



Brussels, 21.9.2016
SWD(2016) 319 final

COMMISSION STAFF WORKING DOCUMENT

European Research and Innovation for Food and Nutrition Security

Staff Working Document on European Research and Innovation for Food and Nutrition Security

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Introduction

This document sets out how EU Research and Innovation (R&I) policy contributes to the major global challenge of ensuring food and nutrition security (FNS). It is a first step in the further development of a more coherent approach to European R&I which aims at mobilising resources and stakeholders to set out aligned R&I agendas in response to recent international political drivers such as the Sustainable Development Goals and the COP 21 climate commitments. It also aims to respond to the current EU political priorities of growth, jobs and investments, an energy union for a low-carbon, secure and competitive economy, the digital single market, a more democratic Union, Europe as a stronger global actor and the circular economy package¹.

The document takes stock of key achievements and developments within EU R&I policy in support of FNS. It serves as input to debates taking place during the European Commission High Level Conference of 12-13 October 2016 entitled *FOOD 2030: Research and Innovation for tomorrows' nutrition and food systems*².

1. Food and Nutrition Security

1.1. Food and Nutrition Security: A Global Issue

Providing FNS in a changing world is an urgent objective due to the increasingly interconnected challenges of natural resource scarcity, climate change, and population growth, which affect European and food systems globally. Ensuring FNS in the long term requires adopting a **food systems** approach underpinned by sustainability³, linking land and sea, and encompassing the entire 'food value chain'. Such an approach should include:

- the sustainable management of land, soil, inland and marine waters, and biodiversity as providers of ecosystem services upon which food production relies;
- primary production practices of agriculture, aquaculture and fisheries providing food and animal feed, including production-specific inputs of nutrients, energy, seeds, plant protection issues, and equipment, harvesting, and storage;
- food processing of primary and value-added food and feed products, including packaging, distribution and logistics;
- food preparation and consumption, as well as;
- the handling of food and related non-food waste streams.

The definition of food systems goes beyond the production and delivery of sufficient food for all (quantity) to include the provision of safe and nutritious food for healthy and sustainable diets (quality). R&I will play a critical role in making our food systems future-proof: more sustainable, resilient, responsible, diverse, competitive, and inclusive:

- Sustainable: with respect to natural resource scarcity and in respect of planetary boundaries⁴;
- Resilient: with respect to adapting to climate and global change, including extreme events and migration;
- Responsible: with respect to being ethical, transparent and accountable;

¹ http://europa.eu/rapid/press-release_SPEECH-15-5243_en.htm

² <http://ec.europa.eu/research/conferences/2016/food2030/index.cfm?pg=home>

³ Food systems should be environmental sustainability, in terms of issues such as climate change, biodiversity, water and soil quality

⁴ Johan Rockström et al.: *A safe operating space for humanity*. *Nature*. 461, 2009

- Diverse: with respect to being open to a wide range of technologies, practices, approaches, cultures and business models;
- Competitive: with respect to providing jobs and growth;
- Inclusive: with respect to engaging all food system actors, including civil society, fighting food poverty, and providing healthy food for all.

Food systems provide food products and services that are essential to humanity, but at the same time exert pressure on ecosystems and the environment. The global food system produces 4 billion tonnes of food, over 90 % of which is produced from land, and the rest from inland and marine waters⁵. Food production from fisheries and aquaculture has been increasing since 1950 exceeding 160 million tons in 2014⁶. Some studies have concluded that total food production should be increased by at least 60 % to feed a world of more than 9 billion people by 2050⁷. Other studies state that the solution lies not in increasing production but rather in improving access to and distribution of food as well as changing diets and reducing food waste⁸. Approximately 1.3 billion tonnes of food are lost or wasted each year⁹ representing 33 % of the total food produced for human consumption.

Pressures on the environment

Food production is by far the largest user of global freshwater¹⁰ supplies, with agriculture being responsible for 70 % of consumption¹¹. Industrial activities related to food systems require approximately 26 % of the EU's energy consumption¹². Food production accounts for 60 % of global terrestrial biodiversity loss. Including primary production, the food sector accounts for more than 25 % of global greenhouse gas emissions^{13,14,15}.

The expected 76 % rise in the global appetite for meat and animal products by 2050 could increase greenhouse gases by 80 %¹⁶ calling for action to mitigate climate change induced by livestock¹⁷. This dietary shift is a further threat to sustainability given the high resource footprint of producing animal-derived food products, a factor underpinning a growing interest amongst some consumers for more 'sustainable diets' based upon alternative sources of protein. It can also be observed that demand-side approaches and policies to support a shift towards healthier and more sustainable diets are emerging^{18,19,20}.

⁵ <http://www.grida.no/publications/rr/food-crisis/page/3562.aspx>

⁶ FAO State of World Fisheries and Aquaculture 2016, <http://www.fao.org/3/a-i5555e.pdf>.

⁷ <http://www.fao.org/news/story/en/item/35571/icode/>

⁸ Bajželj B, Benton T G, Clark M, Garnett T, Marteau T M, Richards K S, Smith P, Vasiljevic M (2015). Synergies between healthy and sustainable diets. Brief for GSDR 2015. <https://sustainabledevelopment.un.org/content/documents/635987-Bajzelj-Synergies%20between%20healthy%20and%20sustainable%20diets.pdf>

⁹ <http://www.fao.org/save-food/resources/keyfindings/en/>

¹⁰ Much of irrigated water in drier areas is "grey" water, in Cyprus could be something like 80 %

¹¹ United Nations Educational Scientific and Cultural Organization 2001a. *Securing the Food Supply*. Paris: UNESCO.

¹² Energy use in the EU food sector: State of play and opportunities for improvement. JRC 2015

¹³ <http://www.sciencedirect.com/science/article/pii/S0306919210001132>

¹⁴ <https://ccafs.cgiar.org/bigfacts/#theme=food-emissions>

¹⁵ Bojana Bajželj, Julian M. Allwood, Jonathan M. Cullen (2013), "Designing Climate Change Mitigation Plans That Add Up", *Environ Sci Technol*. 2013 Jul 16; 47(14): 8062–8069. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3797518/>

¹⁶ Growing Greenhouse Gas Emissions Due to Meat Production, UNEP 2012.

¹⁷ Mario Herrero et al (2016), Greenhouse gas mitigation potentials in the livestock sector, *Nature Climate Change* 6, 452–461 (2016) doi:10.1038/nclimate2925, <http://www.nature.com/nclimate/journal/v6/n5/abs/nclimate2925.html>

¹⁸ World Resource Institute (2016), Shifting Diets for a Sustainable Food Future, Creating a Sustainable Food Future, Installment Eleven, <http://www.wri.org/publication/shifting-diets>

¹⁹ Tara Garnett et al (2016), What works? A review of the evidence of the effectiveness of interventions aimed at shifting diets in more sustainable and healthy directions, Food Climate Research Network, Environmental Change Institute & The Oxford Martin Programme on the Future of Food, The University of Oxford, Chatham House, The Royal Institute of International Affairs, http://www.fcrrn.org.uk/sites/default/files/fcrn_chatham_house_0.pdf

²⁰ Chatham House (2015), Changing Climate, Changing Diets: Pathways to Lower Meat Consumption, <https://www.chathamhouse.org/publication/changing-climate-changing-diets#sthash.TjS1sowv.dpuf>

The growing demand for seafood²¹ also puts significant pressure on marine ecosystems²². The share of fish stocks within biologically sustainable levels has exhibited a downward trend, declining from 90 % in 1974 to 68.6 % in 2013. Of all the stocks assessed in 2013, 58.1 % were fully fished and 10.5 % under fished. In addition, environmentally destructive fishing practices (e.g. the use of bottom-contacting gears disturb benthic habitats) have an adverse impact on seafloor integrity. As global marine capture production has levelled off or has only slightly increased since 1988, how do we satisfy the growing demand for seafood? Although desirable, the expansion of aquaculture, may also put additional pressure on fish stocks due to an increased demand for fish feed, and may have additional negative impacts on the environment (e.g. addition of solids and nutrients to the marine environment, changes in sediment chemistry, farm discharges etc.).

In addition to resource use, the global food system is heavily dependent upon input-intensive crop monocultures and industrial-scale feedlots. This type of production makes food systems highly reliant on chemical fertilizers, pesticides and the preventive use of antibiotics, which can lead to a lower resilient system, negative environmental impacts and societal and health vulnerabilities²³.

Whether on the sea, the land, or in the factory, the actors responsible for our food systems are also the largest group of natural resource managers in the world and thus critical agents of change in any transformation of current consumption and production systems. This complexity and diversity of responsibility is one of the major challenges to the future-proofing of our food systems.

Public health, diets and food safety

Approximately 795 million people, or one in nine of the global population, suffer from chronic undernourishment²⁴, while nearly two billion people worldwide are overweight or obese²⁵. These factors contribute to an increase in the incidence of non-communicable diseases that kill 38 million people each year²⁶, the most common of which are cardiovascular disease, cancer, chronic respiratory, and diabetes²⁷. Depression, musculoskeletal diseases and unhealthy lifestyle factors like physical inactivity are also associated with reduced on-the-job productivity. Evidence suggests that ill-health in the working population leads to substantial productivity losses including absenteeism at 3 % to 6 % of working time, representing a yearly cost of about 2.5 % of GDP, job loss (10 % of the people who were previously employed left their job mainly for health reasons), premature retirement, or premature mortality. Almost a quarter of people currently employed suffer from some form of chronic disorder, many of which affected by obesity. Furthermore, the over consumption of animal based products, as well as of ultra-processed food (often containing ‘empty calories’ and promoted due to their higher profit margins) undermines public health as they also contribute to obesity-related diseases²⁸.

²¹ 'Seafood' comprises marine and fresh water biological resources (as defined in the Common Fisheries Policy) from both fisheries and aquaculture.

²² World Resource Institute (2014), Improving Productivity and Environmental Performance of Aquaculture, Creating a Sustainable Food Future, Instalment Five, <http://www.wri.org/publication/improving-aquaculture>

²³ IPES-Food. 2016. From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agro-ecological systems. International Panel of Experts on Sustainable Food systems.

