ingredients war food safety

### Fragmentation between nations:

- Trade embargos food safety
- Food Access fragmentation food safety



#### 4. Discussion: Databases and their characteristics, accessibility and relevance to indicators.

Firstly, we make the observation that data is a valued and often monetized resource, especially for specialized sectors. With this in context, the available online databases for indicators that are directly or indirectly related with food safety emergence can be classified with respect to the limitations made by the database owners on how they can be accessed.

For the purposes of the current work, we can classify online databases as follows: (i) only query with predefined templates, keywords and pull-down list categories; (ii) allows free format queries directly to the data; (iii) plus download of results in a csv format or similar; (iv) plus download of results in a csv format or similar; (v) combinations of (i) to (iv) with API interface access.

From what we have analysed, the majority of the online databases do not provide API interfaces, the most habitual interface is type (i).

From this classification, next, we can consider how we can access the database from the IT Platform front end (developed in WP4): (a) just provide the link to the online database, the user clicks on the link and then follows the instructions and functionality of the database; (b) plus provide to the user with a set of predefined queries (which could be in the form of a help/readme file specific for each database and for the indicators chosen in this deliverable); (c) Some kind of API programming interface between the online database.

Given the mentioned restrictions, the options which seem most feasible within the scope of the current project are (a) and (b).

#### 5. Interface requirements to integrate databases and indicator data with the Open Digital Hub and tasks developed in WP4.

In close collaboration with Task 1.2, an 'alert system' tool will be built in the open digital hub (WP4). This is a scalable tool that consists of an interactive dashboard that displays the real-time values of the indicators (based on the underlying data) so that they can follow the trends in the indicators via graphs. Users will also set up the alerts feature so that they are notified if indicators move out of the normal range of values. As stated in the Task 1.2 definition, there are specific matters to be tackled:

##### 5.1. Linking of data to the open digital hub (WP4)

The data will be linked to the open digital hub (WP4), such that the platform dashboard displays the real-time values of the indicators, based on underlying data. For this to be possible, in T1.2 the existence of a data source and viability of access will be evaluated for each indicator. Also, data format will be evaluated (e.g. sufficient time series data from previous periods, monthly, yearly to make it possible to identify trends, etc.). Accessibility will be a key challenge: what type of interface is offered to the given data source/database by the data owners.



## 5.2. Database crawling and analysis.

As stated in the task description, “machine learning techniques will be used to crawl available databases, and search for unknown data and for underlying relationships, mainly to identify changes in the stressors and information on their impact on toxicity of the hazards. This will support the prioritization of the indicators and emerging hazards, as well as to identify data gaps.”

The crawling of database is a specific IT technique which is dependent on accessibility and data privacy issues, as well as data availability. The following is a summary of crawling tools which may be used by the software development in WP4.

### 5.2.1 Database crawling.

Crawling is a process where a specifically designed software app discovers data and content which can be subsequently indexed. A database crawling usually requires specific configuration for the type of data to be searched for.

**Legal issues:** while doing web crawling for one’s purposes, then it is legal as it falls under the fair use doctrine such as market research and academic research. However, if you want to use scraped data for third parties, especially for commercial purposes, this can have legal complications. In the United States, for instance, web scraping can be considered legal as long as it does not infringe upon the Computer Fraud and Abuse Act (CFAA), the Digital Millennium Copyright Act (DMCA), or violate any terms of service agreements.

While on a webpage, the crawler stores the copy and descriptive data called meta tags, and then indexes it for the search engine to scan for keywords. This process then decides if the page will show up in search results for a query, and if so, returns a list of indexed webpages in order of importance.

Three examples of most referenced crawling software:

- Google Trends
- Common crawl: <https://commoncrawl.org/>
- AWS Glue: <https://docs.aws.amazon.com/glue/latest/dg/crawler-data-stores.html> (need access credentials, like an api connexion)
- Opensearch: [https://www.opensearchserver.com/documentation/tutorials/crawling\\_a\\_database.md](https://www.opensearchserver.com/documentation/tutorials/crawling_a_database.md)

Further crawling software:

<https://www.octoparse.com/blog/top-20-web-crawling-tools-for-extracting-web-data>

## 6. Conclusions, summary, next steps

This deliverable document has provided a summary of the drivers, subdrivers and indicators selected from the work embodied in Tasks 1.1 and 1.2. From this, a study and selection of available databases have been made, which provide information relevant to the indicators identified. This provides a working document for the implementation of the open digital hub interface to the data repositories, which will be developed in WP4.



