European Commission

The added value of a Food Systems Approach in Research and Innovation

Policy Brief
by Standing Committee on Agricultural Research (SCAR) Strategic Working Group on Food Systems

Independent Expert Report

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Research and Innovation

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SCAR SWG Food systems Policy Brief:

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POLICY BRIEF

The Strategic Working Group (SWG) of the Standing Committee of Agricultural Research (SCAR) on Food Systems zoomed in on one of the cross-cutting topics identified in its mandate: exploring the added value of a food systems approach towards Research and Innovation.

The SWG cooperated to develop this policy brief in three meetings 2018-2019. This brief builds on the findings of the specially commissioned review report 'Synthesis of existing food systems studies and research projects in Europe (Achterbosch et al., 2019)' which was funded by the European Union under grant agreement no.727486 (CASA); as well as on the views and exchanges between SWG SCAR-Food systems, additional literature and a number of experts with relevant competences in Member States.

Summary of main messages

- There is a growing evidence and consensus that a food systems-based approach to Research and Innovation in the combined fields of agriculture, fisheries, food, environment (including climate change mitigation and adaptation), human nutrition and health is crucial for effectively addressing the large and systemic challenges the European food systems are facing.

- A food systems approach attempts to understand the natural, technical, economic and social aspects of several interlinked activity areas from primary agriculture including crop and livestock production and their inputs, yields and emissions to logistics, processing, transforming and packaging of food to marketing, consuming and disposing of waste and the linkages between these elements.

- A food systems approach should improve the understanding of the interdependencies between key parts of food systems at various scales (complexity) and the desired and un-desired outcomes in terms of food, health, environmental and climate impact etc. It would help to identify systemic lock-ins, feedback loops and trade-offs and could pinpoint synergies in terms of changes in one part, which may reinforce positive changes in other parts or outcomes. It will help to create a shared understanding amid complexity, as a basis for coherent action.

- A food system approach towards Research and Innovation integrates the bio-physical focus with an actor-based approach, which enables scientists and other actors to address both the 'what' questions as well as the question 'how' changes and larger scale transformation can be realized.

- A food system approach can be applied at various scales, ranging from local to European to global scale. It can also be applied at either more integrated as well as more thematic issues. A food system approach would require that - part of - the research should be interdisciplinary or transdisciplinary as well as promote multi-actor collaboration.

Recommendations

Use a food systems lens to create a shared understanding on what the systemic issues and R&I intervention points are; to prioritise and to focus on integrative as well as thematic research and innovation actions in the large research domain of food, nutrition and health, agriculture and farming, fisheries and natural resource use and the environment and their interaction.

This research should address the large and systemic challenges that the European food systems are facing. These challenges include the unsatisfactory health, nutrition and environmental outcomes, as well as socio-economic outcomes of the current food

systems. It is essential addressing these challenges in an integrated way, for which a food system approach is a prerequisite.

A part of the research budget should be dedicated to **fundamental and applied food system research** actions with the objective of improving the understanding of how food systems function, focusing on the role of actors and their interactions, to be able to identify leverage points for intervention.

The major part of the research budget (both from EU as well as from Member states) would still fund specific and focussed research actions into specific, systemic challenges / issues but within a strategic view on R&I policies and programming that uses a food systems lens.

Execute focussed research actions into specific challenges using classical disciplines, often in cross-disciplinary teams, with the aim of advancing specific aspects of the intervention logic that was defined from an overall strategic food systems viewpoint. This food systems lens should also secure that research results and innovations in a sub-system are clustered, monitored and evaluated from the overall food systems viewpoint.

All of these recommendations are applicable to research at EU as well as at MS level.

More practical:

Develop a protocol on how to practically programme, implement and evaluate research actions using a food system lens, to facilitate R&I policy makers, funders and researchers. This protocol would integrate existing methods and show how to define systems boundaries, taking into account relevant interdependencies and feedbacks as part of the rationale for the right scale to intervene, and defining the system as part of typical or representative food systems in Europe. The protocol would inspire applicants as well as proposal reviewers.

Initiate research to **develop methodology for identification of lock-ins and barriers** for change in food systems and to look for leverage points for improving a specific outcome without compromising other desirable outcomes and thus based on an understanding of important interdependencies and feedback loops across the system. This would include a review of methods and practices for defining food systems actors and boundaries for specific purposes.

Build a community of practice and other forms of knowledge sharing to speed up learning in food systems research including methods to involve all relevant stakeholders in a wider 'multi-actor' approach in defining demand-driven R&I processes. These stakeholders include practitioners from research, R&I policy makers, food and agricultural policy makers, research funders and food systems actors (including farmers and fishermen, processors, retail) and NGOs.

