STRATEGIC RESEARCH AGENDA

SUSFOOD

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AN FP7 ERA-NET ON SUSTAINABLE FOOD PRODUCTION AND CONSUMPTION

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Authors:

Jeanineke Dahl Kristensen
Department of Food Science, University of Copenhagen (UCPH)
Denmark

Sirpa Kurppa
MTT Agrifood Research
Finland

Béatrice Darcy-Vrillon
Institut national de la recherche agronomique (INRA)
France

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This publication presents the result of cooperation among European Members States and Associated Countries. The SUSFOOD partners created this report to the best of their knowledge, but cannot claim completeness.
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Foreword

SUSFOOD aims at placing sustainable food research high on national agendas and on the agenda of Horizon 2020. This Strategic Research Agenda (SRA) sets out which research areas need to be addressed and how these will be delivered to ensure sustainable development in Europe.

The SRA responds to new developments in food sustainability within the scope of SUSFOOD, covering the full research and innovation cycle, including the Europe 2020 strategy and Horizon 2020.

The SRA is a result of close cooperation within the ERA-NET SUSFOOD, consisting of 25 partners from 16 European countries. Partners include funding and research institutions.

The cross-border coordination of existing national and/or regional research and innovation programmes within the SUSFOOD ERA-NET maximizes impact and adds value to current research by: (I) increasing synergies between research activities and scientific communities, programmes and policies across Europe, (II) minimising fragmentation and identifying complementary research, and (III) contributing to increased innovation and competitiveness in the food sector, and ensuring food sustainability across the supply chain.

The SRA embraces sustainability within a global context, and within the context of sustainability as defined by the ERA-NET SUSFOOD. It takes a multi-disciplinary and whole-systems approach, with a post-farm-gate focus, to research on EU/global supply systems to address the environmental, economic and societal challenges Europe faces to produce sustainable, nutritious, safe, affordable food for a growing population from the same/less land and finite resources.

The strategic goal of SUSFOOD ERA-NET is to reinforce the scientific cooperation between EU Member States and associated states in order to maximise the contribution of research to the development of more sustainable food systems. This SRA is a product of this cooperation.

SUSFOOD promotes a multi-disciplinary approach from biology to food engineering, social science, economics and humanities.
The primary objectives of the SUSFOOD research agenda are:

- Responding to the increasing demand for food by increasing food production sustainably (including with reduced CO2 emissions, energy consumption and water use, and taking account of ecosystem/ bio-diversity impacts) and reducing losses and waste in the food supply chain
- Improvement of the quality, traceability and safety of food in a sustainable way
- Improve the quality of life through better availability and improved access to food and healthy diets
- Improvement of the resilience of the food chain
- Encourage more sustainable consumption behaviour
- Improvement of the European agri-business competitiveness and green economic growth with additional focus on SMEs and job creation

The SRA builds on an interactive process comprising an analysis of selected national and international foresight studies on food sustainability, workshops with all SUSFOOD members and external experts in Ghent, Belgium, and in Copenhagen, Denmark, as well as national consultations and consultations with SUSFOOD External Advisory Group.

It is our hope that this Strategic Research Agenda will be used to set the European food research agenda to ensure sustainable and equitable food supply. Also we hope the SRA will act as a source of inspiration for all researchers working within the field of sustainable food production and/or consumption.

We would like to thank all who have contributed to this document.

Béatrice Darcy-Vrillon
Project Coordinator

Niels Gøtke
Deputy Project Coordinator

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Executive Summary

SUSFOOD has the vision: ***All food chain partners contribute to achieving sustainable*, secure and resilient food systems which feed the world and make sustainable choices the easy and preferable choices for consumers.***

*SUSFOOD defines sustainability as: ***"A food system that supports food security, makes optimal use of natural and human resources, and respects biodiversity and ecosystems for present and future generations, and which is culturally acceptable and accessible, environmentally sound and economically fair and viable, and provides the consumer with nutritionally adequate, safe, healthy and affordable food.***

The SRA embraces sustainability within a global context. The global food system is challenged by increased demand for quantity and quality of food from a global population that will grow from 7 billion today to 9 billion by 2050, and at the same time the global food system must adapt to changes in the socio-economic and demographic structure of the population. These challenges include an increased middle-income group that demands more protein-rich food, increased pressure on natural resources such as water and energy, climate change, demand for more nutritious, safe and economically affordable food for all. While the global food system presents these challenges, the food and drink sector also contributes to the global economy and job opportunities. In Europe in 2011, the food and drink industry generated an annual turnover of 1,017 billion euro, (generating 4.25 million jobs), which makes it the largest manufacturing sector in Europe.

The SUSFOOD SRA takes into account other relevant SRA's for sustainable production and consumption, which is why this SRA focuses on food chain sustainability beyond the farm gate[1] by looking at processing, packaging, transport, retailing, food services, storage and consumer activities. However, SUSFOOD interfaces with primary production on issues such as methods and metrics for assessment and policies.

The SUSFOOD SRA strives to have the highest impact on I) food security, II) pressure on natural resources such as water and energy, III) emissions IV) innovation and knowledge transfer, V) food and health and VI) sustainable food economy, including employment and job creation.

The strategy for ensuring the research has an impact that addresses these core challenges has a multipronged approach. This includes the establishment of a *Meta Knowledge Database (MKB),* providing information on funding and research institutions, recent and ongoing research programmes and an identification of the following *eight key research areas*:

1. Public policy coherence
2. Innovation in food processing technologies
3. Redesign input, waste and side flow strategies to increase resource efficiency and provide added value in food products and processing, manufacture etc.
4. Interdisciplinary research approach to innovation of food products and use of new raw materials for food products
5. Harmonisation of the methods and metrics for integrated assessment of sustainability of food products and food patterns
6. Connection between stakeholders and food systems
7. Understanding consumer behaviour and food choices
8. Integration of information systems for personalized and sustainable choices

Each research area is exemplified with a number of concrete research subjects.

The eight research areas should be viewed holistically, as the outcome of each research area may challenge other research areas. To stress the importance of a holistic approach, the SRA identifies two cross-cutting issues I) localisation of food chain activities and II) equity and ethics, which both need to be addressed as an integral part of each research area.

The implementation of the SRA is initiated by two SUSFOOD calls, maintenance of the MKB, and dialogue with national institutions (private sector as well as governmental), and with EU institutions.

[1] Beyond landing for seafood

1. Vision and Objectives

All food chain partners contribute to achieving sustainable*, secure and resilient food systems, which feed the world and make sustainable choices the easy and preferable choices for consumers.

*The SUSFOOD ERA-NET defines **"sustainability"** in the food area as:
"A food system that supports food security, makes optimal use of natural and human resources, and respects biodiversity and ecosystems for present and future generations, and which is culturally acceptable and accessible, environmentally sound, economically fair and viable, and provides the consumer with nutritionally adequate, safe, healthy and affordable food.

This definition is in accordance with the characteristics set out by the FAO[i]

The strategic goal of SUSFOOD ERA-NET is to reinforce the scientific cooperation between EU Member States and associated states in order to maximise the contribution of research to the development of more sustainable food systems.

SUSFOOD promotes a multi-disciplinary approach from biology to food engineering, social science, economics and humanities.