## References

- [1] AGES. <https://www.ages.at/en/>
- [2] Risk Ranger ( [https://foodsafetyportal.eu/riskranger/rr\\_riskranger.html](https://foodsafetyportal.eu/riskranger/rr_riskranger.html) ).
- [3] European Centre for Disease Prevention and Control. <https://www.ecdc.europa.eu/en/data>
- [4] Surveillance Atlas of Infectious Diseases. <https://atlas.ecdc.europa.eu/public/index.aspx>
- [5] EFSA website. <https://www.efsa.europa.eu/en>
- [6]. International Journal of Food Microbiology, (Vol. 77, Issues 1-2, pp.39-53, 2002)
- [7]. FAO Fisheries Technical Paper (No. 442, 2004).

## Appendices

In the following example screens are shown for search criteria in different databases.

### A.1 FAOSTAT

The screenshot shows the FAOSTAT website interface. At the top, there is a blue header with the FAO logo and the text 'Food and Agriculture Organization of the United Nations'. A search bar in the top right corner contains the text 'powered by Google'. Below the header, there are navigation tabs: 'Data', 'Selected Indicators', 'Compare Data', 'Definitions and Standards', and 'FAQ'. The main content area is titled 'Search Data' and shows the search results for the query 'Consumer behaviour Dietary choice'. The results are listed as follows:

Search Result	Show Data	Download Data
Consumer Prices, General Indices (2015 = 100) (Item) Consumer Price Indices (Prices)	Show Data	Download Data
Consumer Prices, Food Indices (2015 = 100) (Item) Consumer Price Indices (Prices)	Show Data	Download Data
Recovered post-consumer wood (Item) Forestry Production and Trade (Forestry)	Show Data	Download Data

Fig. A.1.4 - FAOSTAT search, keywords “Consumer behaviour Dietary choice”

The screenshot shows the FAOSTAT website interface. At the top, there is a blue header with the FAO logo and the text 'Food and Agriculture Organization of the United Nations'. A search bar in the top right corner contains the text 'powered by Google'. Below the header, there are navigation tabs: 'Data', 'Selected Indicators', 'Compare Data', 'Definitions and Standards', and 'FAQ'. The main content area is titled 'Search Data' and shows the search results for the query 'Health and wellbeing Human health cor...'. The results are listed as follows:

Search Result	Show Data	Download Data
Cost of a healthy diet (PPP dollar per person per day) (Item) Cost and Affordability of a Healthy Diet (CoAHD) (Cost and Affordability of a Healthy Diet)	Show Data	Download Data
Percentage of the population unable to afford a healthy diet (percent) (Item) Cost and Affordability of a Healthy Diet (CoAHD) (Cost and Affordability of a Healthy Diet)	Show Data	Download Data
Number of people unable to afford a healthy diet (million) (Item) Cost and Affordability of a Healthy Diet (CoAHD) (Cost and Affordability of a Healthy Diet)	Show Data	Download Data
World Health Organization (WHO) (Donor) Development Flows to Agriculture (Investment)	Show Data	Download Data

Fig. A.1.2 - FAOSTAT search, keywords “health and wellbeing Human health cor...”

FAOSTAT العربية 中文 English Français Русский Español

Home Data Selected Indicators Compare Data Definitions and Standards FAQ

### Search Data

RESULTS

Demographic development Population

<p>Temperature change (Element)</p> <ul style="list-style-type: none"> <li>Temperature change on land (Land, Inputs and Sustainability)</li> </ul>	Show Data	Download Data
<p>Land Use change + (Total) (Item)</p> <ul style="list-style-type: none"> <li>Emissions totals (Climate Change: Agrifood systems emissions)</li> </ul>	Show Data	Download Data
<p>Land Use change (Item)</p> <ul style="list-style-type: none"> <li>Emissions shares (Climate Change: Agrifood systems emissions)</li> </ul>	Show Data	Download Data
<p>Carbon stock change in forests + (Total) (Item)</p> <ul style="list-style-type: none"> <li>Emissions from Forests (Climate Change: Agrifood systems emissions)</li> </ul>	Show Data	Download Data

Fig. A.1.3 - FAOSTAT search, keywords “Demographic development Population..”