Establish a task force with the responsibility for providing regular syntheses on the results achieved in projects funded by the EC to address systemic challenges/issues and achieve objectives / outcomes in light of the overall FS research agenda and as a basis for **"portfolio management in a food systems perspective".** Thus, the purpose would be to update and revise knowledge needs from a food systems viewpoint as input to formulation and prioritisation of R/I calls in following work programmes, securing that the most important aspects necessary for understanding lock-ins, synergies and leverage points in European food systems are addressed at the proper level. The FS task force would consist of independent experts from civil society, industry and knowledge institutions with demonstrated abilities to think and act across different disciplines and FS activity areas.

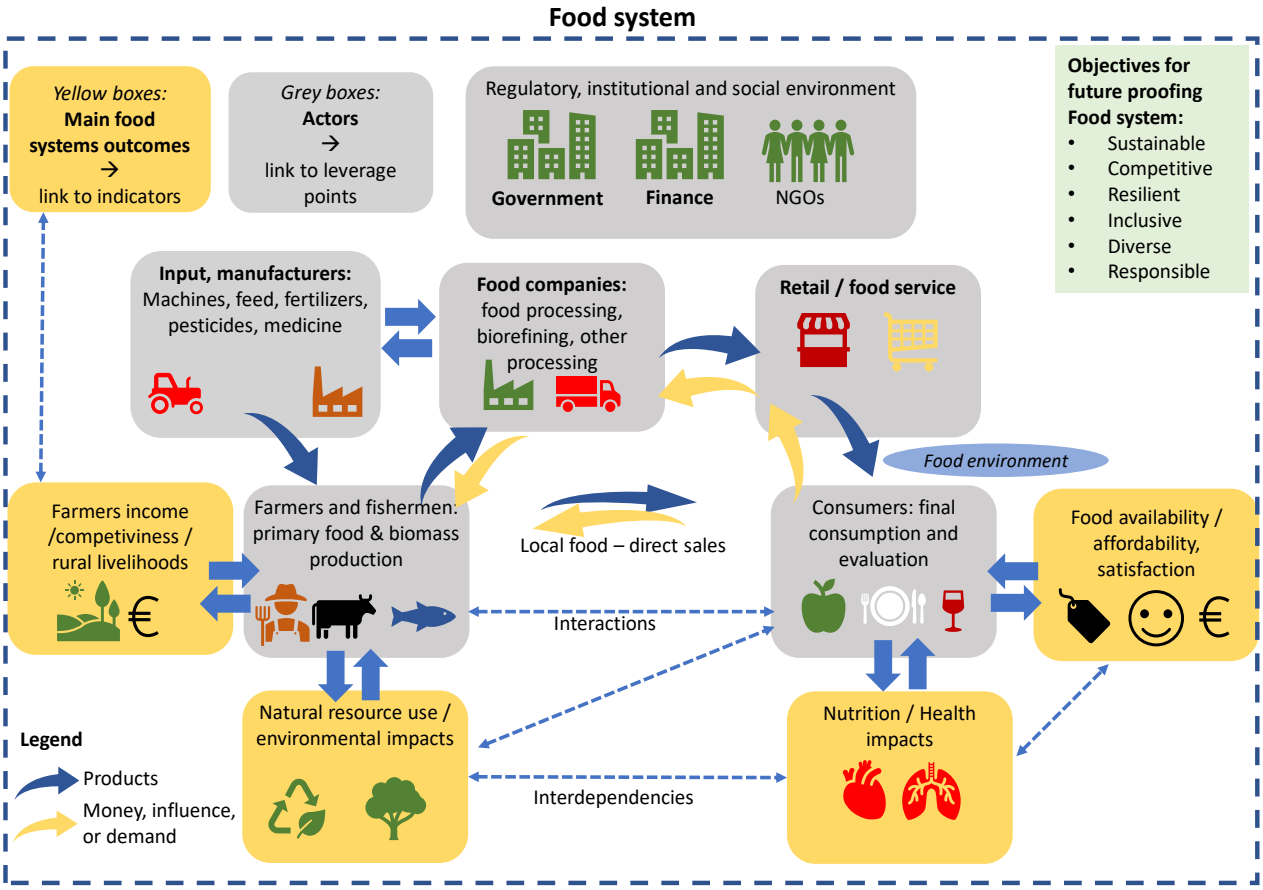

Figure 1. A schematic representation of the food system, with actors, outcomes and relations.

In a food systems approach, the interactions and interdependencies between actors (and their activities) play an important role. For example, what farmers produce under different conditions is determined largely by 'upstream' actors, such as retailers. In the figure, several interdependencies are depicted to illustrate the principle. There are in fact many more, the selection of which depends on the focus of a specific study. Consumers are highly influenced by the food environment (including access to certain foods, prices, availability). Food systems have certain outcomes such as farmer's income, food, public health and environmental impact.

A food systems-based approach towards Research and Innovation puts actors, their activities and interactions between them in a central position. It is important to understand the interdependencies in terms of how actions towards one actor's objectives may create a feedback reaction from other parts of the food system, which again influences future actions and outcomes (desired and/or undesired). This should help identifying effective levers for change, i.e. where to target interventions in a system to maximize positive outcomes and minimize negative feedback and outcomes.