The primary objectives of the SUSFOOD research agenda are:

- Responding to the increasing global demand for food by increasing food production sustainably (with reduced CO2 emissions, energy consumption and water use, and taking account of ecosystem/bio-diversity impacts) and reducing losses and waste in the food supply chain
- Improvement of the quality, traceability and safety of food in a sustainable way
- Improving the quality of life through better availability and improved access to food and healthy diets
- Improving the resilience of the food chain
- Encouraging more sustainable consumption behaviour
- Improvement of the European agri-business competitiveness and green economic growth with additional focus on SMEs and job creation


Photo © Gilles Cattiau

2. Strategic Context

Excellent Science
SUSFOOD aims at placing research on sustainable food high on national agendas and programmes as well as on the Horizon 2020 agenda. The SUSFOOD SRA is based on multi- and cross-disciplinary approaches within food science addressing interests from various partners in the EU, in the public sector and in the private sector.

SUSFOOD takes a systems approach to sustainability which recognises the complexity of the food system, the need to address the key challenge of increasing food production more efficiently whilst reducing impacts on the environment and the need to understand the complexities, trade-offs, tensions and synergies across the system.

Competitiveness and Growth
In 2011, the EU food and drink industry generated a turnover of 1,017 billion euro (generating 4.25 million jobs), and is thereby the largest manufacturing sector in Europe[II]. In addition to the importance of the food sector for the economy, growth of the global food supply is expected to respond to the increased demand from the middle-income group. This group will increase from two billion today to nearly five billion in 2030[III] - impacting on food production in terms of sustainability and job creation. This growth is mainly outside Europe and it is expected that Asia and Africa will account for more than 80 percent of the increased demand for food. The increased demand for food makes export of food a major driver in creating jobs and presents a great opportunity for the European food industry to develop a growing, competitive and sustainable food sector.

Translating research into innovative technologies, practices and information is also needed to enable countries in the EU and worldwide to meet future food and environmental challenges and support a growing economy.

2.1. Global Context
Foresights[IV] on the global challenge for sustainable food production and consumption highlight the need for a systems approach and furthermore that various sectors interact.

2.1.1. Food Security
"Food Security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"[v].

The global food system will experience unprecedented pressures over the next 35 years. The global population will increase from seven billion today to more than nine billion by 2050. Many people are likely to be wealthier, creating a demand for a more varied, high-quality diet that requires additional resources to produce. The emerging markets will shift diets to include more protein-rich foods, in particular animal protein, which is challenging sustainable production.

In 2012, the FAO estimated[VI] that, if this trend of diet evolution is maintained, world food production will need to increase by 60 percent by 2050, involving an additional quantity of nearly 1 billion tonnes of cereals and 200 million tonnes of meat. These additional needs must be covered by increased production and from improved utilisation of available resources, e.g. by better use of side streams (also called waste streams) and by decreasing the amount of waste. vv

To fulfil the demand for increased and more affordable food production, the food system needs to innovate to ensure higher, more efficient and sustainable production, and to add value to side streams or waste which are not used as food at present and which must support a circular economy.

Food needs to be safe, of nutritious quality, affordable, available to all population groups and equitable to reflect social and cultural needs. Another lever to reduce pressure on food systems is to influence evolving consumer diet patterns and behaviours to be healthier and sustainable by helping consumers to make the right food choices.

Food Safety

Scientific knowledge and technology development related to food safety has increased considerably in the 20th and 21st centuries and foodborne disease outbreaks have decreased significantly in developed countries. However, critical gaps exist, and new challenges occur due to increasing microbial resistance, changes in raw materials, and new food products being produced. Increasing the resource efficiency of food processing, manufacture, retailing, and distribution can impact on food safety. For example increased sustainability through changes in food processing and handling e.g. via more energy efficient and sustainable freezing and cooling systems and/or by reducing utilisation of water in cleaning procedures may compromise food safety and subsequently increase waste.

Specific data is very limited on why and where the losses due to waste occur in the retail and consumer end. A large proportion of these losses are due to the fact the food materials and products are either no longer safe to eat, or, consumer perception is that the products are unsafe to eat. The latter highlights the importance of educating and informing consumers, and improving innovation and technology around food safety.

Nutritional Security and Diet Evolution

The FAO estimated in October 2012[VIII] that 870 million people are chronically undernourished and consequently wasted or stunted.
A growing and wealthier population in the future will put food production under pressure. Food markets need to respond to the increasing food demand, set against the context of the related health problems in today's society (increasing obesity and diet-related disease) and to the changes in food preferences and patterns that are heightened by urbanisation, in Europe as well as worldwide. Common to these challenges are that the daily energy intake needs to be reduced in particular in the OECD countries, and that the balance between animal *versus* plant nutrients needs to be investigated, whilst not compromising the nutrient value.

Statistics for *urbanisation*[ix] show that in the more developed regions, 86 percent of the population will be urban dwellers in 2050 (against 78 percent today), and in the developing countries the percentage is foreseen to change from 47 percent to 64 percent; i.e. from 3.6 billion in 2011 to 6.3 billion 2050, in total. People in urban areas tend to increase their intake of more fatty, sugary and processed and refined foods.

The *demography changes* are taking place in Europe as well as worldwide. Whereas the number of persons aged 60 or more in Europe was 22 percent in 2012, this is expected to increase to 34 percent by 2050[xi]. The corresponding percentage for the world population is 11 percent (810 million people) and 22 percent (2 billion people). This will lead to increasing demand for convenience foods and changes in food purchase patterns.

Supporting this future demand for food sustainably will require innovation in product reformulation and food processing to ensure nutritious, quality, safe food with reduced impacts which is palatable to consumers and has increased shelf life. It will also require a better understanding of the drivers affecting food choice and of consumer acceptability of innovative/emerging technologies and novel foods. In addition, supporting this future demand requires an understanding of the drivers for food and nutrition security including food

availability and access. Furthermore it requires an identification of where there is scope for intervention and understanding the role of different actors across the supply chain.

Accessibility, Affordability and Cultural Acceptability

The definition of food accessibility varies between publications; however there is a consensus that accessibility implies availability, and economic access to food. Poverty is therefore a limiting factor in achieving food security.

In 2009, it was estimated[XII] that 16 percent of the population in the European Union lived in food insecurity due to poverty, and the on-going financial depression and rising unemployment rate may have caused this percentage to grow.

When household incomes increase, people tend to modify their food intake in terms of quantity, combination (food choices) and quality. People entering the middle income classes tend to increase their food expenditures on more animal food, such as meat and dairy products[XIII].

Accessibility is influenced by the infrastructure of the distribution chain, *e.g.* the link from producer to retailer and the geographical location of retailers. Supermarkets account for a major part of the food market in the many industrialised countries and a rapidly growing share in the developing countries, notably in urban areas, which are also growing[XIV].

Food consumption is further determined by a number of cultural factors. These can be religious taboos, general habits, and/or preferences, e.g. non-acceptance of e.g. meat, certain types of slaughtering, choice of vegetarian food, and non-acceptance of GMO-foods. Social norms are also highly influential factors[XV].

It is a general trend - *inter alia,* as a consequence of the new information and communication technology – that consumers express their food preferences more explicitly, and this has an impact on acceptability.

Resilience

An efficient, equitable, sustainable food system is dependent on markets, regulatory frameworks and flexible supply chains that can respond to/absorb shocks to build resilience at all levels.

