Health & Safe Food Systems

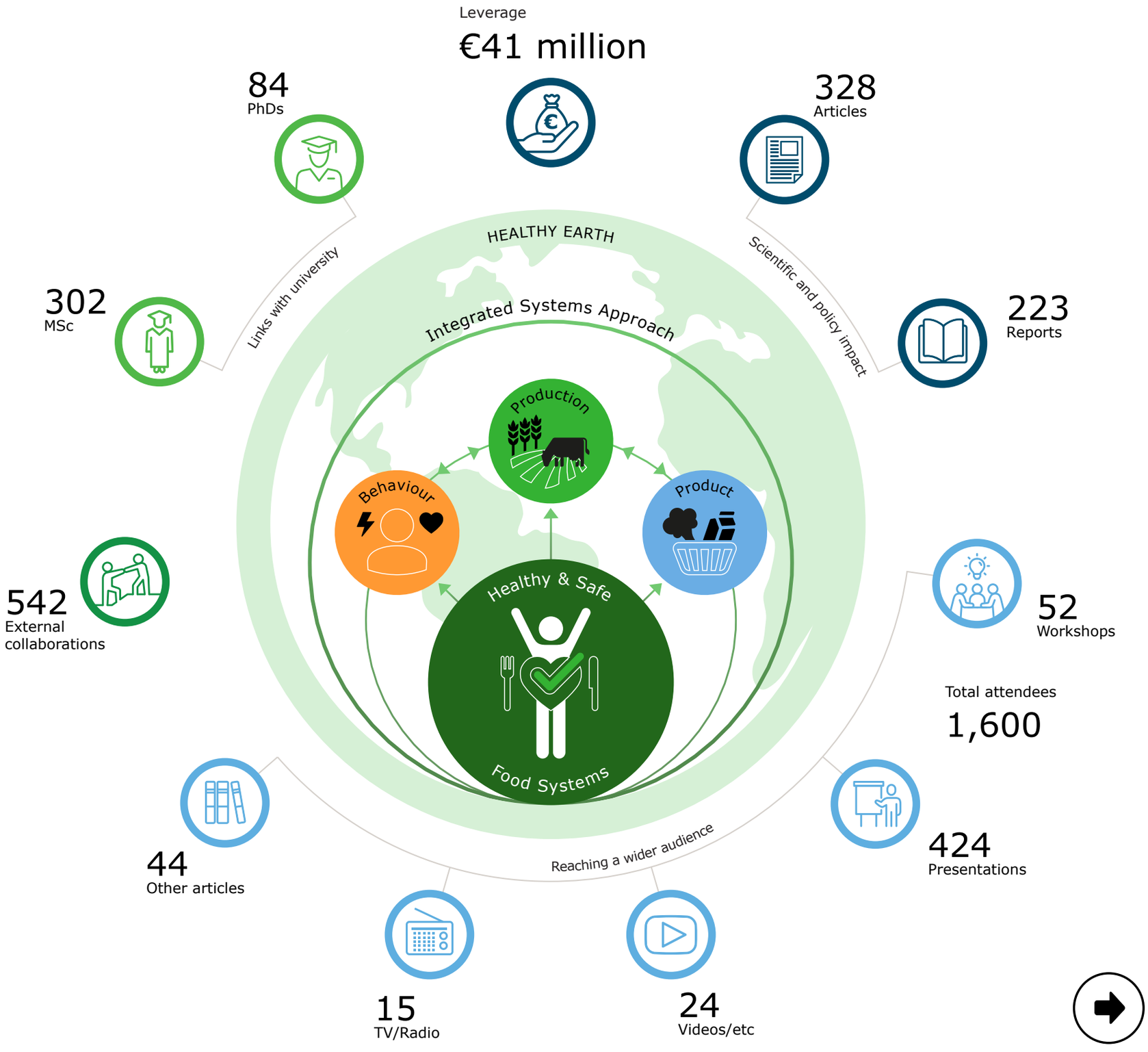
Our vision is providing the world with healthy, nutritious and safe food, helping to build healthy diets and lifestyle while respecting the boundaries of our planet.

The overall goal of this programme is to develop knowledge needed to improve the sustainability, health benefits and while maintaining the safety of our food system, from different perspectives by considering its complexity and related sustainability issues.