1 Rationale

1.1 Crucial challenges ahead

The European food system[1] - from farmers and fishermen to consumers - is currently delivering ample and safe food to Europeans, who benefit from a historically unique and stable supply of high quality and healthy food year-round. The food system at large is providing jobs for millions of people and income for thousands of smaller companies and cooperatives. In many cases, farmers have responded to societal aspirations, for example by reducing environmental impacts or by improving animal welfare. Yet, the food system still faces many challenges: the need to have significantly better public health outcomes from diets (lower rates of diet-related diseases and obesity), a strong reduction of greenhouse gas emissions and other environmental impacts, while safe-guarding ecosystems services including soil quality and pollination and secure diversity, competitiveness, inclusiveness of citizens and overall resilience (EC, 2018, EC, 2019). The important and interlinked challenges in food and agriculture related to increasing future demands for food including animal protein and malnutrition/obesity, the need to reverse the negative impact from current agricultural practices on the environment, natural capital and climate while adapting to climate change has been coined the perfect storm (Nelson, 2010). Balancing increasing food supply with maintaining natural capital will be a challenge in itself (Springmann et al., 2018; IPES Food, 2019) and will require significant changes in diets in the wealthier countries (Willet et al., 2019).

1.2 Need to treat challenges in an integrated way: the food systems approach

Therefore, treating these challenges separately using a thematic, mono-disciplinary approach in Research & Innovation will probably be impossible, since this will not be able to handle interdependencies between key parts of the food system and has risks of overlooking trade-offs and synergies (EEA & PBL, 2017, EC FOOD 2030 Independent Expert Group 2018, IPES-Food 2019, Willett et al., 2019). A number of reports have assessed the food systems from the perspectives of global food security (Global Panel on Agriculture and Food Systems for Nutrition, 2016; HLPE, 2017), environmental impact (EEA and PBL, 2017; TEEB, 2018; UNEP, 2016), biodiversity (IPBES, 2019) health (IPES-Food, 2017) and integrations of these (IPES-Food, 2019; Willett et al., 2019). They have clearly demonstrated that change is needed in ways, which address several interlinked challenges at the same time. Within agriculture, approaches such as Climate Smart Agriculture (CSA), Agroecology and Sustainable intensification (SI) gain growing support as discourses for increasing productivity while reducing impacts of environment and climate and providing adaptation to climate change (Halberg et al., 2015). As these concepts mainly focus on the production side, they seldom take into account the whole food system.

Too often, the problem identification, and thus the perception of necessary and relevant solutions, is too narrow and focuses on specific technological innovations, which may not address important interdependencies in a food system including lock-ins and levers of change.

1.3 Food system approach is getting broad support

Therefore, the food system approach is gaining traction in both the scientific as well as in the business and policy community, as an approach that links many societal issues, such as health and nutrition on one hand and environmental sustainability, biodiversity and climate on the other hand. The food industry considers that low consumer trust and transparency is due to a fragmented supply chain, and has recognized the need for

[1] Food systems are the compounded and connected activities of primary agriculture and fisheries and the related use of input, the processing, transformation, distribution and consumption of food, and the impact of these activities on environment, social conditions and outcomes and public health (Zurek et al., 2015).

engaging consumers more in food innovation and healthy, climate friendly consumption under the headline of developing a citizen-centric food system (EITFood, 2017; Halberg, 2017). The EC (DG research and DG Agri) is framing research and innovation needs in the food and agri sector under the FOOD2030 framework (EC, 2017) and within the 'strategic approach to EU agricultural research and innovation' (EC, 2016). Both strategies use a systems approach and acknowledge the need to complement agricultural systems approaches with food systems when necessary for understanding the roles of actors across different sub-sectors and consequences of partial research and innovation for the overall system. Thus, 'Meeting the challenges facing the agricultural and food and non-food systems means dealing with complexity, and working in an integrated manner so that the proposed solutions are fit for both the problem they address and the main objectives being pursued for the system as a whole' (EC, 2016). The FAO Committee on Food Security also uses a food systems approach and urges: 'Countries need to analyse their food systems to identify areas for policy interventions to promote healthy diets' (CFS, 2016). This, again, calls for research into food systems and developing practices of using a food systems approach for designing and prioritising research and innovation.

1.4 Definition of food systems

In this respect, the 'food system' term is used to acknowledge the complex nature of the classical value chain and includes the natural, technical, economic and social aspects of primary agriculture - from inputs over crop and livestock production to yields and emissions, logistics, processing, transforming, packing to marketing, consuming and disposing of food and the linkages between these elements. Using 'food systems' also point to the fact that food provisioning is not simply a linear process with passive consumers and individual farmers in each end, but a highly complex system with feedback loops[2] linking both biophysical and social elements (UNEP, 2016; National Research Council, 2015; IPES-Food, 2019).