²⁴ <http://www.fao.org/3/a4ef2d16-70a7-460a-a9ac-2a65a533269a/i4646e.pdf>

²⁵ <http://www.who.int/mediacentre/factsheets/fs311/en/>

²⁶ WHO fact sheet on Noncommunicable diseases. <http://www.who.int/mediacentre/factsheets/fs355/en/>

²⁷ WHO Factsheets

²⁸ UNEP (2016) Food Systems and Natural Resources. A Report of the Working Group on Food Systems of the International Resource Panel

Food safety issues on a global level continue to be of concern with an estimated 600 million people – almost one in twelve people globally – falling ill after eating contaminated food, and with 420,000 food safety related deaths every year²⁹.

Food in Society

Food is far more than just a commodity that keeps us alive. It provides jobs and livelihoods and is heavily enriched with historical, cultural, and social values that play a vital role in the way we build our cities, live, thrive, interact, and ultimately contributes to our identity. Food allows to build and develop communities and helps us to socialize, through joint cooking or sharing meals. Examples of social innovation include urban agriculture or community gardening.

The Political Impetus for Ensuring Food and Nutrition Security

The importance of ensuring FNS and the need for global action was highlighted in September 2015 where the world's Heads of State and Governments adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs). These goals will frame global action on sustainable development until 2030 and at least nine of SDGs are of direct FNS relevance. This was followed in December 2015 by the agreement reached during COP 21 in Paris, where the threats to FNS from climate change were highlighted. Over the coming years, the Intergovernmental Panel on Climate Change (IPCC) will prepare special reports on oceans, climate change, desertification, land degradation, sustainable land management, food security and GHG fluxes in terrestrial ecosystems³⁰. The G7 has recently put forward a *Vision for Action on Food Security and Nutrition* which identifies collective actions in three focus areas, namely: empowering women, improving nutrition through a people-centred approach, and ensuring sustainability and resilience within agriculture and food systems³¹. The International Panel of Experts on Sustainable Food Systems (IPES-FOOD) has recently reported that a paradigm shift is necessary to save current food systems from collapse³². Also, a recent UNEP report has called for further research and innovation efforts to decouple food production from resource use and environmental impacts. Finally, the 2016 OECD 'Alternative Futures for Global Food and Agriculture' report explores three contrasting scenarios to illustrate alternative food futures that highlight the fundamental uncertainties surrounding forward-oriented decision making, and point to the crucial importance of international co-operation across multiple policy areas³³. All these initiatives and policy drivers mentioned above will have a significant and direct impact on European FNS R&I agenda-setting where R&I will be called upon to provide effective solutions to tackle the underlying societal challenges.

1.2. Food and Nutrition Security in a European Context

European heritage and identity are strongly associated with agriculture, food production and consumer satisfaction. This is an almost unique global situation dating from the time of the Roman Empire with its vineyards and olive trees plantations scattered across provinces. It

²⁹ World Health Organisation, 2015. WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015. WHO Library Cataloguing-in-Publication Data. Printed in Switzerland. ISBN 978 92 4 156516 5

³⁰ https://www.ipcc.ch/news_and_events/pdf/press/160414_pr_p43.pdf.

³¹ <http://www.mofa.go.jp/files/000159932.pdf>

³² http://www.ipes-food.org/images/Reports/UniformityToDiversity_FullReport.pdf

³³ <http://www.oecd.org/publications/alternative-futures-for-global-food-and-agriculture-9789264247826-en.htm>

continues in modern food production and consumption patterns and their effect on European economy and trade. Moreover food brings people together, thus playing an important role in shaping our culture. The impact of agriculture, aquaculture, fisheries and food production on the economy and society is visible through the centuries. Nowadays it is modern, intensive and multi-functional, yet deeply rooted in its heritage, European agriculture and food production provide an unparalleled diversity of world-renowned food products manufactured according to the most rigorous sanitary standards.

Food as a commodity is part of a larger system called the bioeconomy, which includes the production of biomass and the conversion of biomass into value added products, such as food, feed, bio-based products and bioenergy. It thus includes the sectors of agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of the chemical, biotechnological and energy industries. According to the Standing Committee of Agricultural Research (SCAR), 14 % of global biomass demand in 2011 has been for food and 58 % for feed³⁴. In Europe 61 % of the biomass is mainly consumed for food and animal feed. The 'food, beverage and tobacco' and 'agriculture' sectors are the leading European bioeconomy markets in terms of turnover and employment at 50 % and 19 % respectively. As far as employment is concerned, these same sectors, with the addition of fisheries and aquaculture, provide over 80 % of bioeconomy-related jobs in Europe³⁵.

These three European food-related sectors employ one fifth of the workforce, or 48 million people across 11 million farm holdings, 300,000 food and drink manufacturers (99 % of them SMEs), 1.3 million wholesalers and retailers, and 1.4 million service companies³⁶. These companies contribute 6 % of Europe's GDP and 7 % of external EU trade, mostly in value-added food products. In particular, the food sector faces challenges³⁷ and offers opportunities in international and European markets. A recent study on 'The competitive position of the European food and drink industry' stated that despite positive developments on external trade, economic growth in the EU food and drink industry (Europe's biggest manufacturing sector in terms of jobs and value added) is lagging behind comparable economies³⁸. The food and drink industry, being so closely linked with European culture, also has an important role in the health and wellbeing of EU citizens. In addition, private actors in the food chain have a key role in reducing food waste, especially in modern food systems, as well as in making healthy and sustainable food choices easier for consumers.

The European food sector unites centuries of know-how with innovation in areas such as packaging, storage, transportation and marketing. Thanks to its size and importance, the EU food sector acts as a global benchmark. It is diversified yet standardized, traditional yet highly innovative, local but integrated and consumer-driven. European standards have a global impact on land use, and on food hygiene and consumption, with many worldwide recognized Michelin awarded chefs and restaurants. The European food sector is connected with our history, heritage and identity, with our diversified culture and way of life. Last but not least, it is a unique asset that gives Europe a competitive advantage and improves our trade balance.

³⁴ European Commission (2015), Sustainable Agriculture, Forestry and Fisheries in the Bioeconomy - A Challenge for Europe, 4th SCAR Foresight Exercise <https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none>

³⁵ Ronzon, T., Santini, F. & M'Barek, R. The Bioeconomy in the European Union in Numbers (2015); available at <http://go.nature.com/291rc3I>

³⁶ http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:From_farm_to_fork_-_food_chain_statistics

³⁷ New Economics Foundation (2015), Urgent recall - Our food system under review,

http://b3cdn.net/nefoundation/1bfd1f66401d3b5f4b_fsm6vjoti.pdf

³⁸ [http://bookshop.europa.eu/en/the-competitive-position-of-the-european-food-and-drink-industry-pbEA0416075/.](http://bookshop.europa.eu/en/the-competitive-position-of-the-european-food-and-drink-industry-pbEA0416075/)

Although the European food sector complies with the highest standards on food safety, it is not immune to the global challenges described in section 1.1 and is witnessing similar negative trends with respect to the rise in obesity, food losses and waste, and decline in soil and water quality. For example the exponential growth in EU nutrient use associated with food production, for crops fertilized with liquid manure, slurry and mineral fertilisers, has resulted in negative impacts on soils, water and air³⁹. Overall, agriculture accounts for 70 % of nitrous oxide emissions in Europe and the food chain dominates nitrogen and phosphorous losses to groundwater and surface water⁴⁰.

Regarding nutrition, a balanced and varied diet composed of a wide range of nutritious and tasty foods, adds years to life and life to years. Unhealthy diets, overweight and obesity contribute to a large proportion of non-communicable diseases, including cardiovascular diseases, type 2 diabetes and some cancers, which together are the first cause of death in Europe. Simultaneously, in some countries and among some vulnerable groups, under nutrition remains a concern⁴¹. Recent studies suggest that even in high income countries such as Germany, UK, Netherlands and Denmark levels of food insecurity are relatively high⁴². In 2014, 122 million people (24.4 %) were at risk of poverty or social exclusion and among them 55 million people (9.6 %) were not able to afford a regular quality meal every second day⁴³. Risk of poverty is an increasing issue for food insecurity in Europe: Focusing on the indicator 'inability to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day', in 2013, 55 million people (11 %) reported in 2013 that they were in this situation. This figure is regional-dependent: The percentage of people who cannot afford a regular quality meal every second day ranged from less than 3 % in the Netherlands, Portugal, Spain, Sweden, Denmark and Luxembourg to 25.3 % in Latvia, 32 % in Hungary and a maximum of 51.9 % in Bulgaria⁴⁴. Most Member States now have government-approved policies that aim to promote healthy diets, tackle the growing rates of obesity, and ensure nutrition and food security. Policy developments from across the region indicate that improvements to nutrition and diet require the engagement of many different government sectors and will need to involve action by both the public and private sector⁴⁵.

As a means to respond to the challenge of FNS, the EU has devised cross-cutting and targeted policies and deployed regulations, directives and strategies. The main European FNS-related policies include the Common Agricultural Policy (CAP) and the Common Fisheries Policy (CFP), which are farming and production focussed. These are complemented by environmental policy instruments like the Water Framework Directive and Marine Strategy Framework Directive (MSFD), general food safety law, and internal market rules covering the protection of human, plant and animal health, and the European Commission's 2012

³⁹ Buckwell, A. Nadeu, E. 2016. *Nutrient Recovery and Reuse (NRR) in European agriculture. A review of the issues, opportunities, and actions*. RISE Foundation, Brussels. http://www.risefoundation.eu/images/stories/NRR/NRR_RISE_2016.pdf

⁴⁰ Sutton, M., Howard, C.M., Erisman, J.W., Billen, G., Bleeker, A., Grennfelt, P., van Grinsven, H. and Grizzetti, B., eds. (2011) *The European Nitrogen Assessment*. Cambridge: Cambridge University Press. <http://www.nine-esf.org/ENA-Book>

⁴¹ Adapted from WHO: <http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/nutrition>

⁴² Germany: S. Pfeiffer, T. Ritter and E. Oestreicher (2015). Food Insecurity in German households: Qualitative and Quantitative Data on Coping, Poverty Consumerism and Alimentary Participation. *Social Policy and Society*, 14, pp 483-495 doi:10.1017/S147474641500010X, The Netherlands: Neter JE, Dijkstra SC, Visser M, et al. (2014). Food insecurity among Dutch food bank recipients: a cross-sectional study. *BMJ Open*;4:e004657. doi:10.1136/bmjopen-2013-004657, England: Cooper, N., Purcell, S. and Jackson, R. (2014). Below the Breadline: The Relentless Rise of Food Poverty in Britain, Manchester, Oxford, Salisbury: Church Action on Poverty, Oxfam, TrusselTrust; Denmark: A. Nielsen, T. Bøker Lund and L. Holm (2015). The Taste of 'the End of the Month', and How to Avoid It: Coping with Restrained Food Budgets in a Scandinavian Welfare State Context. *Social Policy and Society*, 14, pp 429-442. doi:10.1017/S1474746415000056.