To explore more of the programme or projects go to wur.eu/healthy-safe-food-systems

WAGENINGEN
UNIVERSITY & RESEARCH

Programme output 2019-2022



Healthy & Safe Food Systems

In this period, the research programme ‘Healthy & Safe Food Systems’ focused on delivering the building blocks to enable a healthy and safe food system while respecting the boundaries of our planet. Over the four years of the research has performed on production technologies and methodologies that provide sustainable, healthy and safe food products, as well as new approaches for ‘healthy and safe by design’-products that better fit consumer needs and wishes. Furthermore, significant progress was achieved in detection/analysis of composition, safety aspects of food products by delivering new sensor and diagnostics technology that can be used ‘in line’. New methods were also developed to empower the consumer with her/his own personal detection technology (e.g. smartphone based) and fulfilling the societal demand of replacing animal testing by a variety of animal-free testing strategies including direct non-invasive monitoring of human health. Research projects also looked at choices at the consumer level to increase understanding how decisions are made and can be influenced to stimulate healthy and safe choices. Food system as a whole was also put under de loop to better understand how microbiological, particularly zoonotic, and chemical threats enter the food system, in order to predict and prevent their occurrence, and make the food system more resilient.

The purpose of this short report is to present an overview of the outputs created during the four year of the programme. It is based on a questionnaire that was completed by project leaders of the projects which ran during that time (not all of them for the full four years). The figures are remarkable in many ways and show what can be achieved through a focused effort delivered within the boundaries of a specific research programme.

Below the figures shown in the graphic above are briefly explained:

- Scientific and policy impact: The figures here represent published, peer-reviewed articles and reports, and also articles and reports in preparation or in press. An overview of the results and output can also be found via the Kennisonline website.
- Reaching a wider audience: A total attendance at dedicated meetings, workshops and presentations of around 1600 people is a round estimate and does not include results of the outreach via social media, posts, popular articles, media appearances. Overall these numbers are very positive in terms of our desire to bring science and research results to a wider community.
- Collaborations: The large number of collaborations is a welcome result of the need to engage with other research institutes and universities, key stakeholders, business and industry in order to take forward many of the projects. These collaborations often involve other disciplines and provide a further multi-transdisciplinary component within projects. This figure reflects the extent to which individual projects involved researchers from more than one of the University institutes. The delivery of a multidisciplinary approach is one of the aims of the programme and majority of the projects did have multiple disciplines involved and reached out to stakeholders also outside of WUR.
- Links between the research institutes and the University: Whilst the programme funding is for Wageningen Research institutes, collaboration with the University chair groups and students was facilitated. One way of achieving this is through the engagement of masters and doctoral students in the research projects, and co financing projects. Furthermore KB programme also facilitated and partially funded a dedicated PhD project. Next to collaborations within the scope of the projects, dialogue, discussions and community building on thematic areas like biodiversity, microbiome, sustainable food system were initiated and facilitated.
- Leverage: The total budget over four years was € 26 million, with around €11 million for regular knowledgebase projects. It also included 2 knowledgebase programmes voor statutory research tasks on food safety and transmissible animal diseases with a total budget of € 15 million to develop the knowledge needed to support the government in the implementation of laws and regulations for safe food and healthy animals, and to guarantee a sustainable environment. The ‘leverage’ achieved from that initial investment, measured through further, related project funding has been just over € 41 million. It should be noted that this does not include intangible benefits of carrying out project work whose innovation and knowledge generation is relevant for capacity building, connecting to influential partners in the development of further innovation, sharing of knowledge and in relation to the discussion of policy and practice and longer term leverage which can be expected.

The ‘KB37’ Knowledge Base — Kennisbasis — funding programme ‘Healthy & Safe Food Systems’ is provided to the Wageningen Research Institutes by the Dutch Ministry of Agriculture, Nature and Food Quality to carry out independent research into pressing and topical issues with high societal impact.