However, while food systems is becoming a buzzword, it is still not evident how such a wide and integrated approach may be used to convene all actors to work together towards a common goal, nor how the food systems concept may frame research and innovation and – possibly – guide the formulation and implementation of a research strategy and – eventually - specific calls? The need to integrate diverse actors directly into research and innovation actions is reflected in parts of the Horizon 2020 calls, but so far mostly within a classical thematic/sub systems approach. There is a need for reflections regarding how to further improve/strengthen the system approach, including how to strengthen the 'multi-actor approach' with representation across food systems actors in order to research and account for complexities and feedback loops (Vaarst et al., 2018). This should clarify how to best improve the use of a food systems approach at program and project level in future research and innovation programs.

Therefore, a task force under the SCAR SWG Food Systems has been asked to reflect upon the added value of a food systems research, and to provide practical guidelines for using a food systems approach towards Research and Innovation. To facilitate its work, the taskforce commissioned a state-of the-art synthesis of relevant existing studies and research projects using a food systems approach.

[2] "A central hallmark of complex systems is the presence of feedback between actors or factors in the system. Feedback describes a dynamic process in which change in one part of a system affects another component, which, in turn, affects the original component again (often with a time lag). Within a complex system, feedback may cross different levels of scale (e.g., within an organism and in the environment surrounding it), sectors (e.g., economic, health, and social), or spatial boundaries". "Feedback can be positive (reinforcing) or negative (balancing)". (National Research Council, 2015).

Approach and main results of the review report: *'Synthesis of existing food systems studies and research projects in Europe'*

The overall question of the report (Achterbosch et al, 2019) was **how** to research, innovate, formulate, implement and evaluate research and innovation policies and support change with a food systems approach. Is this doable at all - and what examples of FS approach exist to learn from?

A systematic review of literature and projects using a FS approach was carried out (for details on search and selection/omission process see main report). A large number of relevant papers and projects were found, of which 52 were chosen for in-depth studies and cross-analysis.

Conclusion: value added from a food systems approach

Looking across the thematic areas there are wide differences in the roles of research and innovation applied to food systems, from analysing and understanding food systems to experimenting and implementing interventions and scaling up. Examples of analysing existing food systems are given below, demonstrating the important interdependencies between food production, consumption/diets and impacts on health and environment/climate, respectively. Some studies also combine the health and environmental/climate impacts of different diets and their linkages with different agriculture and land-use and from this recommend to promote certain diets as leverage points (see box 2). As regards the intervention approaches, 11 studies either experiment with or assess the impact of changing a food system or both. One example is a study, which assesses if organic farming reduces vulnerabilities and enhance the resilience of the European food system (Brzezina et al., 2016). The paper explores holistic approaches to drive system change in food systems taking an ecosystem approach. It takes a true price, net positive, ecosystem approach to formulate an integrated transition agenda at three levels: production landscapes, value chains, consumer end markets. Box 4 gives two recent examples of research and innovation activities aiming at creating synergies between agriculture, diets and impacts on health and environment using a food systems approach. In conclusion, the literature review demonstrated the usefulness of a food systems approach in Research and Innovation.

2 Application of food systems approach towards thematic issues

A common misinterpretation of a food systems based approach to Research and Innovation is that all research should address the whole food system. This is certainly not true: a food system approach can also be applied at more thematic issues. In the section below, we will provide some concrete examples, partly based on the report, partly on other sources.

2.1 Food health nexus

The food and health nexus covers the manifold interlinkages between public health and food systems, which appear at levels of the human physiology, consumer diets at individual and population level, and production systems, in particular those involving livestock and agricultural chemicals. Food safety risk and malnutrition in all its forms are prominent elements of the food and health nexus, yet these studies typically address only partial interactions between food and health. With widespread continuation of malnutrition outcomes in all countries rich and poor (Development Initiatives, 2017), and with the acceleration in the prevalence of overweight and obesity burdens (Abarca-Gómez et al., 2017), there is increasing attention on consumer choice and nutrition outcomes in relation to a wider set of determinants that can be summarized in the 'food (choice) environment'. Together, the papers reviewed under this theme demonstrates the importance and potential of using a food systems approach to research, understand and improve relations between agricultural production, consumer diets and the health impacts of food. And they demonstrate that there is a need to understand Food and health as part of a wider, complex food system.

2.2 Diet and environmental impact

Over the last years, a large number of research projects and papers have looked into the impact of changing diet structures on GHG emissions (Vieux et al., 2012). A few more recent studies focus on the protein challenge: the diet shift to non-meat proteins (Westhoek et al 2014; Forum of the Future, 2018) (Godfray et al., 2018). Also, in the Commission Reflection paper Towards a sustainable Europe by 2030 it is acknowledged that animal-based foods have a particularly high land use footprint, and the growing demand for seafood puts significant pressure on marine ecosystems (EC, 2019). Most of the cases in this theme apply a systems dynamics angle, looking at the cause and effect relations between parts of the food system. Key concepts under this theme are sustainable diets, trade-offs and the protein transition.

