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Common Agricultural and wider bioeconomy reSearch Agenda

# SYNTHESIS OF EXISTING FOOD SYSTEMS STUDIES AND RESEARCH PROJECTS IN EUROPE

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The overall objective of CASA, a Coordination and Support Action (CSA), is a **consolidated common agricultural and wider bioeconomy research agenda** within the European Research Area.

CASA will achieve this by bringing the Standing Committee on Agricultural Research (SCAR), which has already contributed significantly to this objective in the past, to the next level of performance as a research policy think tank. CASA will efficiently strengthen the strengths and compensate for the insufficiencies of SCAR and thus help it evolve further into 'SCAR plus'.

# LESSONS FROM FOOD SYSTEMS RESEARCH IN EUROPE: IMPLICATIONS FOR THE R&I AGENDA

## Summary of main messages

- There is a growing consensus that a systems-based approach towards Research and Innovation in the combined domains of agriculture, fisheries, food, environment/climate, human nutrition and health is crucial to effectively address the large and systemic challenges the European food systems are facing.

- Such an approach could improve understanding the interdependencies between key parts of food systems at various scales (complexity). It would help avoiding the risks of overlooking lock-ins, feed-back loops and trade-offs and could identify synergies. A food system approach towards Research and Innovation may integrate the bio-physical focus with an actor-based approach, which enables to address 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 scale. A food system approach would also imply that at least part of the research should be interdisciplinary or transdisciplinary.

## The recommendations are that

- A Food systems approach is necessary and useful for Research and Innovation at programme and project level. There are, however, still important knowledge gaps in FS methodology and understanding and regarding *how to make use of the FS approach in R&I*.

**Further development of methodology for studying and improved understanding of Food Systems**

- to understand better different European food-systems and to device a typology, which may serve as a reference point for defining more specific challenges, opportunities and knowledge needs for typical FS

- Develop 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 to distinguish local and national levels and how to identify important leverage points as tool for change agents and policy makers

- 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 and other forms of knowledge sharing in food systems research

**Using Food Systems approach as overall guideline for research & Innovation programming**

- 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

- Support should be given to initiatives developing 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

- The stimulation of research into food systems themselves, covering all aspects of food systems (amongst other combining the bio-physical, socio-economic and actor-network aspects of food systems) using a multi-faceted and transdisciplinary approach

- 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 -e.g. the so-called 'food environment'-

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

- Not all R&I activities can or should apply a full food system approach. Therefore, it is important to break down major societal issues (such as reducing obesity or reducing agricultures climate footprint) to manageable programmes and projects, while

keeping the food system in mind. More disciplinary issues (for example plant protection and animal welfare research) should be made more 'food system-conscious'.

- Thus, there is a potential for using the food systems approach as a lens for focusing thematic research into specific challenges using classical disciplines but with the aim of solving problems defined from an overall strategic viewpoint. This lens should also secure that research results and innovations in a sub-system is evaluated from the overall food systems viewpoint

- Therefore, the study proposes to develop a protocol for how to practically design such thematic research using a food system lens;

**Using FS approach for portfolio management:**

- 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

- However, in a future research programming such focused activities need to have a clear justification within an overall food systems thinking. This goes for the description of thematic calls as well as for formulation of proposals and their expected outcomes. Thus, there is need for another layer of portfolio management vis-à-vis a long-term programming within (and between) pillars of Horizon Europe

- 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

- Programming from a Food systems perspective needs close monitoring and overview of funded projects/activities over time and their expected and achieved results vis-à-vis the knowledge needs identified

- A frequent stocktaking for revising state-of-art and knowledge needs will be necessary as input to e.g. bi-annual programming of calls, building on experiences from H2020

- Establish a task force with the responsibility for providing regular updates on the results achieved in projects funded across thematic areas/calls in light of the overall FS research agenda in order to update and revise knowledge needs as input to prioritisation of calls in following work programmes

# 1. RATIONALE

The current European food system[1] - from farmers and fishermen to consumers - faces many challenges: the need to have significantly better public health outcomes (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. Treating these challenges separately using a thematic, mono-disciplinary approach in Research & Innovation will probably be impossible, since it will not be able to handle interdependencies between key parts of the food system and has risks of overlooking trade-offs and synergies. 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), health (IPES-Food, 2017) and integrations of these (Willett et al., 2019). They have clearly demonstrated that change is needed in ways, which address several interlinked challenges at the same time.