Reverse engineering to meet the demand of the industry and consumers

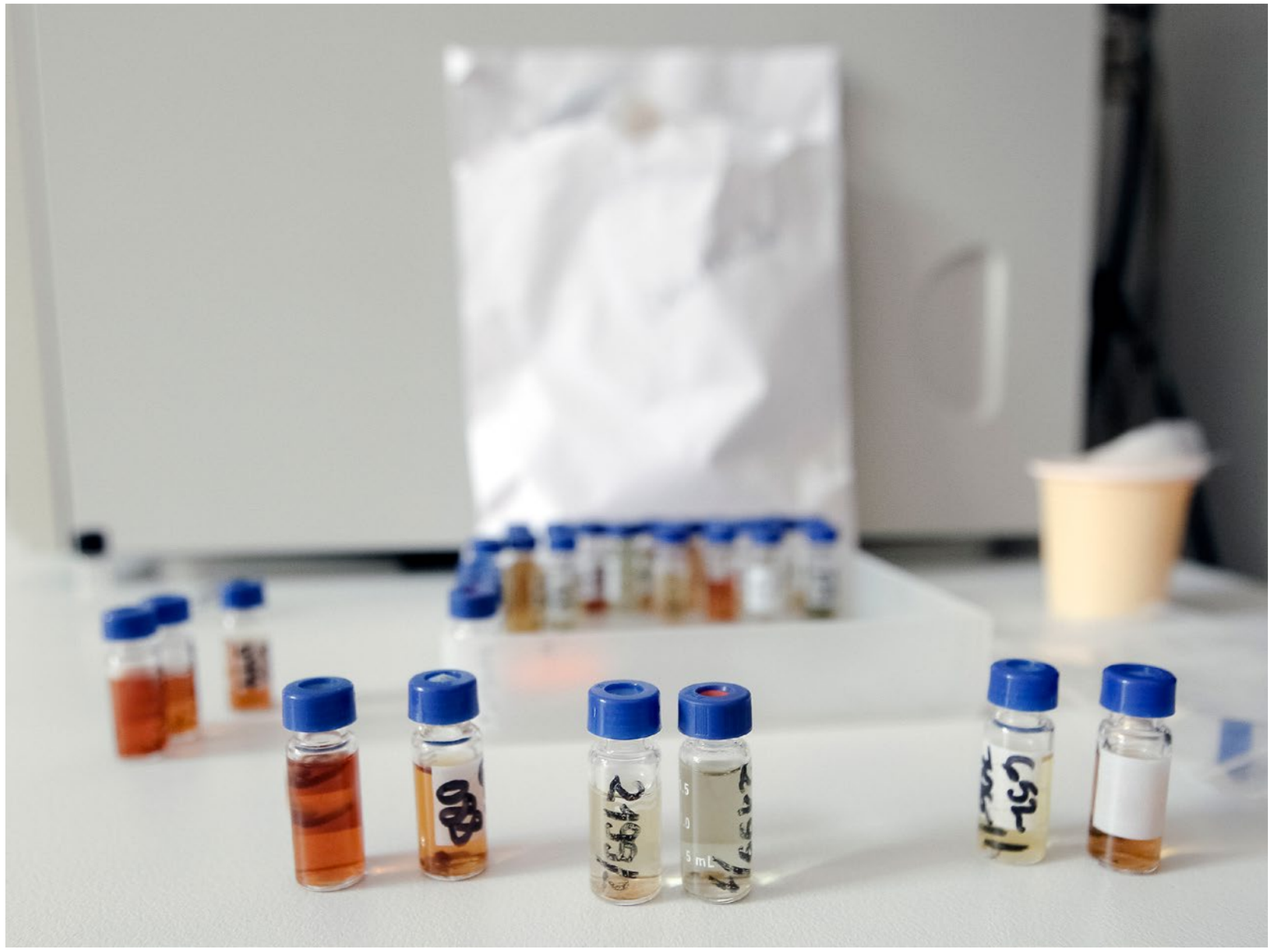
In the concept of reverse design reasoning, so back from the desired food product, it is important to redesign the production process, optimising the quality of required raw materials, processing steps, looking at the whole production chain. In reverse design one should look from the application: what should be the product for, for which consumer, what are the minimal requirements (for consumer and possibly from industry), what are the logical processing steps and what are the (combination) of necessary resources to be included. Where needed, resources can be genetically improved, or production systems adapted to fulfil the requirements of the final product together.

Furthermore, besides the evident health and safety advantages, reverse, targeted, and minimalist design is anticipated to yield cost savings, decrease water consumption and energy input, which will facilitate the transition towards sustainable protein sources, and mitigate product losses. When utilising sources in their natural state with minimal processing, reverse design aligns with principles such as 'safe by design' or 'ethical by design.' Throughout the programmes duration, a comprehensive reverse design methodology was developed, encompassing a wide array of factors. To validate the approach, a collaborative case study was undertaken, utilising real data from a reference case (plant burger) to explore consumer acceptance, environmental impact, and safety considerations, confirming the potential of the reverse engineering approach.