2.3 Food system governance and transitions

The food system governance and transition theme focuses on approaches to understand and influence their governance. Most of the researched cases refer explicitly to food systems while making deeper linkages to biophysical and socio-economic processes that are shaped by or help to shape food system outcomes. Other cases focus on transforming local or regional food systems. Most of the cases in this theme take a systems dynamics angle, looking at ways to change how parts of the food system interact (i.e. finding leverage points while accounting for feedback loops, Figure. 1).

The report describes two alternative views when looking at transforming the food system. The first view is the transition approach proposed by (Nevens et al., 2012). This approach distinguishes six types of action creating a logically 'consistent' process of change. These are: analysing the system; envisioning the future, exploring pathways, experimenting, assessing and translating. Experiments develop in 'niches' under a certain degree of protection from ruling 'regimes'. Experiments are considered possible game-changers if they are successful in connecting the vision to practical action potential, and the monitoring and evaluation of the experiments should support this perspective.

An alternative theoretical concept is the idea of 'small wins' (Termeer and Dewulf, 2018). These small wins constitute a framework of addressing 'wicked problems'. Wicked problems, as developed in public administration theory, are societal challenges that

cannot be fully understood in their complexity, and for which no clear-cut solution can be developed. The elimination of hunger and food insecurity and shifts towards sustainable diets clearly fit this category of challenges. The best guide for action proposed under this theory is to muddle through: take well-underpinned action, evaluate, and improve in the most feasible direction towards the desired outcome. The 'small wins' is therefore essentially an evaluation framework that prevents paralysis in the face of complex challenges.

Key concepts used are feedback mechanisms, nexus thinking, policy coherence and cross-sectoral collaboration, ecosystem services and planetary boundaries, which together demonstrate the potential benefits and opportunities from using a food system approach.

2.4 Findings across thematic areas of the review

While the review found a number of papers and projects using a more or less explicit food systems approach, the review also demonstrated that this is not a mature methodology. There are a number of interesting examples of applications of a food systems approach, but most often there is no clear and explicit analysis of which interdependencies, feed-back loops and leverage points are the most important to address in a given complex food system for a specific assessment or change-related initiative. Some examples of current research activities supported by EC Horizon 2020 are mentioned in box 1, and box 2 gives an example of a locally implemented project demonstrating a food systems approach.

Box 1. Aligned metrics for public and private decision-making on sustainable food systems and healthier diets - SUSFANS & World Business Council for Sustainable Development

EU project SUSFANS developed an innovative framework for the assessment of the impact of public policy on the sustainability performance of EU food systems (Zurek et al. 2018). The SUSFANS framework enables an in-depth assessment of the European food system on 4 sustainability goals: balanced and sufficient diets, viable agri-food economy, reduced environmental impact, equity & social justice. Underlying this new framework are major efforts to harmonise national food intake data for multiple EU countries, mapping these at detailed food group level to sustainability coefficients. Dietary patterns are linked to a modelling framework that accounts for the flow of value and nutrients in the global agri-fish-food-nutrition system. The SUSFANS model can be used to explore pathways towards a sustainable future.

The FReSH (Food Reform for Sustainability and Health) program of the World Business Council for Sustainable Development (WBSCD) supports the diversification of sustainable protein sources in the global diet. The program brings together a group of industry leaders. One of the building blocks for their fruitful collaboration is to align industry partners on a sustainability framework comprising environmental, nutrition, economic and social indicators that can create insight into sustainability solutions with high potential impact. In a process of co-creation, the SUSFANS framework is applied to align precompetitive business strategies under FReSH. In the translation phase, key parameters for private investment decisions, which are specific to each industry, are mapped to the SUSFANS metrics system.

The framework is used to test the potential impact of combined action of industry leaders on diets, the economy, the environment and social justice. Example questions that can be addressed with the framework include: What is the combined effect of product innovation, behaviour change communication and true-cost pricing to promote a whole-diet shift in the protein balance in the EU, towards a more plant-based diet? What potential regional economic opportunities are present for EU's major meat producing regions in taking higher animal welfare as an entry point for a shift towards reduced meat consumption and more plant-based diets?

Box 2: Synergies improving health and reduce environmental footprints through dietary changes

A combination of several themes also leads to interesting approaches. Combining the health (theme 3) and environmental aspects (theme 2) of different diets. The classical example is the comparison of the current meat intensive European diets with alternative diets such as the Mediterranean and a vegetarian diet from health and environmental perspectives (Tilman & Clark, 2014). Thus, combining scientific literature from different disciplines indicates that the diets with reduced meat and fat intake and higher levels of vegetables and legumes reduce incidences of non-communicable diseases (cardio-vascular, diabetes 2 etc.) AND at the same time reduce land use for supplying the food as well as climate impact from the food production. Several similar studies suggest that, while the overall potential is there, the fulfilment of such synergies is not that simple and would require more in-depth analyses and choices as well as mechanisms for re-design of the agriculture in a food systems perspective (Ritchie et al., 2018). The analysis of potential synergies as well as trade-offs among societal objectives through dietary choices demonstrates the potential benefit of a food systems framework and has inspired policy makers to integrate such aspects in dietary recommendations (e.g. reformulate the health-related classical food pyramids to include climate aspects (Gonzalez Fischer and Garnett, 2016). There is a similarity here to the FAO definition of "sustainable diets", which combines objectives for food and nutrition security with protection of environment and ecosystems (FAO, 2010). These concepts with their multiple objectives for improving food system outcomes point to the thematic questions of Food system governance and transitions.