FAOSTAT العربية 中文 English Français Русский Español

Home Data Selected Indicators Compare Data Definitions and Standards FAQ

### Search Data

RESULTS

Environmental contamination Pollution

<p>Environmental protection (General Government) (Item)</p> <ul style="list-style-type: none"> <li>Government Expenditure (Investment)</li> </ul>	Show Data	Download Data
<p>Environmental protection (Central Government) (Item)</p> <ul style="list-style-type: none"> <li>Government Expenditure (Investment)</li> </ul>	Show Data	Download Data
<p>General Environmental Protection, unspecified (Purpose)</p> <ul style="list-style-type: none"> <li>Development Flows to Agriculture (Investment)</li> </ul>	Show Data	Download Data
<p>Environmental policy and administrative management (Purpose)</p> <ul style="list-style-type: none"> <li>Development Flows to Agriculture (Investment)</li> </ul>	Show Data	Download Data

Fig. A.1.4 - FAOSTAT search, keywords “Environmental contamination Pollution”



FAOSTAT

Home Data Selected Indicators Compare Data Definitions and Standards FAQ

### Search Data

RESULTS

Q food production technology products

Per capita food production variability (constant 2014-2016 thousand int\$ per capita) (Item) ① Suite of Food Security Indicators (Food Security and Nutrition)	Show Data	Download Data
Food crop production (Purpose) ① Development Flows to Agriculture (Investment)	Show Data	Download Data
Value Added (Manufacture of food, beverages and tobacco products) (Item) ① Macro Indicators (Macro-Economic Indicators)	Show Data	Download Data
Manufacture of food, beverages and tobacco products (Industry) ① Value shares by industry and primary factors (Food Value Chain)	Show Data	Download Data
Food security and food safety + (Total) (Purpose) ① Development Flows to Agriculture (Investment)	Show Data	Download Data

Fig. A.1.5 - FAOSTAT search, keywords “food production technology products”

FAOSTAT

Home Data Selected Indicators Compare Data Definitions and Standards FAQ

### Search Data

RESULTS

Q distribution global trade

Coefficient of variation of habitual caloric consumption distribution (real number) (Item) ① Suite of Food Security Indicators (Food Security and Nutrition)	Show Data	Download Data
Incidence of caloric losses at retail distribution level (percent) (Item) ① Suite of Food Security Indicators (Food Security and Nutrition)	Show Data	Download Data
Global Alliance for Vaccines and Immunization (GAVI) (Donor) ① Development Flows to Agriculture (Investment)	Show Data	Download Data
Global Environment Facility (GEF) (Donor) ① Development Flows to Agriculture (Investment)	Show Data	Download Data
Global Fund (Donor) ① Development Flows to Agriculture (Investment)	Show Data	Download Data

Fig. A.1.6 - FAOSTAT search, keywords “distribution global trade”

## A.2 RASFF

The screenshot shows the TIM interface with the following details:

- Header:** TIM Tools for Innovation Monitoring. Navigation: Organisation, Location, Topic, News, Quantitative Analysis, Miscellaneous. Actions: Rebuild, Edit, Export, Page Info, Class Filter, Go to, More.
- Left Sidebar:** David Nettleton (Logout), David Nettleton's space, CREATE Dataset, Dietary choice, Pollution, Population change.
- Main Content:** Documents: 12. Filter: Article, EU Project. Date range: 1993 to 2020. Search: highlight text.
- Document List:**
  - Determinants of consumers' choice behaviour for fresh fish types (Year 2020)
  - Integrating nutrition science and consumer behaviour into future food policy (Year 2019)
  - Smoothies: Exploring the Attitudes, Beliefs and Behaviours of Consumers and Non-Consumers (Year 2018)
  - Muslim Consumers' Halal Product Choice Behaviour: An Eye-Tracking Investigation on Visual Choice Process (Year 2017)
  - COMPARATIVE ANALYSIS OF BEHAVIOURS RELATED TO FUNCTIONAL FOODS AMONG SELECTED YOUNG CONSUMERS IN POLAND AND GERMANY (Year 2016)
  - Towards an Integrated Approach to Food Behaviour: Meat Consumption and Substitution, From Context to Consumers (Year 2016)
  - Shaping smarter consumer behaviour and food choice (Year 2016)

Fig. A.2.1 - RASFF query, “Determinants of consumers’ choice behaviour for fresh fish types”

The screenshot shows the TIM interface with the following details:

- Header:** TIM Tools for Innovation Monitoring. Navigation: Organisation, Location, Topic, News, Quantitative Analysis, Miscellaneous. Actions: Rebuild, Edit, Export, Page Info, Class Filter, Go to, More.
- Left Sidebar:** David Nettleton (Logout), David Nettleton's space, CREATE Dataset, Dietary choice, distribution\_global\_trade, Human health condition, Pollution, Population change, war\_conflict.
- Main Content:** Documents: 12. Filter: Article, EU Project. Date range: 2007 to 2022. Search: highlight text.
- Document List:**
  - Trade and the equitability of global food nutrient distribution (Year 2018)
  - Economic and physical determinants of the global distributions of crop pests and pathogens (Year 2014)
  - Does Income and Income Distribution Determine Global Food and Beverage Products Trade (Year 2013)
  - History, Global Distribution, and Nutritional Importance of Citrus Fruits (Year 2012)
  - The Impact of domestic remittances on Households' Income Distribution in a context of Global Food Crisis (Year 2011)
  - Global Income Distribution and Poverty in the Absence of Agricultural Distortions (Year 2009)
  - Global productivity distribution and trade liberalisation: evidence from processed food industries (Year 2008)