Health and safety of food products and early detection of food safety risks

In order to assess the healthiness and safety of food products, comprehensive data is essential. This includes information on product composition, microbial safety, as well as the positive and negative health effects of both ingredients and contaminants. It's also crucial to consider interactions within the product, which collectively influence the overall health impact within a dietary pattern. During the programme efforts have focussed on creating a toolbox and infrastructure across WUR (Wageningen University & Research) to facilitate the generation of relevant data. Substantial progress has been made developing new methodologies along with substantial data which are essential elements to evaluate health and safety aspects in a manner that is efficient, non-destructive and non-disruptive.

In order to ensure safety, early detection is essential as well. Also several methods were developed within KB-WOT Food Safety for the early detection of food safety risks. An example is the retrospective analysis workflow. With this workflow already obtained data can be assessed for the presence of additional and even unknown compounds. The developed workflow including data processing is already applied for the screening of antibiotics, growth promotors and NSAIDs in several WOT Food Safety projects. A second example is the development of a multiplex (spot) microarray lateral flow device for veterinary drugs. Spots are beneficial for the detection of multiple compounds with a single device. In 2023, this device was further developed within the WOT Food Safety to be able to detect other compounds like fipronil, plant toxins and heavy metals.



Making the shift to plant-based proteins in our diet

Both industry and scientific communities are focused on expanding the range of proteins utilised in food products. Achieving this goal requires not only understanding the various protein sources available but also employing technology to make proteins accessible. Furthermore, when shifting towards alternative proteins in our diets, the safety and health implications need to be considered.
Although much is known on alternative proteins health and safety implications still require a better understanding and therefore research.

To assess the healthiness and safety of food products accurately, comprehensive data is indispensable. This includes information on product composition, microbial safety, and the positive and negative health effects of ingredients and contaminants. Additionally, it's vital to consider interactions within the product, which ultimately determine the overall health impact within a dietary pattern.

Throughout the programmes duration, specific emphasis has been given to investigating the impact of storage conditions, processing and identifying the primary proteins and potentially antinutritional components. Moreover, there has been an extension of current knowledge regarding protein modifications during processing, isolation, and their subsequent effects on properties in later applications providing clues for safety and health implications.

Also relevant immunological, DNA and LC-MS methods were developed within the KB-WOT Food Safety to be able to measure different allergens. Moreover, in the programme DNA (including LAMP assay) and LC-MS were developed for the analyses of a range of antinutritional components and contaminants.