⁴³ Eurostat 2015: <https://www.eurofoodbank.eu/poverty-waste/food-poverty>

⁴⁴ Eurostat 2014: Percentage of people who cannot afford a regular quality meal every second day. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_mdex03&lang=UK

⁴⁵ Adapted from WHO: <http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/nutrition>

Bioeconomy Strategy. FNS-relevant policies in the EU are further accompanied by ambitious policies on development cooperation, notably the 2010 EU policy framework on food security, and international trade. Furthermore, in October 2014, the Council of the EU invited the Commission to examine “the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation and sequestration”⁴⁶. Overall, the EU FNS policy landscape is quite rich and of a very high standard.

2. Food and Nutrition Security and the Current Research and Innovation System in Europe

As the R&I system has to play a significant role in providing solutions for long term FNS, a clear understanding of the R&I landscape in Europe and the world is critical for its success. The challenge of ensuring FNS through R&I has become increasingly prevalent on the global political agenda, as outlined in section 1.1. Furthermore, the 2015 Milan World Expo 'Feeding the Planet, Energy for Life' discussed the challenges for research and innovation in food and nutrition, and the Expo 2015 EU Scientific Steering Committee presented a number of specific recommendations⁴⁷. These highlighted the need for R&I to promote multidisciplinary and integrated approaches, to encourage the participation of and information to the public, to improve the impact of innovation and to explore the merits of establishing an international mechanism for FNS akin to the way the United Nations was addressing climate change through the IPCC. The Milan EXPO 2015 led to the 'Milan Charter'⁴⁸ which translates the discussions on global sustainable food systems into concrete societal commitments by public authorities, citizens, civil society and businesses. In parallel, 100 cities signed on 15 October 2015 the Milan Urban Food Policy Pact⁴⁹ that showed the commitment for the coordination of international food policies at local level.

The 2015 fourth foresight exercise of the EU Member States Standing Committee on Agriculture Research, (SCAR)⁵⁰ highlighted the need for system-based approaches in the context of the development of the bioeconomy and the need for policy coherence, which included R&I system for agriculture, fisheries, aquaculture and forestry in Europe. It claims that in order for the bioeconomy to achieve its multiple goals of food security, environmental care, energy independence, climate change mitigation and adaptation and employment creation, it needs to be implemented according to the following set of principles: food first, sustainable yields, cascading approach, circularity and diversity. It furthermore proposes eight R&I priority issues to be addressed⁵¹, while highlighting that R&I ought to be built upon a knowledge and innovation system that should be challenge-oriented, transdisciplinary, socially distributed, reflexive, needing new rewarding and assessment systems, and helping to build competencies and capacities. Furthermore, it recommends the need for better policy coherence.

⁴⁶ http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf

⁴⁷ http://europa.eu/expo2015/sites/default/files/files/Expo-Documents_1115_BD.pdf

⁴⁸ <http://carta.milano.it/en/>

⁴⁹ <http://www.milanurbanfoodpolicyact.org/wp-content/uploads/2016/06/Milan-Urban-Food-Policy-Pact-EN.pdf>

⁵⁰ <https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none>

⁵¹ New paradigms for primary production based on ecological intensification; emerging enabling technologies: the digital revolution; resilience for a sustainable bioeconomy; the new energy landscape; business and policy models for the bioeconomy; socio-cultural dimensions of the bioeconomy; governance and the political economy of the bioeconomy and foresight for the biosphere.

According to FoodDrinkEurope, EU R&I investment by the food and drink sector is 0.27 % of the sector's turnover⁵² which is half as high as in the US and one third of the Japanese value. Studies have demonstrated that it would be profitable to invest more in agricultural R&D⁵³. Food is derived from human interaction with natural habitats and ecosystems and the need for their preservation, while also maintaining public health has resulted in quite traditional industrial structures but ones which are becoming increasingly open to innovation. In fact, the study on 'The competitive position of the European food and drink industry' states that most innovations can be characterised as 'incremental innovations or imitations', while truly innovative products are only 3 % of new products⁵⁴. However the introduction of innovative practices and services in the food sector is now becoming more prevalent. This can be seen from the advances made in information and communication technologies (ICT) and innovation from other diverse cross cutting and ancillary sectors which provide interesting opportunities to help scale-up FNS R&I like 3D food printing, urban agriculture, aquaponics, nutritional additives, and advanced manufacturing. Further R&I investments are also needed to support radical innovation towards more environmentally friendly processes and technologies in order to ensure FNS while preserving and improving natural capital and public health.

The development of innovative technologies, approaches and business models for food systems is a crucial factor for boosting the competitiveness of the European industry⁵⁴. In 2016 the EC issued two fundamental notes on innovation and on sustainability. "*Opportunity Now! Europe's mission to innovate*"⁵⁵ calls upon Europe to "innovate our way to social inclusion and sustainability as well as to productivity, growth and jobs". It claims that focus is needed on people, places and processes and that open governance, open innovation and open global cooperation are crucial. According to "*Sustainability Now!*"⁵⁶, Europe urgently needs to introduce sustainability concepts into its domestic and foreign policies. Agriculture and food are highlighted as one of the sustainability hotspots in need of transformative change and suggest that for a sustainable society, economic growth must be compatible with planetary boundaries and fairly distributed among its citizens: "Europe has a track record for inclusive growth, somehow lost in the last decades. It needs to strive for a new vision: living well and sharing fairly within the limits of the planet."

Food systems are complex and diverse in that they connect multiple industrial sectors, scientific disciplines and actors, operating at multiple geographical scales – from local to global. The compounded effects of climate change, resource scarcity and increasing demands due to demographic pressure add further complexity and uncertainty with respect to their sustainability and resilience in the long term. A way in which to tackle such complexity is to breakdown the issue into manageable parts. As such, the following table outlines some of the main challenges that threaten FNS, the EU R&I priorities (with examples) through which they are being addressed, and the most relevant European and international policies responding to the challenges.

⁵² Data & Trends of the European Food and Drink Industry 2013-2014

⁵³ Alston, J. (2010), "The Benefits from Agricultural Research and Development, Innovation, and Productivity Growth", OECD Food, Agriculture and Fisheries Papers, No. 31, OECD Publishing. <http://dx.doi.org/10.1787/5km91nfsnkwg-en>

⁵⁴ <http://bookshop.europa.eu/en/the-competitive-position-of-the-european-food-and-drink-industry-pbEA0416075/>.

⁵⁵ http://ec.europa.eu/epsc/publications/notes/sn15_en.htm

⁵⁶ http://ec.europa.eu/epsc/pdf/publications/strategic_note_issue_18.pdf

EU R&I in agriculture, fisheries and food and nutrition research and innovation began in 1988 with the second Framework Programme for Research and Technological Development. Over seven consecutive Framework Programmes, the EU will have invested over five billion EUR in agriculture, food and fisheries R&I. The overall result has been the establishment of thousands of pan-European R&I networks that have contributed significantly to capacity building and training, an extensive range of peer-reviewed academic knowledge and intellectual property, along with numerous market-led products, prototypes and services. Moreover EU and Member State R&I has led to related and parallel private and public developments which have improved the competitiveness of European industry and helped retain the EU as a leading global food trading bloc.

As we continue to exhaust planetary resources at our current speed of 1.6 planets per year⁵⁷, we will not be able in the long term to sustain the growing population: Among the conclusions of the 3rd SCAR Foresight exercise⁵⁸, it has been noted that many of today's food production systems compromise the capacity of Earth to produce food in the future. Thus future sustainability underpins the most pressing challenges of FNS R&I which are demarcated in table 1 across the following four priorities:

1. **NUTRITION for sustainable and healthy diets:** Ensuring that nutritious food and water is available, accessible and affordable for all. It involves reducing hunger and malnutrition, ensuring high levels of food safety and traceability, reducing the incidence of non-communicable diet-related diseases, and helping all citizens and consumers adopt sustainable and healthy diets for good health and wellbeing.
2. **CLIMATE smart and environmentally sustainable food systems:** Building climate smart food systems adaptive to climate change, conserving natural resources and contributing to climate change mitigation. It seeks to support healthy, productive and biodiverse ecosystems. Ensuring diversity in food systems (including production, processing, distribution and logistics) including in terms of cultural and environmental diversity. Natural resources (water, soil, land and sea) are used sustainably within the planetary boundaries and available to future generations.
3. **CIRCULARITY and resource efficiency of food systems:** Implementing resource-efficient circular economy principles across the whole food system while reducing its environmental footprint. Circularity is applied for sustainable and resource-efficient food systems and food losses and waste are minimized throughout.
4. **INNOVATION and empowerment of communities:** Boosting innovation and investment, while empowering communities. A broad innovation ecosystem leading to new business models and value-added products, goods and services, meeting the needs, values and expectations of society in a responsible and ethical way. More and better jobs across the EU, fostering thriving urban, rural and coastal economies and communities. Through closer partnerships with industry and food producers, markets that function in a responsible manner thereby fostering fair trade and pricing, inclusiveness and sustainability. Scientific evidence and knowledge from a wide

⁵⁷ <http://www.overshootday.org/>

⁵⁸ Sustainable food consumption and production in a resource-constrained world, 3rd SCAR foresight exercise, <http://bookshop.europa.eu/en/sustainable-food-consumption-and-production-in-a-resource-constrained-world-pbKI3111097/>

diversity of actors underpinning the development and implementation of FNS relevant policies, at all geographical scales (Local to Global).

Table 1: Outline of selected main challenges for FNS, the EU R&I priorities and relevant European and international policies.