Factors include trade, markets, food price volatility, food access and severe weather events. Understanding these issues needs a multi-disciplinary approach to identify trade-offs, tensions and synergies. Furthermore, a focus on how to improve access to markets and understand the complex interactions associated with improving adaption to climate change and resilience is required.

A greater understanding of the risks impacting on the security of food supply chains is needed, including the implications for food safety, consumer trust and food security.


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2.1.2. Resources

Water Consumption

In 2001, the food and drink manufacturing industry in Europe utilised approximately 1 - 1.8 percent of all water used in Europe[XVI]. This water is primarily used as a product (bottled water, drinks etc.), as an ingredient, as a processing agent and for cleaning. In order to maintain a sustainable supply, in terms of both quantity and quality, the industry is challenged to monitor, reduce and recycle water, wherever possible whilst retaining quality.

Energy Consumption

The European food and drink manufacturing industry accounts for about eight percent of the energy use in the OECD area, and is responsible for about 1.5 percent of the total greenhouse gas emissions in the EU-15[XVII]. This is 11 percent of the total emissions from the food chain and although reduction has taken place during 2004, challenges still exist to reduce this further. Energy is used for heating (boiling, drying, pasteurization and evaporation), cooling and electric power.

Research is needed to improve energy efficiency and reduce associated greenhouse gas emissions throughout the supply chain, including in production, processing, refrigeration, transport and storage as well as via waste reduction/recycling. In addition, there is a need for innovation in flexible manufacturing, reducing energy and water use and re-use system, as well as in new technologies and management systems.

2.1.3. Food Waste

More than one third of the food produced in the world today is lost or wasted[XVIII]. In developing countries this is mostly due to poor infrastructure and undeveloped production systems, whereas in developed countries the losses and waste primarily happen during manufacturing and steps downstream and in the homes of consumers.

The European Commission (DGENV) estimates a food waste (without differentiating between the terms loss and waste) of 179 kg per capita[xix]. Forty percent of this is likely to take place during manufacturing, due to variable raw material quality; post-harvest storage losses; short shelf-life due to a) largely

unavoidable waste (bones, carcasses, and certain organs in meat products for example) and due to technical malfunctions, such as overproduction, misshaped products or damaged packaging. Another 40 per cent is estimated to be discarded at the retail level or discarded by the consumers based on a number of factors, such as lack of awareness, knowledge, planning, general attitudes, preferences, labelling, storage, packaging, portion size, and socio-economic factors, such as income level and household size[XIX].

The food waste taking place between production and consumers by wholesalers/retailers may include the food service sector. Causes of the waste in the wholesale/retail sector include inefficiency in the supply chain (e.g. lack of coordination between wholesalers, distributers and retailers), stock management, marketing strategies, marketing standards, high product specificity, and temperature sensitivity. Causes in the food service sector include factors such as portion size, logistics, attitudes, awareness and preferences.

Reducing waste in production, transport, storage (spoilage), retailing and consumption of food would bring benefits including increased food availability, reduced use of inputs (including energy), reduced greenhouse gas emissions and increased competitiveness.

Innovation is needed to reduce losses through improved quality, shelf life and efficient utilization of raw materials in processing; and through optimizing information and communication technologies and using robotics and non-invasive sensors. Innovation in packaging technology is needed to reduce spoilage and extend shelf life, also in the home.

2.2. Other EU Initiatives

Several other initiatives support sustainable production and consumption. However the remits of the other initiatives focus on different entry points. SUSFOOD is the main initiative focussing beyond the farm gate[2].
SUSFOOD complements particularly two JPIs (Joint Programming Initiative).

On the production side this includes FACCE (Agriculture, Food Security and Climate Change), guided by the two main priorities: 1) Fostering collaboration among national research actors to work towards alignment of research programming and 2) Develop innovation at the service of society. The FACCE research is structured around five major interdisciplinary scientific themes: I) Sustainable food security in the context of climate change; II) Environmentally sustainable growth and intensification of agricultural systems under current and future climate and resource availability; III) Assessing and reducing trade-offs between food production, biodiversity and other ecosystem services; IV) Adaption to climate change throughout the food production chain; and V) Greenhouse gas mitigation, carbon sequestration and fossil-fuel substitution in the agriculture, forestry and land use sector.

On the consumption side, SUSFOOD complements the **JPI HDHL** (Healthy Diet for Healthy Life), which has identified the three following research areas: 1) Determinants of diet and physical activity, 2) Diet and food production and 3) Diet-related chronic diseases. Each area has a specific goal and primary initiatives are identified for the periods 2012-2014 and 2015-2019.

Photo © Yves Popineau

[2] Beyond landing for seafood

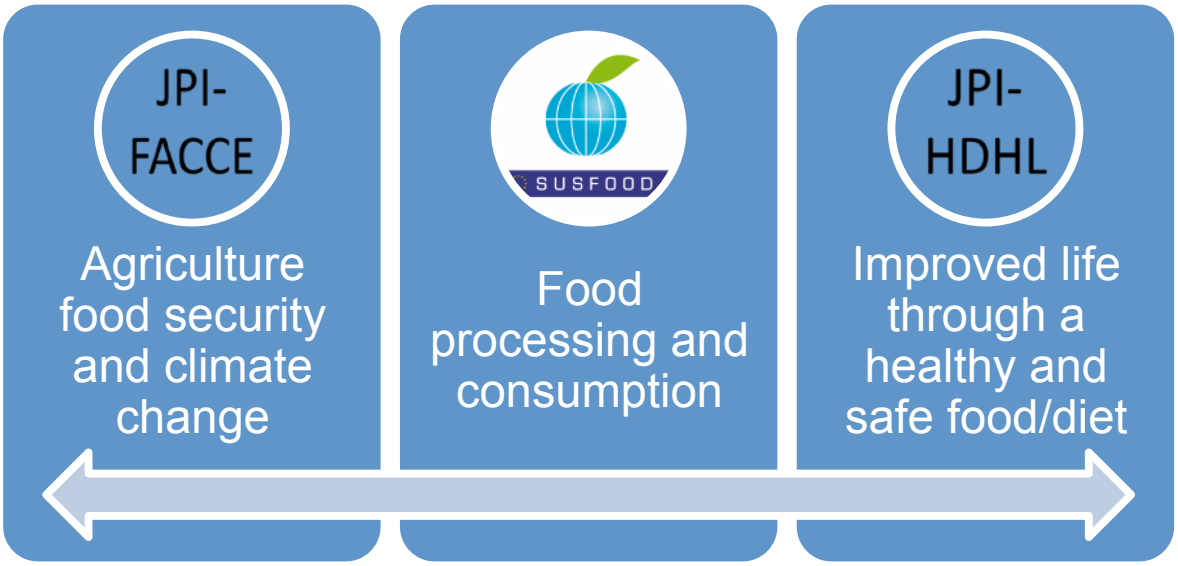

Fig.1 Positioning of SUSFOOD in relation to key European research Joint Programme Initiatives (JPIs)

SUSFOOD complements the industry-led public/private partnerships European Technology Platform **(ETP) "Food for Life",** which addresses some common challenges with SUSFOOD, such as sustainable and ethical production. However, the ETP focusses on innovative technologies.

The ETP for organic production, **TP Organics,** deals in particular with the organic and low-input food and farming sector. TP Organics engages stakeholders along the whole food supply chain, including SMEs and consumers, in determining the research needs of the organic sector.