Proteins


Cereals


Legumes


Seeds & Nuts


Potatoes


Mushrooms


Green leaves


Insects


Seaweed


Cultured meat

Understanding consumer behavior to facilitate sustainable and healthy choices

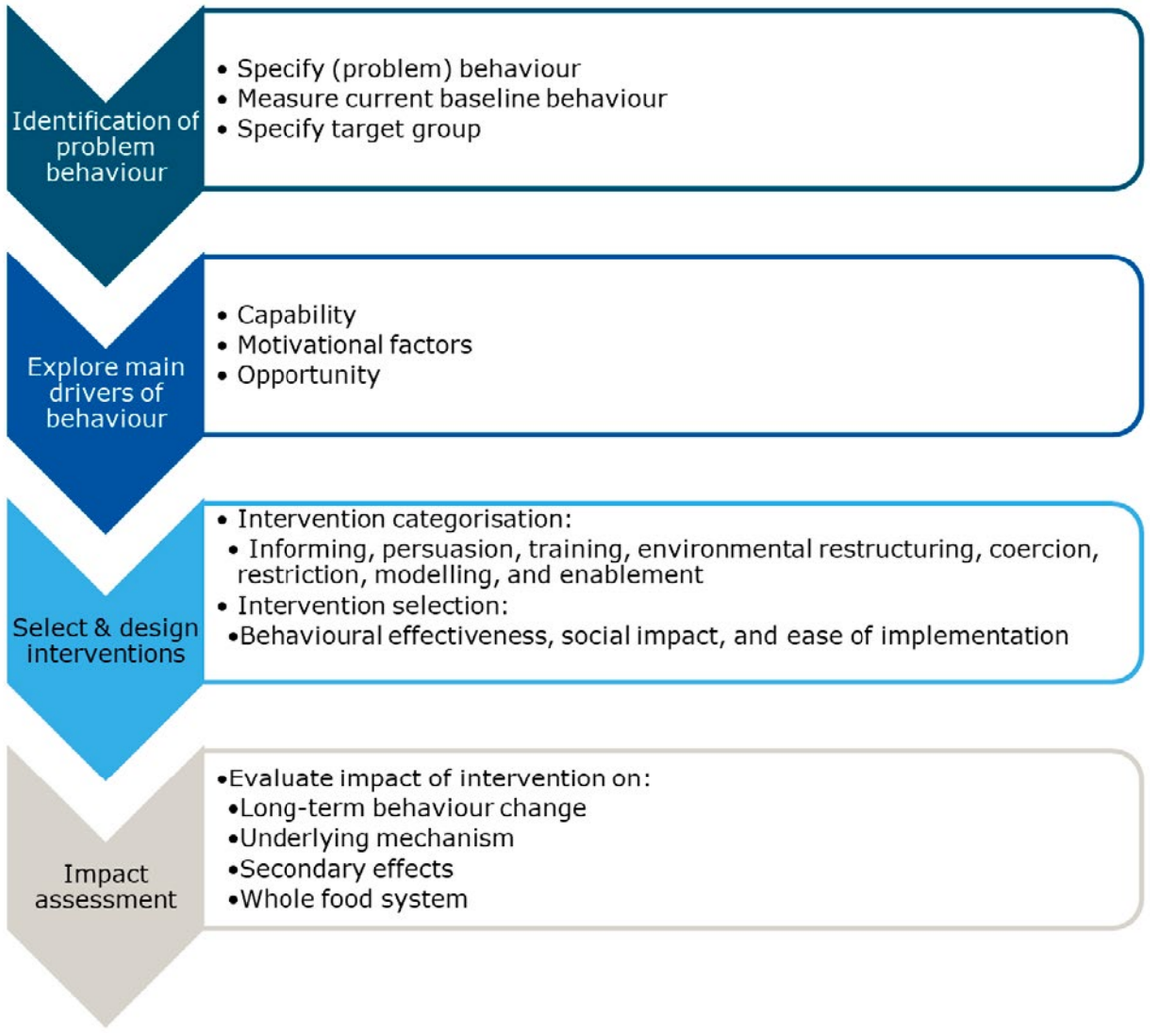
The global community is grappling with numerous health and sustainability challenges, and altering consumer behavior is a key aspect of the solution. However, entrenched consumption patterns present significant hurdles. Fortunately, recent advancements in technology, including Virtual Reality, mobile apps, internet platforms, and artificial intelligence (AI), offer unprecedented opportunities to understand consumer behavior and facilitate behavior change.

Through our exploration within the scope of our programme, we have identified numerous ways in which these new technologies can be harnessed to promote healthy and sustainable behaviors. One notable development is a reusable web service focused on taste preferences, tailored to meal moments and food categories, which offers healthier and more sustainable alternatives. This service has been integrated into a feedback tool, demonstrating the potential to provide consumers with healthier and more sustainable options.

Additionally, an online shopping platform was created that modifies the context by incorporating social norms and true pricing, allowing for real-time product delivery to the consumer's doorstep. Furthermore, Virtual Reality technology has been employed to investigate its efficacy in promoting healthy and sustainable behavior change by immersing users in scenarios that activate a consumer versus civilian role.

Despite the challenges posed by factors such as immersiveness, reliability, and technological complexities, efforts have revealed the promising potential of new technologies in enhancing our understanding of consumer behavior and supporting healthier and more sustainable consumer choices.

Stepwise approach to interventions for behavioural change



Sustainable, healthy and safe production systems

Given the intricate nature of the challenges ahead, we recognise that solutions will not be straightforward. Addressing these issues demands a collective systems approach to facilitate the transition towards a more sustainable and healthy food production system, considering the various stages and interdependencies involved.