Too often, however, the problem identification and thus, the perception of necessary and relevant solutions is too narrow and focus on specific technological innovations, which may not address important interdependencies in a food system including lock-ins and levers of change. The food system approach is therefore, 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 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) respectively within the 'strategic approach to EU agricultural research and innovation' (EC, 2016). Both strategies use a systems approach and acknowledges 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'. 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

[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).

systems and developing practices of using a food systems approach for designing and prioritising research and innovation.

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 circularity and feedback loops[2] of both physical and social nature and with important interdependencies with the biosphere and the eco-systems services which food production ultimately depends upon (UNEP, 2016; National Research Council, 2015).

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). There is, thus, a need for a knowledge synthesis, which reviews existing research and innovation relevant to a food systems approach and gives input to defining knowledge needs and specific potential of a FS approach. This should enlighten how to 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 commissioned a state-of the-art synthesis of relevant existing studies and research projects using a food systems approach to study Europe's food system (as a whole) or geographical parts (countries, regions, cities) and certain aspects (for example nutrition, or environmental issues) as input to formulation of knowledge needs and improvements of implementation modes such as instruments/ approaches (e.g., a wider multi-actor approach) for EC research and innovation programs.

[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).

Against this background, for SCAR, a 'food systems' approach could be relevant in two ways:
a) A research object, in order to better understand production and consumption patterns, the mutual interdependencies and links to human health, the climate and environment, economics and on rural areas ('food system outcomes);
b) An approach to better understand the potential impact of agricultural and FS Research and innovation, as well as to identify research and innovation needs in a FS perspective including focus on emerging alternative FS

# 2. APPROACH AND MAIN RESULTS OF THE STUDY

Central question and methodology

The overall question is **how** to research, innovate, formulate 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?

The objective is to provide a state-or-art synthesis of existing studies and research projects using a Food Systems approach to study Europe's food system (as a whole) or geographical parts (countries, regions, cities) and certain aspects (for example nutrition, or environmental issues) and comparable countries as input to formulation of knowledge needs for EC research and innovation programs. It should be noted that the concept of food systems can be applied at various geographical scales. These exemplary initiatives will therefore be taken from multiple levels, from global to local level.

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.

**Main results and Conclusions from the study**

Table 1 presents the main themes covered by the papers and the scale of their focus.

***Table 1. Studies and projects selected studies for the literature review***

| Food systems research theme | Number of cases | Geography per scale |
|---|---|---|
| 1. Agricultural innovation | 6 | **Global**<br>**EU/Region** (EU, Europe)<br>**National** (United Kingdom, Italy) |
| 2. Agroecology & food systems | 5 | **Global**<br>**EU/Region** (EU, Europe)<br>**National** (Sweden, UK, NL, Italy, Poland, Germany, Hungary)<br>**Regional** (Agro-ecological territories) |
| 3. Development & food systems | 2 | **Global** (Cocoa, Soy & Aquaculture Value Chains)<br>**EU/Region** (EU, Europe) |
| 4. Diet environmental impact | 13 | **Global**<br>**National** (Australia, Germany, France, Belgium, Netherlands, Spain, United Kingdom) |
| 5. Food health nexus | 5 | **Global** (Global, developing countries)<br>**EU/Region** (EU-specific framework)<br>**Municipal** (Madrid) |
| 6. Food system governance | 7 | **Global**<br>**EU/Region** (EU, Tisza River Basin)<br>**National** (The Netherlands)<br>**Regional/Local** ('Local-level action') |
| 7. Food systems transitions | 5 | **Global**<br>**EU/Region** (EU, Europe)<br>**National** (Italy, Germany, France, UK, Spain, NL, Portugal)<br>**Regional** (North-East Brabant, Flanders)<br>**Municipal** (Rotterdam, Berlin, Ljubljana, London, Milan) |
| 8. Food waste systems | 3 | **Global**<br>**National** (United Kingdom)<br>**Municipal** (Milan, Riga) |
| 9. Rural-Urban Linkages | 4 | **Global**<br>**EU/Region** (Alpine Region)<br>**National** (UK, NL Spain, Portugal, Finland, Latvia, Germany, Austria, Slovenia, Italy, Switzerland)<br>**Regional** (Mid-Wales, Province of Lucca, Frankfurt Region)<br>**Municipal** (Gloucestershire, Helsinki, Lisbon, Ljubljana, Styria, Ede, Tukums, Valencia) |
| 10. Sustainable consumption & production | 5 | **Global**<br>**EU/Region** (EU, Europe)<br>**National** (United States) |
| **Total** | **52** | |
| Of which: | 27<br>25 | Self-identified as food systems approach<br>Not self-identified as food systems approach |