The **FoodManufuture project** (funded under FP7) focusses on the food manufacturing sector, but retail, primary production and transport are included when relevant as well as consumers' needs and expectations. FoodManufuture has identified a number of research infrastructure needs and solutions, including solutions from other industrial sectors, to address gaps and barriers in the existing European research infrastructure.

In addition, SUSFOOD cooperates with **several other ERA-NETs,** of which many address specific themes. The cooperation takes place through established advisory groups and is further institutionalised by the establishment of PLATFORM, a forum that networks the bioeconomy-relevant ERA-NET actions. Annex A provides a full list of cooperating partners.


Photo © Christopher Maitre

2.3. Conclusion – Challenges for Sustainable Food Production and Consumption

Set against the context of the global challenges on food security, resource constraints and food waste, and taking into account the other EU initiatives in this field, SUSFOOD has identified a number of core challenges for research relevant for the SUSFOOD ERANET[3]. These challenges reflect environmental, technological, socio-demographic, economic and political dimensions (the numbering is not a priority order):

1. Food security for providing enough food for the world´s growing population with a sustainable and secure supply of safe, nutritious and affordable high-quality food which takes account of resource constraints and the need to adapt to climate change – set within a global context.

2. Pressures on supplies of energy, water, natural resources and adapting to climate change. This requires more effective use and re-use/recycling of resources, and mitigation of and adaptation to climate change.

3. Innovation in development of smart technology and infrastructure across the food chain. Knowledge transfer between all stakeholders to support uptake and use of innovative approaches into practice, tool sets and infrastructure are needed to support sustainable development in the food system. Indicators of change need to be defined to support monitoring and evaluation of progress.

4. Food and health to improve and ensure quality of life of an ageing society will be a leading issue in terms of demographic and social challenges.

5. Change of markets and approaches to a new economy, including value creation, are challenges that have to be taken into consideration to ensure a more resilient and sustainable food economy. Markets have to reflect integrated policies, new governance and innovative institutionalisation. Other specific issues in this area include new approaches to employment and a new understanding of real and equitable prosperity. As far as economic growth and competitiveness are concerned, SUSFOOD has the crucial role of promoting incentives for innovation in order to explore sustainability-oriented business models and value creation in the food supply chain.

6. Contribution to food security by understanding how food demand can be managed. This is a challenge for the whole food system and not only for the end consumer. Indeed, changing consumer patterns can not only be dealt with by more consumer awareness; the whole design of processes, markets and products has to be redesigned.


Photo © Gilles Cattiau

[3] The identification process is described in annex B

3. Strategy

The SUSFOOD strategy for research, which can have an impact on the core challenges, has a multipronged approach, taking into account:

- Foresights and ongoing research
- A focus on research of sustainable[4] production and consumption from a food chain perspective
- Other EU initiatives by aligning and addressing research gaps from an EU perspective to minimize duplication/overlap other initiatives

3.1. Mapping of Research, Funding and Research Institutions addressing Sustainable Food Production and consumption

SUSFOOD has established a Meta Knowledge Base (MKB) to identify overlaps, synergies and gaps, but also emerging needs in research[XX]. The MKB is an open web-based archive which has several functions. It is updated by all the stakeholders and provides a tool for information exchange on national programmes, and on capacities in all the European and associated countries participating in the consortium. This analysis allows calls and other joint activities to be planned. In addition, the database comprises available research posted by researchers in the database with a title, small abstract and carefully chosen fixed keywords and optional keywords. SUSFOOD will continuously promote contributions and use the database through national agencies and EU partners.

3.2. Priority Research Areas

Based on the challenges for sustainable food production and consumption SUSFOOD has – identified[5] eight priority research areas where new knowledge will have an impact on sustainable food

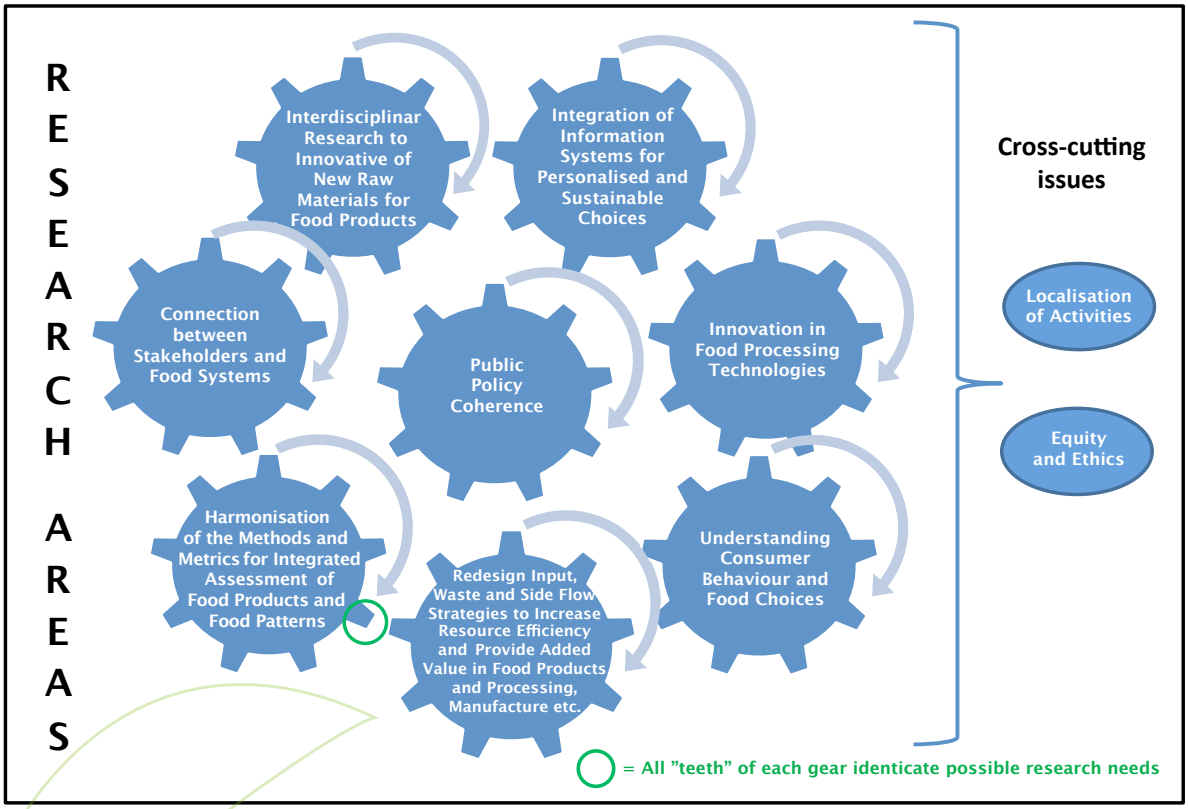

Figure 2. The eight research areas, which have to be seen in a holistic context to achieve the highest impact on sustainability

[4] As defined by SUSFOOD

[5] The process is described in Annex B

production and consumption across industry, society etc.; each research area comprises a short rationale and examples of important research areas.
These eight research areas are valuable on their own; however research in each area may impact on the other research areas (see figure 2), e.g. new food processing technology may result in a need for research in redesign of input and vice versa. All research should always be considered in respect to the SUSFOOD definition of sustainability, the focus for SUSFOOD and to the two cross-cutting issues described below.