Challenges	R&I Priorities	Relevant Policies
NUTRITION & HEALTH		
Malnutrition and hunger	Sustainable and healthy diets	UN SDGs 2, 3 & 6
Obesity and the rise of non-communicable diseases	Personalised nutrition	WHO Health policies
Food safety issues and crises	Alternative proteins sources	EU-Global Food Security
Rising protein demand	Sustainable aquaculture for greater seafood uptake	EU-Blue Growth Strategy EU-Food Safety Policy
Unhealthy and unsustainable diets	Nutrient enriched foods	EU-Health Policy
	Public health systems, societal awareness, consumer behaviour	EU-Global Food Security Policy
	Food safety and traceability	
CLIMATE & SUSTAINABILITY		
Food systems not resilient to changing climate	Climate Smart food systems that mitigate and adapt to climate change, while ensuring environmental sustainability	UN SDGs 11, 13 & 14 COP21 Climate Change
Ensure food quantity and quality in a changing climate	GHG mitigation via good soil management and demand-side approaches	EU-Global Food Security
Ensure food systems also contribute to mitigating GhG emissions	Drought and flood resistant crops	EU-Common Agricultural Policy
Food scarcity and poverty-induced migration	Pest management in a changing climate	EU-Rural Development Fund EU-Common Fisheries Policy
Protect biodiversity	Biodiversity conservation	EU-Development Cooperation
	Biofertilizers	EU-Environment Policies (Marine Strategy Framework Directive, Water Framework Directive)
	Agro ecological intensification	EU-Conservation policies
	Soil, water and land remediation	
	Healthy plants and animals	
CIRCULARITY & RESOURCE EFFICIENCY		
Resource efficiency in food systems	Increase resource efficiency and circularity (land, water,	UN SDGs 7 & 12

<p>Environmentally sustainable food systems</p> <p>Healthy ecosystems to provide sustainable ecosystems services for food production</p> <p>Polluted ecosystems suffering from intensive production practices</p> <p>Limit or reuse food waste for multiple uses</p>	<p>energy, soil, fertilizers, etc) across the food system</p> <p>Reduction and multiple uses of food losses and waste</p> <p>Reuse of fish discards</p> <p>Reuse of fodder for enhancing soil organic matter and reducing soil erosion</p> <p>Smart precision farming to reduce agricultural inputs</p>	<p>COP21 Climate Change</p> <p>EU-Common Agricultural Policy</p> <p>EU-Rural Development Fund</p> <p>EU-Common Fisheries Policy</p> <p>EU-Environment Policies (MSFD, WFD, Circular Economy Package)</p> <p>EU-Global Food Security Policy</p>
INNOVATION & COMMUNITIES		
<p>Make food systems sustainable, resilient, responsible, diverse, competitive and inclusive</p> <p>Empower and engage communities, civil society and consumers in food systems</p> <p>Strengthen rural, urban and coastal communities around food and nutrition security</p> <p>Increase the level of food and nutrition literacy of consumers</p> <p>Unsustainable and unhealthy consumer behaviour</p> <p>Boost new skills, jobs and business models for better functioning food systems</p>	<p>Boosting innovation</p> <p>Empowering communities and consumers in FNS</p> <p>Food in cities: water, energy, health nexus. Short circuits</p> <p>Boosting investment in public and private sector R&I FNS</p> <p>Encouraging Responsible Research and Innovation in food systems</p> <p>Open Science and access to data and information in FNS</p> <p>Quadruple helix innovation, multi-actor and public engagement in food systems</p> <p>Education, skills development and capacity building in FNS and food science</p> <p>New sources of income for farmers and fishers</p> <p>New business models and inclusive/open/eco-/sustainable innovation</p> <p>FNS start-up financing</p>	<p>SDGs 1, 8, 9 & 11</p> <p>COP21 Climate Change</p> <p>EU-Global Food Security</p> <p>EU-European Fund for Strategic Investment</p> <p>EU-Common Agricultural Policy</p> <p>EU-Rural Development Fund</p> <p>EU-European Structural and Investment Funds</p> <p>EU-Common Fisheries Policy</p> <p>EU-Food Safety Policy</p> <p>EU-Environment Policies (WFD, Circular Economy Package)</p>

3. The Research & Innovation Policy Landscape

There is a rich European R&I landscape of FNS funding programmes, strategies, and initiatives led by different EC services⁵⁹ that reflect the complexity of food systems and the multiple aspects related to food production, consumption and health, as described here.

3.1. Research & Innovation Programmes

The most ambitious EU R&I funding instruments supporting FNS include the successive Framework Programmes (FP) for Research and Technological Development which have been in existence since the mid-1980s, and the R&I actions under the financial instrument of Development Cooperation⁶⁰ implemented via the 2012 strategy entitled 'Enhancing and focusing EU international cooperation in research and innovation: a strategic approach'⁶¹. The focus in this document is on European Framework Programmes.

Much progress has been made in supporting FNS-relevant R&I via the successive FPs with nearly 5 billion EUR spent or allocated across the whole food chain between 1988 and 2020. Horizon 2020 (2014-2020) is the largest ever EU Research and Innovation Framework Programme (FP) with nearly 80 billion EUR of funding available over a seven year period for research in all domains. Horizon 2020 has been the main financial instrument contributing to implementing the European Research Area and the Innovation Union⁶², a Europe 2020 flagship⁶³ initiative aimed at securing Europe's global competitiveness. Horizon 2020 is multi-layered across different sectors, instruments, and objectives and is divided across the three pillars of excellent science, industrial leadership, and societal challenges. Societal Challenge 2 covers a wide area of bioeconomy research domains (including FNS) with 3.8 billion EUR of funding over the seven year period, for the purposes of supporting high level collaborative research and innovation across different food system components. There are however other important cross cutting R&I FNS activities being supported through the other pillars and societal challenges of Horizon 2020, particularly in the areas of health, environment, ICT, social sciences and humanities. The approximate amount of EC funding for projects in the area of food, nutrition and agriculture in Horizon 2020 and FP7 is depicted in the following table:

⁵⁹ Food in HORIZON 2020: <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/food-security-sustainable-agriculture-and-forestry-marine-maritime-and-inland-water>

DGAGRI: https://ec.europa.eu/europeaid/sectors/food-and-agriculture/sustainable-agriculture-and-rural-development/agriculture-research_en

DG SANTE: http://ec.europa.eu/health/programme/policy/index_en.htm

EFSA: <http://www.eib.org/efsi/>

JRC: <https://ec.europa.eu/jrc/en/science-area/agriculture-and-food-security>

KIC FOOD: <http://eit.europa.eu/collaborate/2016-call-for-kics>

DG CONNECT: <https://ec.europa.eu/digital-single-market/en/search/site/FOOD>

DG GROW: http://ec.europa.eu/geninfo/query/resultaction.jsp?QueryText=FOOD&query_source=GROWTH&swlang=en&x=3&y=11

DG ENV: <http://ec.europa.eu/environment/eussd/food.htm>

JPI: Joint programming: http://ec.europa.eu/research/era/joint-programming_en.html; e.g. JPI HDHL

<http://www.healthydietforhealthylife.eu>, FACCE-JPI <https://www.faccejpi.com>, JPI OCEANS <http://www.jpi-oceans.eu>

⁶⁰ http://ec.europa.eu/europeaid/policies/european-report-development_en

⁶¹ COM(2012) 497 : <http://ec.europa.eu/research/iscp/index.cfm?pg=strategy>

⁶² http://ec.europa.eu/research/innovation-union/index_en.cfm

⁶³ http://ec.europa.eu/europe2020/index_en.htm

Table 2: EU-Contribution to projects related to food, nutrition and agriculture from 2007 to 2015 in selected parts of FP7 and Horizon 2020⁶⁴. The EC Contribution for FP7 encompasses its whole duration (2007 to 2013), while the figure for H2020 only includes the 2014 and 2015 calls. For H2020, calls from 2016, 2017 and projections for 2018-2020 are not included.

Framework Research Programme	Max. EU Contribution (m EUR)
Theme 2 in FP7	1089.9
European Research Council in FP7	302.4
Marie Curie Actions in FP7	364.2
Total in FP7 (2007-2013)	3095
Societal Challenge 2 in H2020	291.9
European Research Council in H2020	145.9
Marie Skłodowska-Curie Actions in H2020	137.6
Total in H2020 (2014-2015)	1249.6

Even though food industry and consumer based post farm gate R&I has decreased in the current Horizon 2020 programme by almost 50 % from previous programmes, significant food system developments can be reported over these years which include:

- Numerous established capacity building pan European R&I networks which bring together science, industry and other stakeholders to exploit new and emerging research opportunities;
- A Food research base which maintains an affordable, safe, healthy and nutritious food supply in the face of demographic change from an increasing population and urbanisation (notable success in developing an EU food traceability system, better food safety, and a greater understanding of nutrition in wellbeing and diet);
- An agriculture research base to face dwindling natural resources, the effects of climate change, the changing global demographic, and working to provide a sustainable, safe and secure food supply for its citizens. (notable success in improving food quality, development of new markets, such as the organic sector, and addressing abiotic and biotic stress in plants);
- World renowned R&I developments in animal health and the control of infectious diseases and zoonoses; a constantly challenged but successful R&I response to the huge diversity of plant health issues; a sustainable, competitive, multifunctional agriculture and rural development research base providing support to a number of EU policies. (notable success in BSE detection, control of invasive plant pests);
- A research base which underpins better fisheries management and control of fish stocks and promotes the sustainable and competitive development of aquaculture. (notable success in fish stock retention and support and development of a growing aquaculture industry);
- Research in support of EU agriculture, fisheries, international development, environment, health and other policies;
- The strong involvement and participation of food based SMEs in research projects;

⁶⁴ Source: Preliminary analysis from CORDA database (data extracted on 26 Aug 2016)

- Successful efforts to improve member state FNS R&I integration through the European Research Area initiative and in particular through the help of the standing committee for agricultural research SCAR.

It is worth noting that the vast majority of these FNS R&I achievements were of a pre-competitive nature. The benefits from knowledge generation, new collaborative research structures, and pre-competitive enabling technologies cannot be easily quantified in the short term. Nevertheless, even though we measure success more on the capacity building efforts and the direct benefits of collaboration, there are clear examples of new products, improved processes and knowledge breakthroughs which are effectively delivered throughout these programmes.