Fig. A.2.2 - RASFF query, “Trade and the equitability of global food nutrient distribution”

Development of waste-free production technologies for the food industry

Entry type: Article ID: e7c7272955ee35a213f9341c392722a6b5b25a08 Year: 2022

Developing New Software for Functional Food Production

Entry type: Article ID: dcdffc88dd8a346c2f30dc0237946186dd2dab3b Year: 2022

Sustainable utilization of food waste for bioenergy production: A step towards circular bioeconomy.

Entry type: Article ID: ca1245cbe46935ac60ad1bd240396e2507399927 Year: 2022

Effect of plant-based enriching ingredients on the cost-effectiveness of food production

Entry type: Article ID: bf7604cd32391581e49c7eec48db700d71abe06 Year: 2022

PRODUCTION TECHNOLOGY OF FRUIT-FILLED COTTAGE CHEESE FOR BABY FOOD OVER 6 MONTHS OF AGE

Entry type: Article ID: bd8d514a5ee55f8f3ddb3eb1a23422a353536b66 Year: 2022

Interrelated of food safety, food security and sustainable food production

Entry type: Article ID: ab4b894eca5b853c4f1a74eb1af372059823ca9f Year: 2022

Sustainable microalgal biomass production in food industry wastewater for low-cost biorefinery products: a review

Fig. A.2.3 - RASFF query, “Development of waste-free production technologies for the food industry”

INTRODUCTION OF NEW DAYLIGHTING METRICS FOR HEALTH, WELLBEING, AND FEASIBILITY: A STUDY OF THE INDOOR BUILDING ENVIRONMENT

Entry type: Article ID: eff6d3cb29c014d78e18711336cfe394d0132ac Year: 2022

A call for nurses and interdisciplinary collaborators to urgently respond to the health and well-being needs of refugees across the world.

Entry type: Article ID: cc5bbc73d10a6ec6ca6287fa8c53edbeede1c0f Year: 2022

Erratum to How can electric lighting contribute to human health and well-being?

Entry type: Article ID: b1ee22011fe10569e0bed87343e60f63f256de Year: 2022

INTRODUCTION OF NEW DAYLIGHTING METRICS FOR HEALTH, WELLBEING, AND FEASIBILITY: A STUDY OF THE INDOOR BUILDING ENVIRONMENT

Entry type: Article ID: 7e0e1ddb5971fbd5e0de26f636555ab41e7b1a9d Year: 2022

Using zebrafish (Danio rerio) models to understand the critical role of social interactions in mental health and wellbeing

Entry type: Article ID: 6d058999de85cfc6dd2ec0c8154a37abed3bb790 Year: 2022

Minding environment, minding workers: environmental workers' mental health and wellbeing.

Fig. A.2.4 - RASFF query, “Human health condition”

Fig. A.2.4 - RASFF query, “management of natural resources raw materials..”

Fig. A.2.5 - RASFF query, “Pollution”



The screenshot displays the RASFF (Rapid Alert System for Food and Feed) query interface. The top navigation bar includes the TIM logo (Tools for Innovation Monitoring) and various utility icons. The main content area shows a search result for 'Population change', displaying a list of 410 documents. The visible entries include:

- Estimating the Demographic Parameters of *Tuta absoluta* (Lepidoptera: Gelechiidae) Using Temperature-Dependent Development Models and Their Validation under Flu... (Year: 2022)
- Migration in the Context of the Demographic Development of the Russian Far East (Year: 2022)
- GIS-Based Spatial Correlation Analysis: Sustainable Development and Two Generations of Demographic Changes (Year: 2022)
- The Effects of Demographic Trends on the High-Quality Development of the Chinese Sports Industry (Year: 2022)
- Challenges and contradictions in the development of the North and the Arctic: demographic dimension (Year: 2022)
- Socio-Demographic Factors influencing the Sustainable Development of Carpathian Euroregion: Case of Tourism Development (Year: 2021)
- Home-Based Learning (HBL) Teacher Readiness Scale: Instrument Development and Demographic Analysis (Year: 2021)

Fig. A.2.6 - RASFF query, "Population change"