3.2.1 The Eight Priority Research Areas:

(The order of the Research Areas in the list does not reflect any order of priority)

1. Public policy coherence

In order to achieve sustainable food systems, public policies need to be coherent and transparent throughout the system. Thus, there is a need to review and develop policies throughout the food chain, including primary production and how this inter-relates with other policies that impact on food production. Policies may also affect consumption differently in different social groups, and there is a need to understand the impact policies have on various consumer segments, e.g. in terms of differences in affordability, accessibility, and cultural accessibility. System governance has to be connected to critical points in food system operation and to policy perspectives. Developing a better understanding of issues or levers of action concerning EU competition policy in the food sector is of importance.

Sustainability may be achieved by using a "full costing"[6] , covering the whole supply chain from the field to the dinner table.

This Research Area Includes

- Understanding where there are tensions/ coherence within the present policies to achieve sustainable production and consumption, including consequences impacts of policies targeted at the primary sector (at farm level), for the secondary sector (beyond the farm gate) and consumption
- Understanding how policy levers can overcome barriers and tensions, what the consequences are for the production and for the consumption at various social levels of "full-costing policies", of innovation and investment policies, and of labelling/food safety/food standards
- Understanding trade-offs/tensions between policies supporting sustainability; e.g. price policies versus nutrition policies, promotion of development of plant protein versus animal protein, promotion of bio-fuel production versus food production, impact on lower income people
- Understanding how to balance between regulation and incentives (including subsidy/taxation of certain food items) to achieve a sustainable food production or/and consumption. Conditions for a legitimate public policy.
- Understanding and developing how to integrate sustainability and nutritional recommendations

Expected Outcome:
Insight on the extent to which policies and regulations may impede sustainable production and consumption. Identification of opportunities, levers and interventions to support development of coherent policies on sustainability. This insight will provide tools for all stakeholders to review and renew policies supporting sustainable food production and consumption.

2. Innovation in food processing technologies

There is a need for flexible, innovative food manufacturing, and resilient processes and systems. Opportunities must be identified to increase competitiveness, efficiency, and economic growth in a low-carbon European food and drink sector. Research needs to support innovative solutions to achieve sustainably produced food, through more efficient food processing, packaging and distribution

[6] "Full costing" means that the price on food should include all costs related to the product; this encompasses the damage to the environment and the use of natural resources that need to be replaced in the food system.

embracing the retail and catering sectors and to produce food which is safe, healthy, sensorial, affordable, and nutritionally balanced. This will require development of new technologies or improvement of existing technologies to retain and improve the nutritional qualities of the raw materials through gentle or changed processing methods. Flexible and resilient processes and systems are needed to overcome the increased variability of raw materials in the future (due to agro-ecology, climate change and extreme climate events, global trade, and other factors), and optimize resource efficiency through reduced energy, water use and improve environmental impact through reducing greenhouse gases. New processes are needed to upgrade and valorize components from alternative sources to food grade ingredients based on functional directed isolation of food components from complex plant-, algae- or animal-based matrices (included aquatic) to ensure optimal use of raw materials.

This Research Area Includes

- Development of separation technologies; new extraction, filtration and heat treatment or alternatives to heat treatment technologies consuming less material, water and energy
- Use of minimal processing, less specialised processes and alternative technologies to fractioning
- Development of processes based on fermentation technologies or enzyme technology
- Development of engineering solutions and process/systems automation for increasing efficiency and flexibility in food processing, packaging, manufacturing, and distribution
- Improvement of the match between processing technologies and raw materials availability and quality to maximise exploitation and functionality and to reduce waste
- Development of flexible technologies and systems to optimize use of increasing raw material variability in quality, location and price


Photo © Christopher Maitre

- Development of novel packaging concepts, materials and designs which promote re-use or recycling, minimise the overall environmental impact of food and are consistent with functionality
- Development of smart technologies for single process operations
- Food process design, including supportive modelling of food processes, develop ICT-based management systems, process control/ optimization, systems for control and monitoring, including on/in-line rapid analyses based on advanced sensors, rapid data acquisition and multivariate data handling (Process Analytical Technologies – PAT)

Expected Outcome:

More resource-efficient and innovative food processing technologies for food processing and manufacturing that address sustainability.

3. Redesign input, waste and side flow strategies to increase resource efficiency and provide added value in food products and processing, manufacture etc.

The food supply chain is complex and at all stages resources are used, greenhouse gases are emitted and waste is generated. Rising prices of raw materials, energy and water, together with water scarcity, regulation of greenhouse gases and waste management have an increasing impact on food production.

In order to achieve more sustainable and resilient food production – including prolonging shelf life without compromising food safety, nutritional and sensorial characteristics – there is a strong need for research supporting redesign of the supply chain and the whole production chain from raw material to consumption, to create the most efficient production, valorise products and side streams, optimize use of raw materials, ingredients, energy and water, and changes of packaging materials. The redesign should accommodate demanded food qualities including food safety, organoleptic and nutritional quality. The research may include impact assessment, including economic aspects of reduced (food) waste.

This Research Area Includes

- Valorisation of raw materials, waste and side streams based on a zero-waste philosophy upgrading to more healthy foods, use of processing side streams that are normally not used for foods and valorisation of waste into food ingredients, fine chemicals or feed. Specific areas of interest are production chain re-engineering, bio-refinery and bioprocessing including use of enzymes and fermentation to add value to side streams and waste
- Based on analysing critical points in the food chain, development of new sustainable food manufacturing processes and technologies to reduce water and energy input. Specific focus areas include hygienic design of food processes and equipment (food safety), development of technologies to reduce energy consumption (including more efficient cooling and freezing processes and storage) and improving product quality (including food safety, nutrition, organoleptic), development of packaging and surface materials, and coatings for process equipment


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- Modelling and simulating redesigned processes and food chain (through multi-model integration)
- Supply chain management, energy, water and environment in connection with future production systems, including distribution services, waste management, recycling, and choice of packaging materials
- Development of new materials and new polymer compounds for novel packaging of food

Expected Outcome:

More efficient use of raw materials, resources, processing techniques and waste reduction for maintaining or improving microbiological, chemical, organoleptic and nutritional food quality.

4. Interdisciplinary research approach to innovative food products and use of new raw materials for food products

There is a need for research in the use of new raw materials for production of ingredients or foods based on side streams or by-products, which are important sources for a sustainable food production. To ensure affordable, safe and locally accepted foods that fulfil nutritional requirements for various consumer segments, there is a need to identify new ingredients from by-products, new and/or underexploited species, and whole crop harvesting systems. Likewise, there is a need for development of new ingredients with high nutrient density, taking into account the bioavailability of the nutrients. Development of new gentle methods to fractionate raw materials and isolate the compounds in focus without reducing their functional properties is essential for obtaining the right quality ingredients. There is a strong need to develop tools and protocols for registration of new types of raw materials as well as novel food products, and legislation has to be simplified.

This Research Area Includes

- Functionalization of new and underexploited raw materials, including development of plant-based, insect, algae or other sea product alternatives to conventional animal protein products, using new and traditional raw materials
- Understanding the effects of various processing methods on the quality of the raw material. Identification of novel and innovative attributes in raw materials
- Reformulation and preservation of food products in response to consumer demands through processes with lower environmental impact
- Increased and secured nutritional and safety quality of foods and bioactive substances by understanding food microbiology and toxicology
- Development of infrastructures supporting negotiation with regulatory authorities in the EU and on export markets for approval of novel foods and food chains

Expected Outcome:

Increased and broadened raw materials used for food production and consumption optimizing quantity and quality (nutritional, microbiological, chemical and organoleptic), and reducing waste, including addressing related technological and administrative impediments.