Market uptake of R&I developments can take up to 20 years on average and actual uptake is complicated by the high number of food SMEs, and the fragmented nature of the food sector. In addition, there is a declining share of EU R&I public investment in food, and even though the private sector has sustained levels of investment it still lags behind its international peers. Indeed the stringency of regulatory procedures for new food products appears to have a direct and significant impact on the rate of return and viability of investing in the development of such products. Furthermore, R&I would benefit from increased upstream multi-actor and public engagement to foster more societally relevant and acceptable outcomes, which in turn can reduce time to market uptake and foster greater acceptability of outcomes⁶⁵.

3.2. Research & Innovation Policy Development

In addition to providing R&I financial support through Horizon 2020, the EC has been active in supporting the implementation of the European Research Area and Innovation Union, both of which set out a framework that underpins European R&I programme alignment, leveraging of funds, sharing of resources and infrastructures, and access to data and knowledge by:

Engaging and mobilising a wide diversity of actors: So as to foster improved cooperation and openness amongst multiple food system actors including policy makers, research performers and funders, private and public sector, and civil society. This ongoing work includes liaising with other EU Institutions (EP, STOA, EP Committees, CoR, EESC⁶⁶), EU Member State R&I public funding & policy making bodies (SCAR, JPI, PC), EU public authorities (regions and cities), food research communities, industry, investors, foundations and private non-profit funders, international organisations and initiatives (ex: CGIAR, SUN), international cooperation and third countries, educators and higher education establishments, museums and science centres, non-governmental and civil society organisations, professionals, entrepreneurs, farmers, fishers, extension services, researchers, students, consumers, citizens and civil society at large.

Furthermore, within the context of Horizon 2020, citizens across Europe are providing their inputs as a means to ensure that European R&I reflects the needs and expectations of society. This process of citizen-inspired R&I agenda setting began with the VOICES pilot process in 2014, which led to over 115 million EUR in R&I funding on urban waste, including food waste⁶⁷. Following a more bottom up approach, the CIMULACT initiative⁶⁸ (Citizen and

⁶⁵ https://ec.europa.eu/research/swafs/pdf/rome_declaration_RRI_final_21_November.pdf

⁶⁶ The EESC has adopted 26 May 2016 an exploratory opinion (NAT/677) on a more sustainable food system (<http://www.eesc.europa.eu/?i=portal.en.nat-opinions.37923>)

⁶⁷ <http://www.voicesforinnovation.eu/>

Multi-Actor Consultation process for Horizon 2020) is engaging more than 1000 citizens in 30 countries in Europe, along with a variety of other actors, in shaping a desirable sustainable future. In 2016, the need for sustainably produced, healthy, clean and responsible food has been highlighted by citizens as a major societal need, and in particular the importance of increasing awareness of what we eat, more knowledge on nutrition, animal welfare, reuse of food waste, use of green energy in food production, environmental food transport, gardens integrated into settlements, healthy food shops, accessible to all, new food types and food safety.

Alignment of European public and private R&I policy and programming: with respect to public R&I programme alignment, this takes place via interactions with Member States through SCAR and the Joint Programming Initiatives (JPI). With respect to the FNS-related private sector, this takes place via the European Technology Platforms (ETP) and public-private partnerships, where the objective is better leveraging and increased R&I investments.

Strengthening the Science-Policy-Society Interface: EU R&I also contributes towards strengthening the EC science-policy interface. FNS R&I actions are supporting implementation of relevant EU policies like the Common Agricultural Policy, the EU risk-based food safety regulatory framework, environment policies, and in particular those fostering sustainability, health and safety, and circularity, that seek to balance innovation with precaution. Some examples include:

- The **Common Agricultural Policy (CAP)** is focused on sustainable production and works in tandem with food safety and environmental policies, internal market rules, food labelling and other initiatives to educate and inform the public. For example, and regarding the Science-Society interface, the CAP has implemented the European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI).
- The EU risk-based **food safety regulatory framework:** the assessment of scientific evidence for supporting EU food safety policies is being carried out by the European Food Safety Authority (EFSA). In order to provide support to tackle existing and emerging food safety risks, EFSA relies on the availability of research and innovation outcomes to deliver robust scientific opinions for risk management considerations and policy support. FNS R&I actions provide new data and methodologies which contribute to the needs of EFSA's food safety risk assessment activities. EFSA plays an important role in collecting and analysing data to ensure that European risk assessment is supported by the most comprehensive scientific information available. The agency produces scientific opinions and advice that forms the basis for European policies and legislation relevant to food and feed safety; nutrition; animal health and welfare; plant protection and plant health. EFSA also considers, through environmental risk assessments, the possible impact of the food chain on the biodiversity of plant and animal habitats. EFSA has to date delivered scientific advice on a wide range of issues such as antimicrobial resistance in the agri-food chain, Salmonella, food additives such as aspartame, allergenic food ingredients, genetically modified organisms, pesticides, and animal health issues such as avian influenza. Furthermore, the communication of food related risks is another key part of EFSA's mandate, which entails providing appropriate, accurate and timely information on food safety issues to raise awareness and explain the implications of their scientific work.

⁶⁸ <http://www.cimulact.eu/>

Anticipating policy needs: Foresight exercises provide concrete evidence and suggestions to specifically provide input to policy-making. These include providing scientific and technical evidence for policy development, facilitating policy implementation, embedding participation in policy-making, supporting policy definition and reconfiguring the policy system. In the area of FNS, the 2013 foresight of the EC Joint Research Centre (JRC) on 'Delivering on Food safety and nutrition in 2050'⁶⁹ assessed the preparedness of European policies in terms of future challenges to food safety and nutrition and to ensure the sustainability of EU food systems. The conclusions from the study address both consumer and producer behaviour, encourage scientific research directed towards safer foods and healthy diets and promote diversity in food systems. The 2015 foresight on 'Global Food Security 2030- Assessing Trends in View of Guiding Future EU Policies'⁷⁰ calls for an evolution of present-day policies on food security and beyond into a Common Food Systems Policy in which both the systemic and global dimensions of food security are fully incorporated. An additional foresight study completed in 2015 has identified opportunities for triple-wins at the junction of health, environment and bioeconomy⁷¹. Further foresight studies tackle research priorities for foods and diets⁷², the challenge of resilience in a globalised world⁷³, or the state of the bioeconomy and principles leading to a sustainable bioeconomy⁷⁴.

Knowledge centres: Further scientific support and monitoring of FNS-relevant policies is needed to back foresight studies and impact assessments that rely on comprehensive repositories of data. These centres allow the Commission to regularly assess the progress and impact of the ongoing actions in the area of FNS and provide robust evidence for EU policy making. Eurostat, for example, is the EU statistical office and provides statistics at a European level that enable comparisons between countries and regions in any area. In the area of environment, the European Environment Agency (EEA) provides independent information for those involved in developing, adopting, implementing and evaluating environmental policy. In the area of bioeconomy, the *Bioeconomy Information System and Observatory*⁷⁵ (BISO) at the JRC deals with data collection, dissemination (including generation of 'new' data and information) and analysis.

3.3. Research & Innovation Strategies

From a strategic perspective, much of the EU R&I funded under SC2 is set within the context of the 2012 *Bioeconomy Strategy*, but it also integrates the key elements of the recent *Strategic Approach to Agricultural Research and Innovation* paper that describes the challenges for primary production and rural livelihoods⁷⁶. Furthermore FNS R&I under Horizon 2020 complements the *EU Development Policy on Agricultural Research for development (AR4D, 2014)*⁷⁷ and the EU policy framework on food security, along with links to elements of the *Third Health Programme*⁷⁸, while also embedding the aquaculture and

⁶⁹ http://ec.europa.eu/food/safety/future_en.htm

⁷⁰ <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/global-food-security-2030-assessing-trends-view-guiding-future-eu-policies?search>

⁷¹ European Commission, DG RTD (2015), The junction of health, environment and the bioeconomy. Foresight and implications for European research & innovation policies, <http://bookshop.europa.eu/en/the-junction-of-health-environment-and-the-bioeconomy-pbKI0514154/>

⁷² <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/tomorrows-healthy-society-research-priorities-foods-and-diets?search>

⁷³ http://espas.eu/orbis/sites/default/files/generated/document/en/jrc-resilience-in-a-globalised-world_en.pdf

⁷⁴ <https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none>

⁷⁵ <https://biobs.jrc.ec.europa.eu/>

⁷⁶ <http://ec.europa.eu/programmes/horizon2020/en/news/designing-path-strategic-approach-eu-agricultural-research-and-innovation>

⁷⁷ https://ec.europa.eu/europeaid/research-and-innovation-sustainable-agriculture-and-food-and-nutrition-security_en

⁷⁸ http://ec.europa.eu/health/programme/policy/index_en.htm

fisheries R&I dimension of the *Blue Growth Strategy*⁷⁹. Each of these strategies help achieve the goals of the R&I agenda setting and are briefly described below.

The Bioeconomy Strategy: The bioeconomy related to the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. FNS is at the heart of the bioeconomy with a focus upon the sustainable provision of sufficient food for health and wellbeing. Launched in February 2012, Europe's *Bioeconomy Strategy*⁸⁰ proposes the bioeconomy as a viable alternative to depleting fossil fuels and as a sustainable natural alternative in the shift to a post-petroleum society. The strategy streamlines existing policy approaches in this area, and is structured around investments in research, innovation and skills; reinforced policy interaction and stakeholder engagement; enhancement of markets and competitiveness. It calls for new R&I and supports science and technological leadership to drive tangible improvements in Europe's social, economic and environmental welfare. FNS is an integral part of the bioeconomy strategy, which has underpinned much of the R&I under Societal Challenge 2 of Horizon 2020.

A strategic approach to EU agricultural research and innovation⁸¹: Challenges faced by agriculture and rural areas and the long-term character of research activities call for a strategic view on EU funding activities. The approach is the result of a wide process which was kicked-off at the Milan EXPO in June 2015 and followed by workshops, stakeholder consultation and a major conference early 2016. It provides the basis for agricultural research programming activities under Horizon 2020 and beyond. Its focus is on land-based primary production from agriculture and forestry while extending to food and non-food chains and the rural economy. It identifies five thematic areas to focus further EU R&I investment. The approach highlights the need for agricultural R&I (and in particular primary production) to follow a systems approach and address food and non-food systems as well as rural territories. It places a focus on inter and transdisciplinarity, ICT as an enabling technology, socio-economic research and support EU policies related to CAP, and rural territories and food/non-food systems. The approach recalls the importance of boosting innovation through a multiactor approach implemented through the European Innovation Partnership 'Agricultural productivity and sustainability'⁸².