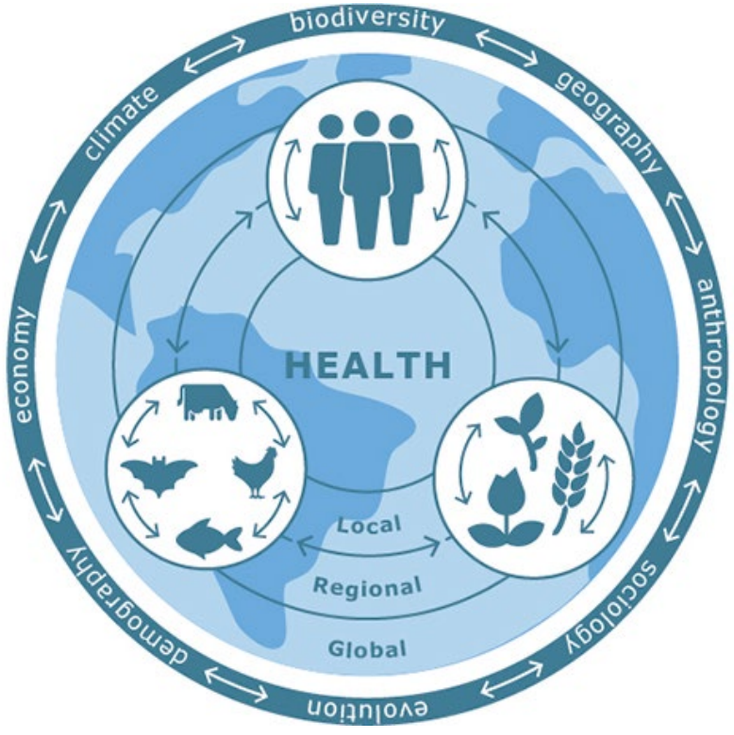
Additionally, several key aspects require attention:

1 Development of innovative models and strategies to assess the vulnerabilities and resilience of breeds, pre-products, processes, and production phases within food and feed product chains. This includes the implementation of early signaling tools for health or disease status and immunity.
2 Implementation of robust surveillance and monitoring strategies to address new and re-emerging health threats within food and feed production chains.

These models and strategies are essential for predicting threats such as infectious diseases, pests, chemical contaminants, residues, and the development of antimicrobial resistance across the entire food production chain, enabling timely intervention. Moreover, innovative and effective prevention, intervention, and control tools and strategies within food production systems and the environment are imperative. An example is the work on alternatives for animal models in which we can study vector competence of potential emerging pathogens. Within the KB-WOT contagious diseases, 3D blood vessels have been developed for studying infection and pathogenesis of tick-borne viruses.

Within the scope of our programme an initial framework was developed to allow the focus on resilience of animals and plants in different system levels and to identify and predict food safety and health threats. Through analysing, characterising and categorising data on plant, animal, supply chain and environment as well as behaviour of the different actors. Protocols have been established to determine the full genome sequence of pathogens and microbiome profiles in relevant matrices.