5. Harmonisation of the methods and metrics for integrated assessment of sustainability of food products and food patterns

For stakeholders to be able to assess and value the sustainability of food products in a chain perspective there is need to develop harmonised and transparent methods and metrics to measure, monitor and assess sustainability of food production and consumption. The methods and metrics will be aligned and include primary production, as this will affect the end product.

The methods and metrics will comprise nutritional, environmental, social and economic impacts. Measuring sustainability of consumption and eating patterns will be included. Harmonisation of methods will make it possible to quantify relevant parameters for sustainability and underpin food security, traceability and alerting, and risk management.

Policies to improve the sustainability of the global food chain must be evidence led, based on transparency and open data sharing. Policy makers, industries and other stakeholders should be able to access the right data for research and be able to communicate the trade-offs between the dimensions of sustainability (economic, social and environmental), and derive knowledge for use in practice.

The development of models will be based on collected data, e.g. in a public European database, of extensive measurements of the sustainability of products and tests of measuring methods. This will eventually be transferred into modelling of food systems at various scales and simulation of alternative food systems. Use of indicators is part of the theme. The establishment, maintenance and running cost of this modelling should be considered.

A trustworthy system will ensure European competiveness on the international market.

This Research Area Includes

- Development of new methodologies to quantify sustainability parameters
- Identification of relevant data, including predictive data, and environmental, nutritional, social and economic critical points for various food items/ products from raw material to consumption
- Identification of measuring methods and developing of models
- Coherence. Understanding trade-offs between the different dimensions of sustainability
- Analyses on how new data collection and models interact with national systems and legal aspects
- Development of traceability methods for the supply chain
- Development of cheaper and less complex analytical methods as tools for rapid screening of food quality from the safety and nutritional point of view
- Modelling of food systems at various scales and simulation of alternative food systems

Expected Outcome:

Tools for assessing the sustainability attributes of various food products and food systems, including transparency of the critical points and how this relates to private strategies, national systems and legal aspects.


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6. Connection between stakeholders and food systems

There is a need for a multi-stakeholder approach to redesign and optimize food systems for more sustainable food production that meets consumer demand. Sustainable production and consumption of food i.e. with reduced impact on the environment and climate will be most successful when all the food chain actors (i.e. the food industry, government, distributers and consumers) work together to encourage, produce and consume a healthy, nutritious, affordable and sustainable diet and avoid food spoilage at each step of the food chain.

Collaborative networks and tools are necessary in order to transfer the knowledge from research into practice and for stakeholders to use it. Improvement of the distribution chain by development of new models of organisation and management, marketing and new distribution channels and networks could be important factors to achieve sustainability.

Development of the linkages between stakeholders will be challenged by trust, transparency, confidence and competitiveness. Changes in behaviours and perceptions throughout the food chain are needed to achieve sustainability. Such changes may include changed structures and improved and/or increased share of information, however stakeholders need to perceive more advantages than disadvantages to do so. Changes in the food system towards more sustainability may change power relations, which needs to be taken into account. To support establishment of new linkages and new structures demands understanding the present structures and motives.

This Research Area Includes

- Analyses of various stakeholders´ (policy makers, producers, manufactures, distributors, and consumers) perceptions of sustainability, identifying the tensions, barriers, synergies and opportunities to encourage sustainability
- Understanding society's engagement in food production and how to increase it. Factors may include behaviours, business drivers and socio-economic factors impacting on the food chain and business environment
- Understanding how the supply chain influences agricultural production and reacts to public policies, and how this can be used in a positive way
- Understanding how the supply chain addresses the needs of the low-income populations for affordable sustainable products
- Gathering evidence to support impact assessments including how various food chains and food waste affects sustainability and food prices
- Understanding how relationships between stakeholders can be developed including identification of critical points, how to overcome these, and at which cost/benefit
- Understanding how different organizational structures in the food chain can increase the resilience of food systems towards crises, extreme events, price volatility
- Socio-economic analysis for understanding how to develop markets for ecosystems services and ecosystem-based models for the supply chain
- Development of new models, structures, and business platforms including the development of online tools to approach entrepreneurs, technologists, and inventors
- Creation of new market, of organizational and management structures, and of distribution channels and networks

Expected Outcome:

Knowledge of various stakeholders' perception of sustainability and insight into challenges and opportunities to achieve sustainable and resilient food systems, including new market opportunities.

7. Understanding consumer behaviour and food choices

To facilitate sustainable consumer behaviour, insight is needed into the factors that determine consumer behaviours and choices. This involves studies of what drives consumer purchasing practises, priorities (cultural, sensorial), preparation methods, storage and discarding of food items made by the consumers.

This research area encompasses socio-economic, cross-cultural and individual barriers and drivers to adopting healthy and sustainable diets. Relevant factors are consumer attitudes and relationships as well as the role of formal and informal education, social learning, commercials, discounts, nudging, etc. The change in demography and acceptance of new technology to support sustainable production and consumption is expected to impact on food choices.

Changes may take place based on improved knowledge, affordability, prioritisation of use of resources based on attitude, including cultural factors, knowledge, accessibility, and the interaction of these factors. In addition to improved knowledge of how products appeal to the customer, changes in consumer attitudes, expectations and behaviour requires improved knowledge on how to increase the populations´ motivations factors for choosing sustainable foods.

There is a mutual interaction between changes in consumer choices and changes in the range of products supplied to consumers, including how the food availability has an impact on the behaviour and choices of the consumer.

Change in diets for a larger group of consumers will have repercussions on social and economic aspects in the food sector.

This Research Area Includes

- Identification of consumer trust in/perception of/acceptance of/expectations and demands to sustainability and sustainable products and marketing of such products. This may include length of food chain
- Identification of consumer barriers and drivers for changing behaviour with respect to purchasing, storage, waste, preparation, purchasing and eating innovative sustainable food, acceptance and use of new technologies, and the consequence of this, as well as how to overcome the barriers (single or combined factors/information). The research should address economic (e.g. at national/household level), social (e.g. cultural), environmental nutritional and food safety impacts
- Understanding how to quantify the impact of large-scale diet changes
- Identification of behaviour change levers to promote uptake of healthy affordable food
- Understanding and developing tools for how healthy, nutritious and safe diets can be achieved as part of increased sustainable food production
- Understanding consumer attitudes to change of food habits in respect to sustainable consumption e.g. partial change from animal to vegetarian protein intake and other new products, and if there are any trade-offs when adapting to healthy and sustainable diets and how to overcome consumer barriers
- Understanding consumer views, conceptions of and reactions towards labelling sustainability (combining factors such as food spoilage, food quality and food waste), and how to change consumer views toward a positive development
- Understanding behavioural opportunities for achieving sustainability in the home (cooking, optimal resource management, waste management, and how households) can have a positive impact on the sustainability of foods systems. Impact on policies and redesign of products for optimal home use
- Understanding drivers, including marketing, for consumer food choice and what affects supply chain behaviour to help encourage more sustainable practices
- Understanding consumer acceptance of new technologies to increase sustainable production and consumption

Expected Outcome:

Insight into how sustainability choices can become the preferable choice for the consumer.