Box 3: Achieving co-benefits in the energy-food-health nexus at city level – From Food Waste to Healthy Off-Season Food, the case of Riga, awardee of the Milan Urban Food Policy Pact

The review revealed a number of project activities at the scale of city region food systems. One included an experiment 'From Food Waste to Healthy Off-Season Food, the case of Riga', as an example of multiple levels of synergy and connection between waste, nutrition, energy and food systems awareness. As noted, this ecological management practice has created a chain of co-benefits including food waste turned into green energy and highly nutritious food with significant positive environmental impacts. As a result of this practice, the atmosphere is protected from 2000 m3 of environmentally harmful gases per hour and Riga's citizens are provided with healthy off-season vegetables…. Riga was one of the awardees of a larger annual process that highlights city case studies among signatories of the Milan Food Pact (2017) , and a recently published compendium of practices captures efforts across the transition roles for research and innovation assessing, anchoring and scaling (references in the review report).

Box 4. Examples of food systems thinking in action:
The Green Protein Alliance and the New Nordic Diet approach

I. The Green Protein Alliance (GPA) is an alliance between 25 members, including retailers (the two largest retailers of the Netherlands), the catering industry, food producers and 10 knowledge partners in the Netherlands, supported by the Dutch Government (Green Protein Alliance, 2017). Their common goal is to restore a healthy and sustainable balance in protein consumption. The current ratio of plant-based: animal-based protein in the Dutch diet is 37:63. GPA's ambition is to realize a 50:50 balance no later than 2025. Members of the GPA are involved in producing more and better meat analogues, plant-based alternatives for dairy as well as in the production of pulses and nuts. The GPA not only applies a full-food chain approach, by stimulating sustainable production and healthy products, their members (including the retailers and catering industry) are actually helping their customers making this shift. Regarding the consumption shift, the GPA envisages this as a social innovation that requires a strong communication strategy, to accompany the improved product portfolio of plant-based protein products that is delivered by its membership from the food industry. Social media channels are used extensively to involve vloggers, chefs and other influencers and role models in changing the attitudes.

II. An example of a project with more direct intervention and experimentation of changes in food systems is the New Nordic Diet approach, which was initiated by a consortium of chefs, horticulturalists, diet specialists and researchers from food science, health and social science. The concepts of so-called 'Mediterranean' and 'New Nordic' diets have been developed and promoted as specific interventions to develop and scale-up healthy and environmentally friendly diets based on a predominantly plant-based cuisine comprised of locally grown fruits and veggies in season (more berries, cabbage, root vegetables but less tomato and cucumber), whole grains, rapeseed oil, fish and shellfish, high quality meat but less of it, and more organic produce (Al-khalidi, 2014; Renzella et al., 2018). The project exemplifies a food systems approach where motivating consumers and chefs to change diets would be a leverage point for changing both health outcomes, agricultural production and environmental impact similarly to ambitions for "sustainable diets" (box 3). It should be noted, however, that evidence of a wide up-take in the Scandinavian countries of elements from the New Nordic Diet is still lacking as is also in-depth analysis of how this would be linked with changes across the food system (e.g. positive or negative feed-back loops between consumption, production and outcomes of health and environmental impact).

3 Wider implications: suggestions on the way forward

Overall, it is clear that solving the challenges of the "perfect Storm" in food and agriculture (section 1) requires a comprehensive and multi-faceted approach to research and change management building on a food systems understanding. This review demonstrates that a food systems approach is indeed a constructive framework from research to innovation to policy guided change management. However, it also demonstrates that it will require further developments of methodologies for Food Systems research and innovation as well as a conscious use of such a framework for designing and monitoring research programmes and missions.

3.1 What do we see as wider implications? Is the food systems approach a useful approach for R&I?

The review study has demonstrated that understanding and acting with a food systems view is a useful and - in fact - necessary approach in the light of the multi-faceted challenges linking governments, input industry, farmers, fishermen, food companies, retailers and consumers/citizens. A food system approach is helpful in identifying relationships and interdependencies between the systems elements and can help to grasp the complexities between these elements. This includes specifically how interventions in one element of a food system may have unforeseen effects on food production, consumption and environmental outcomes because of processes of reinforcing or counteracting via feed-back loops (TEEB, 2018). It is also possible to reverse the reasoning: The traditional sectoral and thematic approach to R&I has failed to prevent failures in the overall food system. More specifically, little R&I has addressed issues such as obesity, animal welfare, environmental degradation and famers' incomes in a way which engage the necessary actors representing different elements of the food system in focus and sufficiently account for complexities between them.