The Blue Growth Strategy: Supported under Horizon 2020, and addressing multi-use offshore floating platforms combining different sea activities at a fixed location such as renewable energy, aquaculture, fisheries, new vessel design, as well as related necessary technologies (sensors, robots cages, etc.); large-scale marine biomass integrated bio-refineries able to develop a range of value-added products (food, feed, pharmaceuticals, cosmetics, as well as third-generation biofuels), and regulatory barriers for multi-offshore activities. H2020 also supports SME effort for innovation in aquaculture and marine biotechnology.

EU Health Strategy⁸³ '*Together for Health*'.⁸⁴ adopted in 2007 focuses on smart investments⁸⁵ in sustainable health systems, investing in people's health, particularly through

⁷⁹ http://ec.europa.eu/maritimeaffairs/policy/blue_growth/index_en.htm

⁸⁰ <http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy>

⁸¹ https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/agri_strategypaper_web_1.pdf

⁸² <http://www.eip-agri.eu/>

⁸³ http://ec.europa.eu/health/strategy/policy/index_en.htm

⁸⁴ http://ec.europa.eu/health/strategy/docs/whitepaper_en.pdf

⁸⁵ http://ec.europa.eu/health/strategy/docs/swd_investing_in_health.pdf

health-promotion programmes, investing in health coverage as a way of reducing inequalities and tackling social exclusion. The third Health programme⁸⁶ is the main instrument that the Commission uses to implement the EU Health Strategy. This programme sets co-funding actions to (1) promote health, prevent diseases and foster supportive environments for healthy lifestyles taking into account the 'health in all policies' principle, (2) protect Union citizens from serious cross-border health threats, (3) contribute to innovative, efficient and sustainable health systems and (4) facilitate access to better and safer healthcare for Union citizens.

The Strategy for Agricultural Research for Development: The 2014 AR4D focusses on three R&I themes: sustainable inclusive agriculture for growth; nutrition with particular attention to children and women; resilience to food security crises. Furthermore, it fosters two cross-cutting issues: gender and pro-poor focus, and climate change. The financial instruments for the implementation of the AR4D (the GPGcP of the DCI, and the EDF), are very different from Horizon 2020 in that they are largely relayed to international donors. The ensuing R&I projects and initiatives are generally smaller and solicited via a bottom-up approach. The total funding however is quite consequential and has a regional focus: out of a total of 320 m EUR (for period 2010-13), over half of the AR4D support is targeting Africa.

3.4. Working with Members States for Research & Innovation Alignment

Institutionally, the EC is working closely with EU Members States with a view of building R&I policy coherence and alignment. SCAR established in 1974, renewed in 2005, and now representing 37 countries, has grown to become a respected source of advice on European agriculture, forestry, fisheries and food system R&I, along with being a catalyst for the coordination of national research programmes. Its remit is to develop a strong foresight process, devise common research agendas, map research capacities in the Member States, and provide strategic policy advice. Over a ten year period encompassing both FP6 and FP7 it has mobilised over 500 million EUR in R&I investments through nearly 30 different ERA-Nets⁸⁷. These provided significant added-value in terms of synergies between national programmes, efficiency gains and impacts, through joint calls for research and a host of additional collaborative activities. This leverage effect in terms of the net Member State spend over the period is actually quite low but it is the beginning of a process that will hopefully lead to a greater financial and structuring platform of a more permanent nature⁸⁸.

In addition to working closely with the SCAR, the EC is also engaging with the Members States via Joint Programming Initiatives (JPI) established under the European Research Area (ERA). The JPIs act as platforms for research funders in the Member States to align their national R&I agenda to tackle important issues of common concern. They bring added-value in the terms of the identification and implementation of R&I priorities in Horizon 2020, and beyond. There are currently three JPIs (FACCE, HDHL and OCEANS) that are working jointly in support of FNS R&I. These initiatives are further complemented by the ERA-NET⁸⁹ instruments. More recently, in addition to the JPI a new alignment mechanism has been established under Horizon 2020 called the European Joint Programme (EJP) Cofund, where two calls for Cofunds relevant to FNS addressing zoonosis⁹⁰ and human biomonitoring⁹¹ have already been launched.

⁸⁶ http://ec.europa.eu/health/programme/policy/index_en.htm

⁸⁷ <http://www.era-platform.eu/era-nets/>

⁸⁸ https://ec.europa.eu/research/scar/pdf/24-09_ce_scar_role.pdf

⁸⁹ <http://www.era-platform.eu/>

⁹⁰ <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/sfs-36-2017.html>

⁹¹ <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/sc1-pm-05-2016.html>

4. Stocktaking of Ongoing Research & Innovation Drivers

Horizon 2020 is a major catalyst of FNS R&I through a wide diversity of actions that provide solutions to one or more of the four FNS priorities (nutrition, climate, circularity, innovation). These actions are grouped into four enabling drivers a) **research**, b) **innovation and investment**, c) **open science**⁹², and d) **international collaboration**.

4.1. Research

EU supported research has been critical in advancing FNS via its successive framework programmes. In particular, progress has been made in the areas such as sustainable farming with a large emphasis on understanding the biology and improving the health of soils, air and water quality, plants, and livestock. Significant progress has also been made with substantial contributions to food safety (providing scientific results in support of evidence-based EU policies to tackle food-borne diseases) and nutrition, plant biotechnologies, novel food processing, seafood⁹³, understanding consumer needs and supporting the consolidation of the food chain. Horizon 2020 emphasises the need to address crosscutting approaches to FNS R&I like the integration of social sciences and humanities, sustainability and climate change, small and medium enterprise, responsible research and innovation, including gender, science education, public engagement⁹⁴, and open access to data and knowledge. Also worth mentioning are the Marie Skłodowska-Curie Actions⁹⁵, the European Research Council⁹⁶ and the Leadership in Enabling and Industrial Technologies (LEIT) which are delivering on FNS. Furthermore, the strategic partnership with the European Space Agency on Earth Observation for Food Security relies on existing space infrastructure and services like Copernicus that already provide data giving useful information to assess food security. However, additional observation requirements for food security are currently lacking. The scope of the strategic partnership is to coordinate already planned activities, align work programmes in some key fields of common interest and to have a coherent work plan with activities to be carried out, including complementary funding on both sides. The priorities include monitoring of agricultural crops, water availability, land use and agricultural soil status and sustainable expansion of fisheries and aquaculture production.

4.2. Innovation and Investment

The basic premise of open innovation under the Innovation Union is to introduce more actors into the innovation process so that knowledge and ideas can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship⁹⁷. This is in particular the approach deployed within the EIP-AGRI which aims to boost innovation through the establishment of a process of genuine knowledge co-creation.

⁹² http://ec.europa.eu/research/innovation-union/pdf/expert-groups/rise/study_on_open_science-impact_implications_and_policy_options-salmi_072015.pdf#view=fit&pagemode=none

⁹³ FP7-related projects: ECSafeSeafood (<http://www.euronews.com/2015/06/15/is-seafood-still-safe-to-eat>); Aquaexcel (<http://www.euronews.com/2014/06/16/a-tasty-and-sustainable-future-for-fish-farming/>);

Transdott (<http://www.euronews.com/2010/07/23/farming-bluefin-tuna>)

⁹⁴ Including the multiactor approach

⁹⁵ So far, 501,8 m EUR have been granted in Marie Curie Actions under FP7 and H2020 for projects related to food, nutrition and agriculture (Source: CORDA, 26 Aug 2016)

⁹⁶ So far, 448,3 m EUR have been granted for ERC projects under FP7 and H2020 related to food, nutrition and agriculture (Source: CORDA, 26 Aug 2016)

⁹⁷ http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=eip

With respect to R&I investments, synergies are being explored between Horizon 2020 and other relevant funding instruments such as the European Fund for Strategic Investment (EFSI)⁹⁸, the European Agricultural Fund for Rural Development (EAFRD)⁹⁹, and the European Structural and Investment Funds (ESIF)¹⁰⁰. For example synergies with ESIF imply that R&I actors are encouraged to work more closely with place-based actors such as regions and cities via the agri-food smart specialisation platform¹⁰¹. Furthermore, active collaboration with industry and private funders promotes strengthening the existing dialogue with European Technology Platforms¹⁰² (Aquaculture, Food for Life, Plants of the Future, Organics and Manufacture) and Joint Undertakings (Biobased Industries consortium BBI), and public-private collaborations and provides opportunities to foster responsible investments and new business models. Current R&I actions with a focus on boosting innovation and R&I investment in FNS include:

- **Demonstration projects for Blue Growth:** Supported under Horizon 2020, and addressing multi-use offshore floating platforms combining different sea activities at a fixed location such as renewable energy, aquaculture, fisheries, new vessel design, as well as related necessary technologies (sensors, robots cages, etc.); large-scale marine biomass integrated bio-refineries able to develop a range of value-added products (food, feed, pharmaceuticals, cosmetics, as well as third-generation biofuels), and regulatory barriers for multi-offshore activities. Such projects also support SME effort for innovation in aquaculture fisheries and marine biotechnology.
- **European Technology Platforms (ETPs)¹⁰³:** The ETPs are stakeholder fora for driving innovation, knowledge transfer and, ultimately, growth and jobs. ETPs develop R&I agendas and roadmaps for action at EU and national level, supported by both private and/or public funding. They mobilise stakeholders, particularly those who can foster more private sector involvement in R&I, to define a common vision in a given sector and build an innovation agenda on agreed priorities and share information across the EU. They also contribute to the wider uptake of research results and innovations across the food chain, sometimes through links with similar organisations in Member States. They contribute to the definition of the research priorities including those under the Research Framework Programmes and to a better alignment between academia, policy makers and private actors. Several ETPs are active in the field of FNS, including Food for Life, TP Organics, Aquaculture, Fisheries and Plants of the Future¹⁰⁴.
- **Public-Private Partnerships (PPPs)¹⁰⁵:** Strengthening collaboration with industry via the ETPs has given rise to new ambitious PPPs uniting all actors in a sector who would otherwise find it too risky to invest on their own. Examples of a working 'contractual' PPP include: “**Factories of the Future**”, which incorporates the food industry, but others in areas like nutrition or consumer science can be envisaged; the **Bio-based Industries Joint Undertaking** (BBI JU)¹⁰⁶ which was established in 2014 and locks down a 3.7 billion EUR Public-Private Partnership between the EU and the Bio-based Industries