One health concept for evaluating emergency preparedness



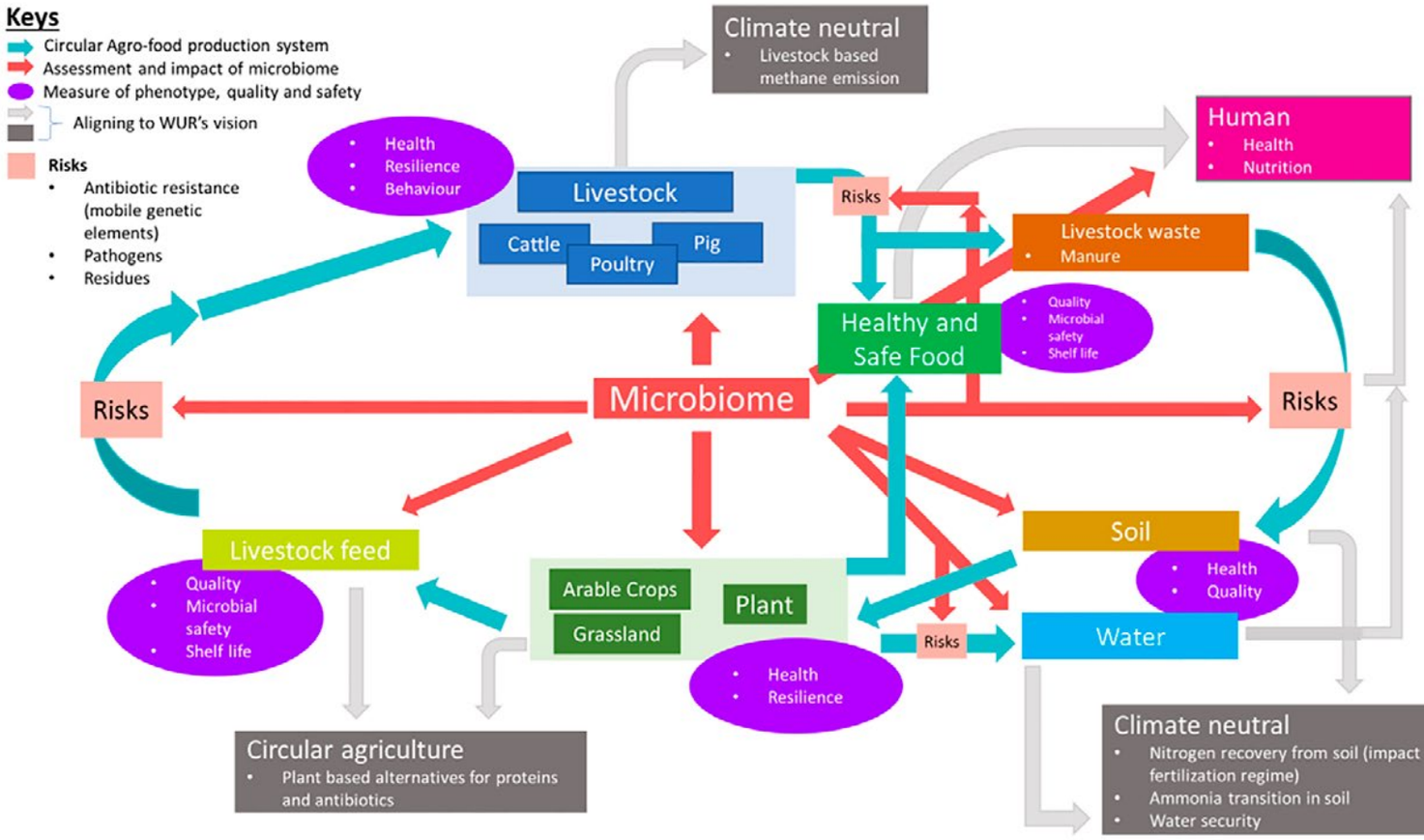
Microbiome connected in the food system

Microbiome is the intricate network of microbial communities that exist within and interact across various components of the food production, processing, distribution, and consumption chain. This concept underscores the interdependence and symbiotic relationships between microorganisms and their environments, including plants, animals, soil, water, and humans, within the food system. Within the KB-WOT contagious diseases an in vitro intestinal model of the intestinal microbiota of broilers is already established. This model is primarily intended to study transfer of plasmids containing antibiotic resistance genes between bacteria. With this model it is possible to test interventions against this plasmid transfer, and test interventions that can reduce colonisation of the intestinal microbiota by resistant bacteria.

We foresee that understanding microbiome and connectedness will enable understanding of the whole system. Next to understanding of the microbiome, focus was to work on a joint pipeline for performing functional metagenomics, to uncover of the so-called 'black matter' in aforementioned datasets. A pipeline was created that focused on the identification of genes and function prediction through a series of computational tools. Collaboration with the UNLOCK consortium has been instrumental in this progress, relying on their recently made efforts on FAIRifying metagenomic data analyses and storage.

Through text-mining approaches OMICs generated data could be linked to external databases, tapping into public sources of functions described for specific genes,

Circular agro-food system and the microbioom



metabolites. The developed models for entity recognition and linking were used to identify co-occurrence of bacteria and metabolite entities in scientific papers, along with the sentence for provenance, aiding the biological researcher in uncovering de novo functionality for microbe or metabolite of interest. Further novel statistical approaches for meta-omics integration of data were identified, enabling identification of connected elements of biological pathways at different levels.