3.2 Which are the strengths and weaknesses of a food systems approach towards R&I?

The main strength of an FS approach is its potential to understand and consider the complexity in terms of interdependencies between different elements of the food system and to link biophysical, economic and social aspects. Moreover, an FS approach might contribute to highlighting the synergies and trade-offs between different components of the food system, as well as to better grasp the potential unintended consequences caused by interventions designed from a reductionist research approach.

Like all systems approaches, one should recognise that the system in focus is an artefact with borders decided and elements described for a specific purpose and understanding – it does not exist as such. Thus, any food systems representation is a simplification of the 'real world' and depends on purpose and the perspectives taken by scientists and stakeholders. This requires a rigorous and transparent process, but the methodology for this seems not well established within food systems work. This challenge includes the methodology for defining the boundaries of a specific food system in focus and for using such a 'model' as a guiding concept for targeting and focusing on specific problems and interventions in a consistent way.

3.3 What are the (proven?) benefits of using the FS approach in R&I?

The above examples from the review study of more or less explicit use of the FS approach demonstrate the power of the concept for observing and understanding complexities, the consideration of which is necessary for devising measures for change across interlinked food production, marketing, consumption, recycling. Moreover, food systems thinking may improve the understanding of economic, social and environmental/climatic drivers and consequences and devise a holistic understanding of how to account for trade-offs. The real advantages of the FS approach as a driver and guide for actual change through consumers, other economic actors and policy initiatives still need to be documented scientifically, but examples exist as given in the review and boxes.

3.4 Developing the potential of making food systems thinking a key approach in future R&I programming

The review and analysis demonstrate the necessity and usefulness of a food systems approach at programme and project level, which is summarized here. There are, however, still important gaps in knowledge and application in FS methodology and understanding and regarding how to make use of the FS approach in R&I, at various levels.

4 Recommendations:

4.1 Further development of methodology for studying and improved understanding of food systems:

- There is a need to better understand different European food-systems and to develop typology, which may serve as a reference point for defining more specific challenges, opportunities and knowledge needs for typical FS (in parallel to the last 25 years of defining and researching typical European farming systems).

- Development of a pragmatic and widely accepted methodology for an effective and feasible analysis of food systems including how to define the borders of specific FS and how to identify the important leverage points as tools for change agents and policy makers. This would include the evaluation of existing methodologies, including the question why currently the use of these methodologies is not widespread.

- Determination of the right scale to intervene and how to formulate R&I calls and proposals, which explicitly account for important interactions and feed backs in the overall system, and which have significant potential impact on overall outcome or negative impact in other sub-systems.

- How to operationalize, in methodology and practice, the distinction and interdependencies between different scales, from local to national to European to global food systems.

- While traditional research has focused on the production side (agriculture and fisheries) and the consumption side (diets, and their effects on human health) much less in known about the stages between the two, the role of the various actors – e.g. processing, marketing and retail - and their dynamics in relation to e.g. forming food consumption on the one side and production/processing on the other - e.g. the so-called 'food environment'.

- The food systems knowledge gaps also include 1) the potential of new forms of consumer engagement by industry in food innovation, 2) the changing roles of actors due to individualisation and digitalisation of retail and consumer relations, and 3) interlinked consequences of innovative gentle processing techniques on consumers' health and wellbeing, primary production, packaging, food waste and environmental impacts across the system.

- How to speed up learning and create a community of practise including methods to involve all relevant stakeholders across a food system in a wider 'multi-actor' approach, building on participatory approaches and providing an experimental space for practitioners from research, the food systems actors (including farmers and fishermen), NGOs and policymakers.

- Spend 5-10% of future R&I budget on fundamental and applied FS research with the aim of understanding different types of current food systems in terms of socio-economic functioning (including various FS actors and lock-ins), bio-physical functioning (including desired as well as undesired outcomes), complexities in terms of

interdependencies and feed-back loops, cultural aspects, the political economy of FS including points of intervention/levers of change.

- Speed up learning: build a community of practice in food systems research by e.g. commissioning a multi-actor group to produce good practice guidelines for FS R&I , e.g. using principles of work as under EIP focus groups or similar. Mandate the SCAR SWG Food Systems to convene symposia where invited scientists and FS practitioners/change agents may exchange experiences and most pertinent challenges and formulate good practice guidelines for FS R&I.

- Give overview of initiatives in EC and MS working on developing improved FS from specific perspectives (local, city-region, climate smart etc.) and the degree to which this is backed from science and innovation efforts (e.g. building on experiences from initiatives such as Fit4Food2030 city labs).

- Define a set of viewpoints and related indicators for 'future proofing' FS by R&I that consider the six transformational goals of FOOD 2030 (sustainability, resilience, diversity, responsibility, inclusiveness and competitiveness) along with other objectives such as efficiency and climate neutrality. This should build on existing initiatives (e.g. SUSFANS, box 1, TEEB), and be flexible to allow for context dependencies.