8. Integration of information systems for personalized and sustainable choices

Based on existing information systems, research is needed to identify which type of information and in which mode of expression information has an impact on consumer behaviour inside and outside the home, why and how it has an effect on sustainability, safety and nutrition. There is a need to target specific groups of the population (elderly, young people) and various socio-economic categories. There is a need for, at the individual level, better understanding of assessments of food safety/organoleptic/nutritional quality/waste (shelf life). In addition, consumers may have a need for understanding and trust in new food production methods, particularly with increased urbanization.

This Research Area Includes

- Developing methods and technologies improving transparency of what is sustainable within food systems for consumers and stakeholders
- Developing smart labelling of the sustainability of food and diets meeting the need of the consumers including e.g. chips and other IT solutions
- Understanding level of transparency and type and combination of information tools (databases, media, policies) affecting various types of consumer groups, and how this effects the consumers
- Understanding the impact of ICT technologies (smartphones and social media) and how combination of technologies affects changes in individuals' choices
- Development of ICT technologies to change individual consumer choices

Expected Outcome:

Enabling consumers to purchase and prepare sustainable food.

3.2.2 Cross-cutting Issues

SUSFOOD has identified cross-cutting challenges which need to be addressed as an integral part of the priority research areas:

- ***Equity and ethics***
  With reference to human rights, all research related to sustainable production and consumption needs to take food access and availability, infrastructure, and information and communication technologies into account. The vulnerability of a larger number of people and the increasing inequality between and inside countries imply that the access for all consumers, including lower-income people, to sustainable food should be addressed as a priority.

- ***Localisation of food chain activities***
  Research related to sustainable food production and consumption should be clear on I) the determinants of the localisation of the different activities at different geographical levels, II) how trends impact on re-localisation of activities, and III) the consequences of the re-localisation on the whole system.

  This includes the possible effect of/how localisation (production, manufacturing and consumption) affect actors in the food chain towards sustainable production and consumption (expanding "fair-trade" thinking to domestic products).

3.3. Next Steps

The SRA will be used actively

- for collaboration with other national and EU initiatives promoting sustainable food production and consumption in a food chain perspective
- to place sustainable food production and consumption high on the national agendas and in EU fora/programmes
- to encourage future collaboration between the SUSFOOD partners

Annex A.
Examples of initiatives in connection to SUSFOOD

RELATED PROJECTS	EXAMPLES OF INITIATIVES IN CONNECTION TO SUSFOOD
ERA-NETs[7]	
ICT-AGRI	**Coordination of European Research within ICT and Robotics in Agriculture and Related Environmental Issues:** • Global information systems regarding e.g. quality and traceability • Development of new sensors • Automated systems regarding production
ERA-CAPS	**Coordinating Action in Plant Sciences:** • Pursue the development of a common agenda for plant science in Europe. • Create a joint research programme • Through external engagement, ERA-CAPS will enable interaction between researchers, funders and relevant European initiatives
CORE Organic Plus	**Coordination of European Transnational Research in Organic Food and Farming:** • Sustainable production of high-quality food • Reduction of dependency on high energy and resource inputs • Improvement of environment and nature conservation • Climate change adaptation
RURAGRI	**Facing sustainability: new relationships between rural areas and agriculture in Europe:** • Urban development, i.e. urban or semi-urban economic activities, infrastructures and habitat, patterns of human and material flows • New technologies/production systems that reduce e.g. chemical inputs and improve water management • Development of new ecological products
ANIHWA	**Animal Health and Welfare of farm animals, including fish and bees:** • Systematic exchange of information and mapping of national research activities and facilities • Gap analysis • Development of a Strategic Research Agenda • Assessment of funding mechanisms and opportunities • Strategic activities
ERASYSBio	**Towards a European Research Area for Systems Biology - A Transnational Funding Initiative to Support the Convergence of Life Sciences with Information Technology & Systems Sciences:** • Synthetic biology, Metabolic bioengineering • Non-medical aspects of metagenomics • Modelling
SAFE-FOOD ERA	**Food Safety - Forming a European platform for protecting consumers against health risks:** • Process-induced risk - Health risks from chemical contaminants formed during processing of foods • Traceability - Documented and harmonised routines for recall of food products from the value chain - Development of reliable traceability methods and systems • New and/or re-emerging chemical or microbial risks in food production chains in an expanding European market
COFASP	Cooperation in Fisheries, Aquaculture and Seafood Processing: • Address actions based on results of the earlier ERA-NET MariFish and the running ERA-NET SEAS-ERA • Enter into the area of blue biotechnology

Joint Programme Initiatives	
HDHL	**The Healthy Diet for a Healthy Life:** • Ensuring the healthy choice is the easy choice for consumers • Developing high-quality, healthful, safe and sustainable food products • Preventing diet-related, chronic diseases and increasing the quality of life; delivering a healthier diet
FACCE	**Agriculture, Food Security and Climate Change:** • Safe, nutritious and affordable food of high quality • Sustainable food production • Breakthrough technologies able to face environmental transformations induced by climate change
OCEANS	**Healthy and Productive Seas and Oceans:** • Enable the advent of a knowledge-based maritime economy, maximising its value in a sustainable way • Ensure Good Environmental Status of the seas and optimise planning of activities in the marine space • Optimise the response to climate change and mitigate human impacts on the marine environment
European Technology Platforms	
European Technology Platforms	**ETPs offer great opportunity for interacting with industry and other stakeholders, comparing strategic thinking and possible joint implementation models. Relevant Technology Platforms include:** • Food for Life – healthier diet, quality food products, sustainable food production • ManuFuture – new high-added-value products, new manufacturing engineering, emerging manufacturing science and technologies • TP Organics – organic food quality, organic food processing, sustainable and healthy diets and food for health and well-being • Plants for the Future - healthy, safe and sufficient food, bio-energy production, consumer choice • SusChem – industrial biotechnology, new materials with tailored properties, reaction and process design
FP7 Projects and Other Initiatives	
FAHRE	• Mapping of food research funding, identifying the key players and processes involved at regional, national, and transnational level • Assessment of needs and capacities in food research addressing aspects such as infrastructure, equipment, etc. to identify gaps and overlaps • Explore areas where greater cooperation between countries may strengthen the ERA in food
FUSIONS	• Harmonisation of food waste monitoring • Improved understanding of the extent to which social innovation can reduce food waste

[7] These ERA-NETs and other bioeconomy relevant ERA-NETs are networked through the FP7 project PLATFORM, which provides for mutual learning and a forum for overarching strategic issues concerning ERA-NETs and the realisation of the European Research Area, the Innovation Union, Horizon 2020 and the European Bioeconomy.

Annex B. The processes of the Development of the SUSFOOD SRA

The SRA is developed through an interactive active process among the 25 partners from 16 European countries. SUSFOOD has used a variety of approaches to develop the SRA including mapping, using national and international foresight studies (see reference IV in annex C) and the simultaneously established online database (SUSFOOD MKB). Video-conferences, consultations of SUSFOOD governmental bodies, workshops for all partners and invited experts from other European initiatives and occasional special industrial expertise, and gathering insights from national consultations are other means used during the process.