**Thematic areas covered by Food systems research**

The papers reviewed covered ten thematic areas, some with a technical focus on food waste, agroecology or food-health or food-environment linkages while other papers focused more on processes and options for change (innovation, governance, transition). This division obviously is not exclusive and other topics such as food-water and the triple combination of food-health-environment exist in the literature (see box below). A few examples are given here, for a full coverage of topics please refer to the main report.

**Food health nexus**

The papers exemplifying 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'.

Most of the cases in this theme take a systems dynamics angle, while other cases rather take a complex adaptive systems angle. Key concepts under this theme are vulnerability, resilience and adaptive management. 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 due to non-linear interdependencies between these elements, there is a need to understand Food and health as part of a wider, complex food system.

**Diet and environmental impact**

Among 13 studies chosen some look at the impact of changing diet structures on GHG emissions (Vieux et al., 2012), the effect of incorporating the societal cost of carbon emissions into the price of food (Briggs et al., 2013) and estimating the water footprint of different diets (Vanham, 2013). A few more recent studies focus on the protein challenge: the diet shift to non-meat proteins (Forum of the Future, 2018) (Godfray et al., 2018). Most of the cases in this theme take 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.

**Food system governance and transitions**

The 12 cases under the food system governance and transition themes focus on using a diversity of food system approaches to influence governance of the food system, including sector-specific assessments of models toward circular designs (Dairy case), and an experimental basin-wide participatory adaptive framework (Tisza). Others attempt a focus on knowledge brokerage between different food system actors and the potential for testing and implementing novel policies and strategies (FOODLINKS), while another develops a systematic process of inquiry that explicitly account for water-land-food-energy-climate (WLEFC) interactions for better understanding relationships and providing integrated knowledge for planning and decision making. Most of these 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. Half of the cases are projects, the other half papers. Most cases explicitly refer to food systems. Most of the cases in this theme take a systems dynamics angle, looking at ways to change the ways in which parts of the food system interact. 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. Box 0 gives an example of two methodologies used within this theme.

**Box 0: Small wins versus the transition approach**

The report describes two alternative views to look 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'. The regime is the status quo or mainstream way of doing things and how this is perpetuated by beliefs and attitudes on the one hand, and rules and incentives on the other. 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 concept 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.

While the review found a number for 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 the 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: 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 $m^3$ 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).

**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 from understanding and exploring food systems in a synthetic analysis to experimenting and implementing interventions and scaling up. Examples of exploring existing food systems are given above demonstrating the important interdependencies between food production, consumption/diets and impacts on health respectively environment/climate. Some studies also combine the health and environmental impacts of different diets and their linkages with different agriculture and land-use to produce certain diets (see box 3). 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. Thus, the usefulness of a food systems approach was demonstrated in literature for a number of purposes covering a wide set of linked topics.

**Box 3: 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 reduces incidences of non-communicable diseases (cardio-vascular, diabetes 2 etc.) AND at the same time reduces 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 (and 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). This points to the thematic questions of Food system governance and transitions.

**Box 4. Examples of food systems thinking in action: The Green Protein Alliance**

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). 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 important and interlinked challenges in food and agriculture behind what is coined the perfect storm (combined health, climate and environmental impacts of current food production and consumption, increasing future demands for animal protein, negative impact on agriculture from climate change and deteriorating natural capital) needs a comprehensive and multifaceted 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.

**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 of governments, 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. This is also true within agricultural research and innovation, where there still seems to be a weak presence of systems approaches, in spite of several decades of development of farming systems thinking.

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

The main strength of 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, a FS approach might contribute to highlight 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.

At the same time, this is the main challenge: There appears to be no state-of-art methodology or procedure to define the boundaries of a specific food system and for using such a 'model' as a guiding concept for targeting and focusing on specific problems and interventions in a consistent way. 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.