4.2 Using Food Systems thinking as overall framework for research & innovation programming, proposal and project level

- A food system approach may be used to look for the most pertinent knowledge needs, challenges and development potentials to the focus of R&I into food, agriculture, fisheries, aquaculture, the environment and health while, at the same time, accounting for their interdependencies. A specific focus should be on identifying leverage points for improving a specific outcome without compromising other desirable outcomes, and thus based on an understanding of important interdependencies and feedback loops across the system. In other words, thematic research and innovation that may empower actors to improve their situation while reducing the trade-offs and increasing synergies within the systems towards commonly agreed goals.

- The variation in thematic focus of the reviewed papers suggests that a food systems research agenda should have a wide and cross-disciplinary set-up with tools to support and facilitate that research and innovation in food and agriculture integrates non-technical aspects such as food systems governance, transition pathways including finding levers of change and ways to overcome lock-ins.

- Specifically, support should be given to initiatives developing methodology for identification of lock-ins and barriers for change in food systems; e.g. to which extent dietary improvements from a health perspective may be the leverage for changing agricultural systems and land use to reduce climate impact and maintain natural capital. This requires also improvement of analytical tools to assess a priori the potential trade-offs and synergies from innovations and how take-up and improvement may be supported or hampered by feedback loops.

- Taking a starting point in a food systems understanding will help focus and prioritise thematic research and innovation actions, which may not eventually cover an entire system. Not all research and innovation activities need (or can) necessarily cover a full system; there is need for more thematically focused projects using a more disciplinary and experimental methods.

- Therefore, in a future research programming thematically focused activities need to have a clear justification within an overall food systems thinking (figure 1). This goes for the description of thematic calls, their expected impacts as well as for formulation of proposals and their expected outcomes. Thus, the proposals and the projects should be required to outline not only their specific outcomes / impacts, but also how the activities may impact a whole range of various food system activities from production

to consumption, and a whole range of outcomes: FNS, environmental welfare and social welfare, etc.

- Development of a food systems research and innovation programming should take care to identify and formulate specific challenges and potential solutions for very different types of food systems. This could build on and enlarge the existing approach from H2020 of identifying specific knowledge needs and opportunities for different farming systems such as 'Mediterranean', 'organic agriculture' and 'agroecology' as a basis for prioritising these systems either in separate calls or as explicit parts of broader thematic calls.

- Thus, an FS approach should acknowledge the potential and challenges of the different FS such as large-scale supermarket driven food systems as well as food system innovations in terms of local food, agroecological food systems, urban farming and integration of food and non-food systems in the wider bioeconomy.

- The FS programming should also take into account multiple objectives and policy aspects of food systems such as public procurement combining nutrition and health with specific production requirements and/or local food for environmental protection. Moreover, tools and methods for including health aspects in food systems research and innovation will become even more important in order to tackle non-communicable diseases and anti-microbial resistance and provide citizens with diets suitable for a variety of life-situations including elderly with special needs in line with existing research strategies formulated by e.g. JPI HDHL.

- Taking a starting point in requirements for improved diets (from health, environment and climate perspectives) is an option to formulate important research and innovation needs for development of new innovative farming systems linked with new processing and biorefineries, which may deliver the necessary produce for diversified food provisioning.

- In light of the above, there is a need to develop and support FS R&I with a consumer/citizen centred focus engaging actor representatives not usually included in agriculture and food science.

- The requirements for a circular bioeconomy, where fossil-based products may be replaced by biomaterial have implications for land use and agricultural systems why such aspects should be integrated in a food systems approach to ensure that alternative use of biomass will not compromise food equity.

- Programming from a food systems perspective needs regular monitoring and stocktaking of funded projects/activities over time and their expected and achieved results vis-à-vis the knowledge needs identified. Such "portfolio management in a food systems perspective" would be a research management innovation in itself and could build on experiences from Horizon2020's combined efforts of Advisory Groups and Commission staff.

- Thus, it would be recommendable to establish a Food System Advisory Group with the responsibility for providing regular updates on the results achieved in projects funded across thematic areas/calls in light of the FS research agenda as input to prioritisation of calls in following work programmes. The FS AG would consist of independent experts from civil society, industry and knowledge institutions with demonstrated ability to think and act across different disciplines and FS activity areas.

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There is a growing evidence and consensus that a food systems-based approach to Research and Innovation is crucial for effectively addressing the large and systemic challenges the European food systems are facing. Such a food systems approach attempts to understand the natural, technical, economic and social aspects of several interlinked activity areas from primary agriculture to logistics, processing, transforming and packaging of food to marketing, and consuming and the linkages between these elements. A food system approach towards Research and Innovation integrates the bio-physical focus with an actor-based approach, which enables scientists and other actors to address both the 'what' questions as well as the question 'how' changes and larger scale transformation can be realized. This policy brief contains concrete recommendation on how to put such an approach into the day-to-day practice of designing and implementing R&I programs and projects. This is relevant both at the level of EU, as well as that of Member States.

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