The first step in developing the SRA was a mapping of gaps for sustainable food production and consumption in the light of the grand challenges as described in the existing foresights. The mapping was sketched-out in preparation material for a first workshop for all partners and invited experts. The material highlighted the mapping listing themes and sub-themes under four headings "Valorisation of food and food products", "Engineering of the food production chain for resource efficiency" and "Consumer preferences and behaviour" and "Horizontal issues in SUSFOOD". For each subtheme a list of research topics was attached to the preparatory workshop material.

Following presentations by experts, participants prioritized and modified the most (for them) important topics for the first three themes. These were as follows:

"Valorisation of food products":

- Alternative business strategies for low consumption
- Legal support for the registration of novel products
- Redesign waste and side flow strategies
- Policy coherence to help business to make sustainable food an easy choice for consumers

"Engineering of the food production chain for resource efficiency":

- Less water, less energy and less waste across the supply chain
- Harmonize methods and metrics to measure impact – environmental, social and economic impacts e.g. LCA
- New and future food processing technologies flexible and novel processes and automation techniques

"Consumer preferences and behaviour"

- Role of education in shaping consumer behaviour
- Attitudes and relationships between consumer behaviour and food choice
- Barriers and drivers (including access and affordability) to adopting healthy and sustainable diets
- Integrated assessment of nutritional quality (health influences) and sustainability of food products and their consumption
- Multi stakeholders' social learning processes for food system re-design, including open and public innovation, participation of different sizes of enterprise, social learning processes, education
- Personalized information systems (nutrigenetics) on nutrition and real-time availability of this nutritional info and sustainability info

The selected topics were then (within the groups) valued according to the Horizontal issues "Food system conception", "Reducing inequalities", "Localization of activities" and "The three dimensions of sustainability".

The outcome of the workshop was later streamlined, which resulted in eight research topics and four horizontal issues. To assess the eight topics and the four horizontal issues against the national research strategies and interests, a national consultation procedure was initiated.

The national consultation showed that in general there was a high level of consistency between the national priorities, but also that there was need for additional clarification of the content and alignment. This resulted in the eight included Research Areas and the two crosscutting issues, which have been supported by the SUSFOOD External Advisory Group and were finally been re-evaluated with a second national consultation.

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Partners

BELGIUM:	Instituut voor Landbouw- en Visserijonderzoek - ***ILVO***
DENMARK:	Københavns Universitet - ***UCPH***
	Styrelsen for Forskning og Innovation - ***DASTI***
ESTONIA:	Eesti Vabariigi Pollumajandusministeerium - ***EVPM***
FINLAND:	Maa ja Elintarviketalouden Tutkimuskeskus - ***MTT***
	Maa- ja Metsätalousministeriö - ***MMM***
France:	Institut National de la Recherche Agronomique - ***INRA***
	Agence Nationale de la Recherche - ***ANR***
	Le réseau français des instituts techniques de l'agroalimentaire - ***ACTIA***
GERMANY:	Bundesanstalt für Landwirtschaft und Ernährung - ***BLE***
	Bundesministerium für Ernährung und Landwirtschaft - ***BMEL***
	Forschungszentrum Jülich GmbH ***Jülich***
ITALY:	Ministero delle Politiche Agricole Alimentari e Forestali - ***MIPAAF***
NORWAY:	Norges Forskningsrad - ***RCN***
POLAND:	Narodowe Centrum Badan I Rozwoju - ***NCBiR***
ROMANIA:	Unitatea Executiva Pentru Finantarea Invatamantului Superior, A Cercetarii Dezvoltarii Si Inovarii - ***UEFISCDI***
SLOVENIA:	Ministrstvo za izobraževanje, znanost in šport - ***MIZS***
SPAIN:	Elika Nekazaritzako Elikagaien Segurtasunarako Euskal Fundazioa - ***ELIKA***
	Instituto de Fomento de la Region de Murcia - ***INFO Murcia***
	Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria - ***INIA***
SWEDEN :	Forskningsrådet för Miljö, Areella Näringar och Samhällsbyggande ***FORMAS***
The NETHERLANDS:	Ministerie van Economische Zaken - ***EZ***
The UNITED KINGDOM:	The Technology Strategy Board - ***TSB***
	The Secretary Of State for Environment, Food and Rural Affairs -***DEFRA***
TURKEY:	T.C. Gıda Tarım ve Hayvancılık Bakanlığı - ***GDAR***

Associated Partners in the Framework of the Calls

BELGIUM:	Agentschap voor Innovatie door Wetenschap en Technologie - ***IWT***
FRANCE & SPAIN:	Fondation Daniel et Nina Carasso - ***FDNC***
GERMANY	Bundesministerium für Bildung und Forschung - ***BMBF***

SUSFOOD External Advisory Group

BEUC, European Consumer Organisation	Camille Perrin, *Belgium*
BEE, European Environmental Bureau	Mikael Karlsson, *Belgium*
PLATFORM, FP7 ERA-net	Christine Bunthof, *The Netherlands*
FACCE, Joint Programming Initiative, Agriculture, Food Security and Climate Change	Heather McKahnn, *France*/Isabelle Albouy, *France*
HDHL, Joint Programming Initiative, A Healthy Diet for a Healthy Life	Pamela Byrne, *Ireland*/Wim Saris/Casper Zulien de Swarte/Jolien Wenink, *the Netherlands*
Oceans, Joint Programming Initiative, Healthy and Productive Seas and Oceans	Kristinn Thorud, *Norway*
Food for Life, European Technology Platform	Ulf Sonesson, *Sweden*
Plants for the Future, European Technology Platform	Grégoire Berthe, *France*/Jean-Claude Guilllon, *France*
TP Organic, European Technology Platform	Bram Moeskops, *Belgium*
FUSION, FP7 Collaborative and Support Action	Toine Timmermans, *the Netherlands*
FOOD MANUFUTURE, FP7 Collaborative and Support Action	Lisbeth Munksgaard, *Denmark*
inprofood – Towards sustainable Food Research, FP7 Research Project	Klaus Hadwiger, *Germany*
SENSE, FP7 Research project	Begoña Pérez Villarreal, *Spain*
Food and Drink Europe, European Food and Drink Industry	Beate Kettlitz, *Belgium*
EuroCommerce, Retail, wholesale and international trade sectors in Europe	Christel Delberghe, *Belgium*
EUREKA, International platform for Research and Development	Puck ten Kate, *the Netherlands*/Martijn Lammers, *the Netherlands*, Maarten Schans, *the Netherlands*
EuropaBio, European Association of Biotechnology Industries	Carel du Marchie Sarvaas, *Belgium*/ Nathalie Moll, *Belgium*
Food Force, Research Association	David Boxer, *United Kingdom*
Marine Stewardship Council, international non-profit Organsiation	Edouard Le Bart, *France*
SCAR, Standing Committee on Agricultural Research	Egizio Valceschini, *France*
JRC-IRMM, Joint Research Centre, Institute for Reference Materials and Measurements	Elke Anklam, *Belgium*
IDDRI, Institute for Sustainable Development and International Relations	Sébastien Treyer, *France*

SUSFOOD Observers

MAAF, Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt, *France*
MENESR, Ministère de l'Education nationale, de l'enseignement supérieur et de la recherche, *France*
MRI, Max Rubner-Institut, *Germany*
vTi, Johann Heinrich von Thünen-Institut**,** *Germany*

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SEVENTH FRAMEWORK PROGRAMME