**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 FS approach demonstrate the power of the concept for observing and understanding complexities and interdependencies, the consideration of which is necessary for devising measures for change across interlinked food production, marketing, consumption, recycling and economic, social and environmental/climatic drivers and consequences. The real advantages of the FS approach as a driver and guide for actual change through consumers, other economic actors and policy initiatives still needs to be documented scientifically, but examples exist as given in the review (table 1) and boxes.

**What is 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 a programme and project level, which is summarized here. There are, however, still important knowledge gaps in FS methodology and understanding and regarding *how to make use of the FS approach in R&I*, at various levels.

1. **Further development of methodology for studying and improved understanding of Food Systems:**

- There is a need to understand better different European food-systems and to device a 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).
- A pragmatic and widely accepted methodology for an effective and feasible analysis of food systems is still lacking including how to define the borders of specific FS and how to identify the important leverage points as tool for change agents and policy makers;
- 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 have significant potential impact on overall outcome or negative impact in other sub-systems.
- How to overcome, in methodology and practice, the distinction between local and national 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 -e.g. the so-called 'food environment'-.
- The food systems knowledge gaps include also the potential of new forms of consumer engagement by industry in food innovation and the changing roles of actors due to individualisation and digitalisation of retail and consumer relations as well as 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 existing participatory approaches and providing an experimental space for practitioners from research, the food systems actors (including farmers and fishermen), NGOs and policymakers.

***We therefore, recommend:***

- 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. mandating 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. Commission a multi-actor group to produce good practice guidelines, e.g. using principles of work as under EIP focus groups or similar.
- 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 transformation al goals of FOOD 2030 (sustainability, resilience, diversity, responsibility, inclusiveness and competitiveness). This should build on existing initiatives (e.g. SUSFANS, box 1, TEEB), and be flexible to allow for context dependencies.
- Strengthening the overview and knowledge regarding Food Systems science in SCAR as a basis (for SCAR) to formulate the most pertinent knowledge needs as well as support for planning/designing calls and implementation instruments founded in a food systems understanding

**2. Using Food Systems approach as overall guideline for research & Innovation programming**

- The variation in thematic focus of the reviewed papers (in table 1) suggest 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.

- From this perspective, a food system approach may be used as a framework 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. 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.
- 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.
- In most cases, studying the 'whole' food system will be too broad. Therefore, a pragmatic delimitation is needed. This will involve geographic and thematic demarcation. Research and innovation often starts from dissatisfaction with the current situation (food systems outcomes, or the 'what we get'). Then, one has to make a smart choice for a pragmatic delimitation, balancing getting lost in complexity vs. oversimplification while accounting for the crucial interactions and feed backs in the system, with significant potential impact on overall outcome or negative impact in other sub-systems.
- This requires also improvement of analytical tools to assess a priori potential trade-offs and synergies from innovations and how take-up and improvement may be supported or hampered by feedback loops.

**3. Using FS approach for portfolio management:**

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. However, in a future research programming such focused activities need to have a clear justification within an overall food systems thinking. This goes for the description of thematic calls as well as for formulation of proposals and their expected outcomes. Thus, there is need for another layer of portfolio management vis-à-vis a long-term programming within (and between) pillars of Horizon Europe.

This also means that in the development of a research and innovation programme and later prioritisation one 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, a 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. It 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 noncommunicable 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. Likewise will the requirements for a circular bioeconomy, where fossil based products may be replaced by biomaterial have implications for land use and agricultural systems – again necessarily integrated in a food systems approach to ensure that alternative use of biomass will not compromise food equity.

The different thematic focus of the reviewed papers (in table 1) suggest 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.

Programming from a Food systems perspective needs close monitoring and overview of funded projects/activities over time and their expected and achieved results vis-à-vis the knowledge needs identified. Building on experiences from H2020; e.g. the advisory group for SC2 was asked once or twice to contribute to such an overview and the EC prepared thematic overview sheets for the Food2030 event. A frequent stocktaking for revising state-of-art and knowledge needs will be necessary as input to e.g. bi-annual programming of calls.

Thus, it would be recommendable to establish a task force 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 in order to update and revise knowledge needs as input to prioritisation of calls in following work programmes.

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