⁹⁸ <http://www.eib.org/efsi/>

⁹⁹ http://ec.europa.eu/agriculture/cap-funding/funding-opportunities/index_en.htm

¹⁰⁰ http://ec.europa.eu/regional_policy/en/funding/

¹⁰¹ <http://s3platform.jrc.ec.europa.eu/agri-food>

¹⁰² http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=etp

¹⁰³ http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=etp

¹⁰⁴ <http://www.eatip.eu/>; <http://www.fabretp.eu/>; <http://etp.fooddrinkurope.eu/>; <http://www.etpgah.eu/>; <http://www.forestplatform.org/>; <http://www.plantetp.org/>; <http://www.tporganics.eu/>; <http://www.manufacture.org/manufacturing/>; <http://prosumernet.eu/>

¹⁰⁵ http://ec.europa.eu/research/industrial_technologies/ppp-in-research_en.html

¹⁰⁶ <http://www.bbi-europe.eu/>

Consortium. The BBI JU operates under Horizon 2020 and is driven by a vision and Strategic Innovation and Research Agenda (SRIA) developed by the industry consortium. It will benefit from 975 million EUR of EU funds and will leverage 2.7 billion EUR of private investments along with additional private and public funds, such as close synergies with EU Structural Funds. The BBI JU has links to FNS with respect to food industry adoption of circular economy principles (resource efficiency, reuse of food waste). This includes the exploitation of the biodegradable fraction of municipal solid waste streams containing food residues from households or from caterers or large food retailers for use as an economical and sustainable feedstock. A potential end product is improved nutritional quality plant proteins which could replace animal protein and address the 'protein deficit'.

- **Fostering innovation via the European Innovation Partnerships (EIP)¹⁰⁷**: Established under the Innovation Union the EIPs are about fast-tracking innovation and accelerating breakthroughs to markets. They are challenge-driven, focusing on societal benefits and a rapid modernisation of the associated sectors and markets. EIPs act across the whole research and innovation chain, bringing together all relevant actors at EU, national and regional levels in order to: (i) step up research and development efforts; (ii) coordinate investments in demonstration and pilots; (iii) anticipate and fast-track any necessary regulation and standards; and (iv) mobilise 'demand' in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market. There are currently five EIPs: active and healthy ageing¹⁰⁸; agricultural sustainability and productivity (EIP-AGRI)¹⁰⁹; smart cities and communities¹¹⁰; water¹¹¹; and raw materials. Within the context of FNS R&I the EIP-AGRI is directly relevant to boosting FNS innovation. The EIP-AGRI¹¹² was endorsed by Council in June 2012, and launched a Strategic Implementation Plan in July 2013. EIP-AGRI combines knowledge systems, empirical knowledge of practitioners and scientific knowledge of applied research in a multi-actor approach. It has been further developed by the Commission and the Member States under the strategic working group on agricultural knowledge and innovation systems of the Standing Committee of Agricultural Research (SCAR AKIS). The EIP-AGRI fosters a bottom-up approach to agricultural innovation and the integration of different funding streams (in particular access to rural development funds) at local and regional level. Through its multi-actor approach it brings together farmers, advisors, researchers, agribusinesses, NGOs and other actors as partners in agricultural, food and forestry innovation. At a European level many Horizon 2020 projects are linked by applying the same multi-actor approach. The EIP-AGRI Network is gathering information on best practices from local, regional and European level and has supported the work of 18 focus groups on issues such as mixed farming systems, livestock/cash crops, benchmarking of farm productivity and sustainability performance, innovative short food supply chains and reducing emissions from cattle farming.
- **Smart Specialisation Strategies¹¹³ to boost the innovation potential of regions**: There were 85 of the EU regions participating in the Smart Specialisation Platform¹¹⁴ who

¹⁰⁷ <http://ec.europa.eu/eip/agriculture/>

¹⁰⁸ http://ec.europa.eu/research/innovation-union/index_en.cfm?section=active-healthy-ageing

¹⁰⁹ <http://ec.europa.eu/eip/agriculture/>

¹¹⁰ <http://ec.europa.eu/eip/smartcities/>

¹¹¹ <http://www.eip-water.eu/>

¹¹² <http://ec.europa.eu/eip/agriculture/en/content/EIPAGRIabout>

¹¹³ <http://s3platform.jrc.ec.europa.eu/>

¹¹⁴ <http://s3platform.jrc.ec.europa.eu/>

indicated Agri-Food as one of their key investment areas under smart specialisation¹¹⁵. These regions are keen to boost their innovation potential on FNS-relevant issues (labelled as ‘agriculture, forestry, and fishing’). In 2016, a Smart Specialisation Platform Agri-Food was established at EU level to accelerate the development of joint investment projects in the EU by encouraging and supporting interregional cooperation in thematic areas linked to agriculture and food based on smart specialisation priorities defined by regional and national governments¹¹⁶. This platform relies on a bottom-up dynamic to cooperate on transformative systemic change in agri-food between EU regions, but is facilitated and supported by the European Commission amongst others by complementary deployment of EU funding instruments (ESIF, Horizon 2020).

The Smart Specialisation Platform Agri-Food engages different services at the European Commission and promotes interregional partnerships in specific agri-food priority domains such as food traceability combining regional smart specialisation investments and their support through different European instruments. It should be noted that an EC ‘Seal of Excellence’ certificate can be awarded to applicants of above threshold level proposals not retained under Horizon 2020 as an aid to help them find alternative funding sources and as an aid to help boost overall FNS regional and place-based innovation¹¹⁷.

- **European Fund for Strategic Investments (EFSI):** This is a new partnership between the Commission and the European Investment Bank (EIB)¹¹⁸ providing additional sources of risk-bearing capacity, targeting projects delivering higher societal and economic value, and complementing the projects currently financed through the EIB or existing EU programmes. It takes the form of a ‘guarantee fund’ backed by existing EU funds including the Connecting Europe Facility¹¹⁹ and the Horizon 2020 programme. So far very few FNS-relevant projects have been supported via this fund and with the total EFSI fund coming to around 315 billion EUR, food system projects have drawn down less than 0.1 %.
- **InnovFin under Horizon 2020:** The joint EC-EIB initiative InnovFin (EU Finance for innovators) offers financial products for R&I for small, medium and large companies, and the promoters of research infrastructures. The financing tools under InnovFin include analysing and potentially improving the investment/lending conditions of companies/projects in the agriculture, food and beverage industry, Bio-based Industries, and the blue economy. The aim of InnovFin is to make over 24 billion EUR of debt and equity financing available to innovative companies to support 48 billion EUR of final R&I investments by 2020.
- **SME Instrument under Horizon 2020:** Horizon 2020 funds high-potential innovation through a dedicated SME instrument, which offers seamless business innovation support with funding coming from the Societal Challenges and the Leadership in Enabling and Industrial Technologies (LEITs) pillars. Provided with about 3 billion EUR in funding over the period 2014-2020, the SME Instrument helps high-potential SMEs to develop ground-breaking innovative ideas for products, services or processes that are ready to face global market competition. Available to SMEs only, the new scheme has opened a

¹¹⁵ Eurostat Nuts2 level

¹¹⁶ <http://s3platform.jrc.ec.europa.eu/agri-food>

¹¹⁷ <https://ec.europa.eu/research/regions/index.cfm?pg=soe>

¹¹⁸ <http://www.eib.org/efsi/index.htm>

¹¹⁹ <https://ec.europa.eu/digital-single-market/en/connecting-europe-facility>

new highway to innovation to food SMEs through phased, progressive and complimentary support. So far, 236 m EUR have been granted in food-related projects¹²⁰.

- **Fostering the knowledge triangle via Knowledge and Innovation Communities (KICs)**¹²¹: The KICs are partnerships that bring together businesses, research centres and universities and they are supported by the European Institute of Innovation and Technology (EIT) under Horizon 2020. They allow for innovative products and services to be developed, new companies to be started, a new generation of entrepreneurs to be trained. KICs carry out activities that cover the entire innovation chain: training and education programmes, reinforcing the road from research to the market, innovation projects and prizes, as well as business incubators and accelerators. For example, the ongoing Climate-KIC¹²² focuses on climate change mitigation and adaptation, supporting projects relevant to FNS including adapting water use in the agriculture sector (AGADAPT), producing azolla biomass for a large scale production of proteins and raw materials for food and non-food purposes (Azofast), creating a community of practice for integrated food clusters to develop resource efficiencies in food production and supply, and developing tailored remote sensing solutions for farmers to monitor report and verify their greenhouse gas emissions (Cool Farm Tool Space). Future opportunities for implementing the knowledge triangle in the area of FNS will soon be available following the selection (November 2016) and launch of a dedicated Food-KIC in early 2017. The EIT Food: Food4Future - Sustainable Supply Chain from Resources to Consumers¹²³ will complement the EIP-AGRI and JPIs and pool national research efforts to integrate the food supply chain in the agriculture, forestry and land use sectors.

4.3. Open science

Open Science represents a new approach to the scientific process, based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools. Within the context of FNS, it contributes to the development and implementation of cloud-based services and world-class data infrastructures to ensure science, business and public services reap the benefits of the “big data” revolution for FNS, while preserving consumer privacy. Open Science is underpinned by the deployment of FNS research infrastructures and data access, sharing, interoperability and re-use, as a means to ensure high quality and transparent scientific collaboration, societally relevant and responsible R&I outcomes, and innovative downstream products, services and technologies. Open Science is at the heart of the European Open Science Cloud¹²⁴. Under the 'capacities' programme we find FNS R&I activities that support researcher mobility, skills development, and which stimulate public and private FNS traineeships, fellowships and researcher exchanges.