New emerging hazards

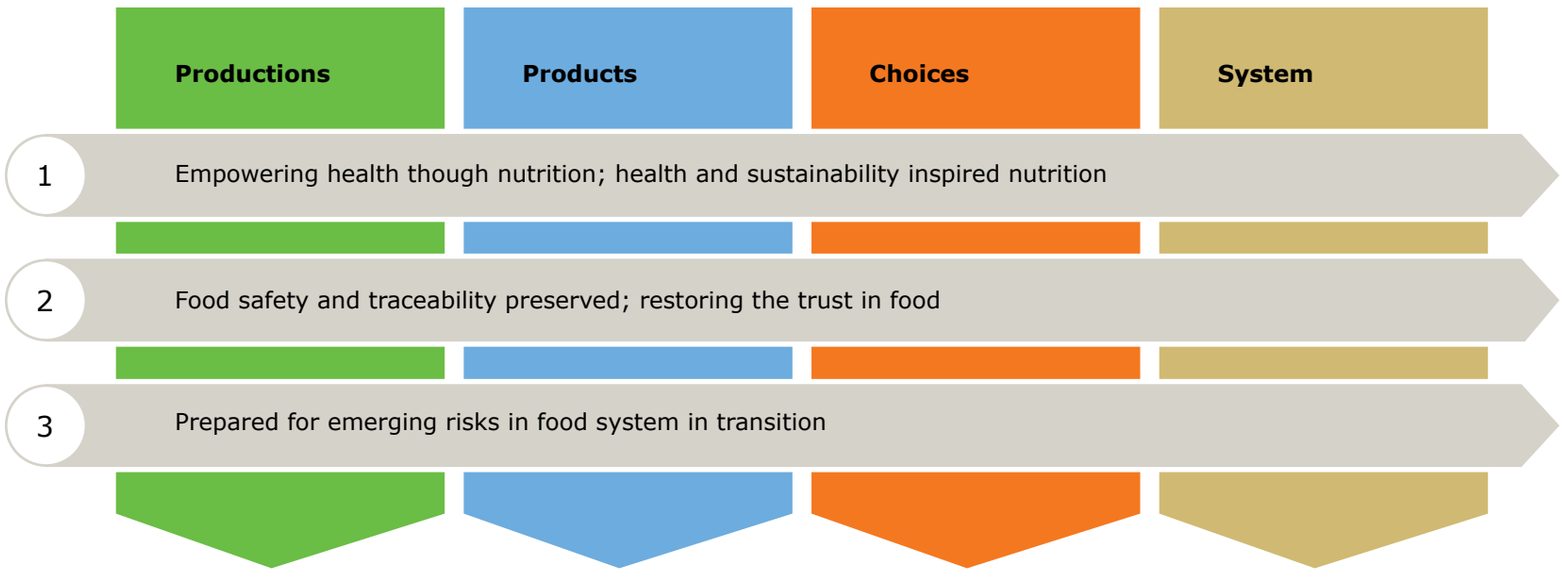
As the food system transformation progress, it is of utmost importance to be able to detect new emerging hazards, because of potential toxicity or allergic reactions. Here, a fit for purpose is of extreme importance. In the course of the KB-WOT Food Safety programme, for this purpose different methods were developed to detect hazards like chlorinated paraffins, mineral oils and PFAS. The improved detection methods for chlorinated paraffins and mineral oils were used in the WOT Food Safety projects. Within the KB-programme biochemical methods and immunoassays for PFAS were developed in order to better predict the risks of PFAS and mixtures of PFAS. Moreover, to prioritise (new) emerging compounds a tool was developed within the KB-WOT Food Safety. Properties as biodegradation or bioconcentration factors were used to prioritise the compounds. Not all properties are known for all compounds and for that reason in silico tools were developed to obtain the required data.

Future Outlook

The Healthy and Safe Food Systems programme has been delivering important building blocks for enabling of sustainable, healthy, and safe food products. In 2023 and 2024, the programme will continue developing knowledge to make food products more sustainable and healthier, to better understand the health and sustainability impacts as well as safety hazards. We recognise that our food systems are changing due to, for example, climate change and biodiversity decline and that we are in the process of transforming them for improved sustainability. We therefore aim to approach health and safety impacts with consideration of these factors and their implications. We are confident that developing knowledge, strategies, and tools to identify, analyze and eliminate the risks that may emerge because of these factors and implications, will help improve preparedness. The programme approaches the food system from multiple angles considering products, production consumption/ choices/behavior and system and is organised in 3 multidisciplinary thematic areas, which are presented in the figure below, with sustainability and resilience of the food system as a basis for all these themes.

By using these three themes as starting points for developing overarching solutions, we intend to impact the whole system in terms of increasing the safety and healthiness while taking the transitions into account and transforming food systems to ensure that we remain within the planetary boundaries. Moreover, performing research on these defined themes using a multidisciplinary approach, we envision innovative approaches and well-defined outputs and impact.

With its track record in multi-disciplinary research in the food domain and its large network of collaborators, Wageningen University & Research is uniquely suited to take on the challenge of safeguarding and improving the health and safety of the agri-food system in transition, thus contributing to the sustainable development goals, the availability of high-quality food and the overall health of our population.



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