Current FNS R&I actions where Open Science is being furthered include:

- **Open Access** to scientific peer reviewed publications and research data under Horizon 2020 is anchored as an underlying principle in Horizon 2020, and for which guidance is available via the OpenAir platform¹²⁵. A novelty in Horizon 2020 is the Open Research

¹²⁰ Source: Data extracted from CORDA on food, nutrition and agriculture-related projects on 26 Aug 2016

¹²¹ <https://eit.europa.eu/activities/innovation-communities>

¹²² <https://eit.europa.eu/eit-community/climate-kic>

¹²³ <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/3095-eit-food.html>

¹²⁴ http://europa.eu/rapid/press-release_IP-16-1408_en.htm

¹²⁵ <https://www.openaire.eu/h2020openaccess/>

Data Pilot which aims to improve and maximise access to, and re-use of, research data generated by projects under Societal Challenge 2. In projects under the pilot, the data needed to validate the results presented in scientific publications must be made available as soon as possible. This will be done according to a project data management plan¹²⁶ (DMP), for which OpenAIRE provides the Zenodo repository¹²⁷ where researchers can store experimental data and publications. Furthermore, open data and data sharing are increasingly at the centre and/or bridging Horizon 2020 projects. The Horizon 2020 project RICHFIELDS¹²⁸ aims to create an infrastructure for innovative research on healthy food choice, preparation and consumption of EU-citizens, closely linked to their behaviour and lifestyle. The project CAPSELLA will collect open data relevant to agrobiodiversity-based and sustainable food systems by focusing on three scenarios: field, seed and food¹²⁹. Finally, Commission policies in Open Access aim to have structuring effects beyond their recipients; several scientific partners of the GODAN initiative¹³⁰ that are based in Europe (overall about 100) can count on financial support for Open Access and Open Data via Horizon 2020 projects.

- **European Cloud Initiative:** Builds on the Digital Single Market (DSM) Strategy aiming to maximise the growth potential of the European digital economy¹³¹. It will develop a trusted, open environment for the scientific community for storing, sharing and re-using scientific data and results within the European Open Science Cloud¹³². It aims to deploy the underpinning super-computing capacity, the fast connectivity and the high-capacity cloud solutions needed via a European Data Infrastructure¹³³. Focussing initially on the scientific community, the user base will be expanded to the public sector and to industry, creating solutions and technologies that will benefit all areas of the economy and society. Achieving this will require a collaborative effort open to all those interested in exploiting the data revolution in Europe as an essential component of global growth. For instance, it will harness existing cross-national efforts such as METROFOOD-RI, an Emerging Infrastructure on the 2016 ESFRI Roadmap by means of which it will be possible to carry out different activities supporting data collection and measurement reliability, as well as basic and frontier research in food and nutrition¹³⁴. It will start by federating existing scientific data infrastructures, today scattered across disciplines and Member States. This will make access to scientific data easier, cheaper and more efficient. For instance, the Copernicus Sentinel satellites generate data which make up the Europe's Copernicus environmental monitoring network useful for emergency planning after earthquakes and hold great promise to provide data for scientists, agricultural experts and environmentalists¹³⁵. The European Cloud will also provide a secure environment where privacy and data protection will be guaranteed by design, based on recognised standards, and where users can be confident concerning data security and liability risks.
- **'Responsible Research and Innovation' (RRI):** is a cross-cutting issue in Horizon 2020 and has been successful in mobilising a wide diversity of actors, in particular through the 2014 Rome Declaration¹³⁶ under the Italian Presidency. It aims to strengthen R&I through

¹²⁶ <http://www.dcc.ac.uk/resources/data-management-plans>

¹²⁷ <http://www.zenodo.org/>

¹²⁸ http://cordis.europa.eu/project/rcn/200239_en.html

¹²⁹ <http://www.capsella.eu/>

¹³⁰ <http://www.godan.info/>

¹³¹ COM(2015) 192 final

¹³² Preparatory work started through a Commission High Level Expert Group, tasked to issue advice on its set-up: <http://bit.ly/1RK7lhh>

¹³³ Preparatory work undertaken i.e. through advisory groups such as the e-infrastructures Reflection Group

¹³⁴ <http://www.metrofood.eu/>

¹³⁵ See <http://www.godan.info/documents/godan-success-stories-issue-1> and <http://geospatialworldforum.org/speaker/SpeakersImages/the-value-of-open-data-sharing-open-data-the-sdgs-and-the-economics-of-data-infrastructure.pdf>

¹³⁶ <https://ec.europa.eu/digital-single-market/en/news/rome-declaration-responsible-research-and-innovation-europe>

multi-actor and public engagement, gender, ethics and integrity, science education and better access to knowledge. In particular, this approach to R&I stimulates transdisciplinary and participatory research and citizen science approaches, knowledge sharing and co-creation, whereby researchers, farmers, fishers, industry, policy makers and civil society collaborate with a view of achieving R&I outcomes of greater societal relevance and acceptability. An example of this approach can be found in the BIG PICNIC initiative on food and agriculture citizen science¹³⁷ and a series of multi-actor projects funded under SC2¹³⁸.

Furthermore, the findings of a 2015 EC expert group on Science Education for Responsible Citizenship¹³⁹ revealed that our future could be undermined by unevenness in basic science literacy across Europe, which is necessary to ensure a rigorous understanding and use of scientific knowledge in decision-making, particularly in domains such as health, environment, food, energy and consumption. The report reveals that there are wide disparities in participation in science education, in formal, non-formal and informal settings, across regions, cultures and gender which are blocking full involvement in society of all citizens and talents. As a way to foster RRI and boost education the “Science with and for Society” programme part of Horizon 2020 is supporting actions like the Future in Food Programme¹⁴⁰ and the PLACES initiative¹⁴¹, which established European cities of scientific culture.

4.4. International Collaboration

This driver relates to the increasing importance of international cooperation in research and innovation and sets out the gains that the EU can make by maintaining its presence at the highest level of international scientific endeavour. In the context of FNS, it seeks R&I policy alignment in areas like framework conditions, standards, and thematic initiatives, wherein the EU is well-positioned to have an impact at a global level, and in coordination with Members States. Furthermore FNS multilateral and bilateral collaboration is being maintained and fostered through existing dialogue platforms, such as the EU-Africa High-Level Policy Dialogue on science, technology and innovation¹⁴², PRIMA, the EU-China flagship on Food, Agriculture and the Bioeconomy, the ASEAN¹⁴³ and the All Atlantic Ocean Research Alliance¹⁴⁴ relevant to aquaculture and fisheries. Current R&I initiatives where International Collaboration is found include:

- **FNSSA – Pro-poor innovation and research, for Food and Nutrition security and sustainable agriculture¹⁴⁵**: The overall objective of this initiative is to improve food security for the poorest and most vulnerable, to help eradicate poverty and hunger for current and future generations, and to better address under-nutrition thereby reducing child mortality. Focus is on enhancing the incomes of smallholder farmers, the resilience of vulnerable communities and on helping partner countries reducing the number of stunted children by 7 million by 2025. Healthy ecosystems contribute to reducing risk and vulnerability of the poor and provide vital environmental services and opportunities for

¹³⁷ <https://www.bgci.org/news-and-events/news/1332/>

¹³⁸ http://ec.europa.eu/agriculture/research-innovation/projects/index_en.htm (projects marked as MAA)

¹³⁹ http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf

¹⁴⁰ https://www.sfdf.org.uk/sfdf/schools_programme

¹⁴¹ <http://www.openplaces.eu/>

¹⁴² <http://ec.europa.eu/research/iscp/index.cfm?lg=en&pg=africa>

¹⁴³ <http://ec.europa.eu/research/iscp/index.cfm?pg=asia>

¹⁴⁴ <http://ec.europa.eu/research/iscp/index.cfm?lg=en&pg=transatlantic-alliance>

¹⁴⁵ <http://www.africa-eu-partnership.org/en/newsroom/all-news/towards-jointly-funded-eu-africa-research-and-innovation-partnership>

alternative livelihoods (non-farm rural employment). Improvements in sustainable agriculture can only be sustained if both the supply and demand side of supply chains is addressed. The globalised nature of many supply chains means that efforts are needed at global level to link the different parts of such chains and in particular the business climate.

- **High-Level Dialogue for EU-Africa Cooperation:** A partnership between the EU and the African Union on "Food and Nutrition Security and Sustainable Agriculture" was launched by the EU-Africa High Level Policy Dialogue (HLPD) on research and innovation, and endorsed by the EU-Africa Summit in 2014. An expert group has been established and tasked with preparing a roadmap around three pillars: sustainable intensification, food systems for nutrition, responsible supply chains and markets and trade. The roadmap was adopted in April 2016 in Addis Ababa with a focus on sustainable intensification, agriculture and food systems for nutrition, expansion and improvement of agricultural markets and trade. The aim is to stimulate R&I of mutual interest that contributes to lifting 500 million people out of poverty by 2030. This dialogue on research and innovation has already produced three topics for the call 'Sustainable Food Security' for the Work Programme 2016/2017 of the SC2 with a total amount of 25 m EUR.
- **Partnering with China for Food, Agriculture and Biotech (FAB):** In China more than half of the population live in urban areas, much like in Europe and this is expected to increase. The Chinese diet is also changing as people are adopting more western diets. Due to these similarities FAB research cooperation and knowledge exchange is mutually beneficial. Interaction is primarily with the Chinese Academy of Agricultural Sciences and the Ministry of Science and Technology, which has supported cooperation within Horizon 2020 with the establishment of a co-funding mechanism¹⁴⁶. So far, between 2014 and 2017 and with an EU estimated contribution of over 90 million EUR, areas for joint research have covered key challenges such as alternative feed sources for livestock, prevention of animal and crop diseases, soil quality, food waste, biological contamination of crops and sustainable use of agricultural waste, co-products and by-products and urban agriculture.
- **Partnership in the Mediterranean (PRIMA¹⁴⁷):** Freshwater in the Mediterranean is a scarce resource, and 70 % of it is used for agriculture, mainly for irrigation. PRIMA (Partnership for Research & Innovation in Mediterranean Area) is an international partnership for R&I in the Mediterranean basin aimed at the development and application of innovative solutions to optimise the management and use of fresh water for food production and processing and to ensure food security. An Expert Group and an Impact Assessment have explored the possible participation of the Union in the PRIMA initiative through a joint programme action requiring three levels of integration, scientific, managerial and financial. Integration of national R&I programmes on water use in food production and processing will substantially contribute to FNS objectives in the Mediterranean area. The EU-African High Level Dialogue and the Partnership for Research & Innovation in the Mediterranean Area (PRIMA) also have a strong international development component which places the achievement of the SDGs as an overarching objective. These partnerships also require a good cooperation and alignment with EU development policies and instruments, and related actors and networks like the

¹⁴⁶EU-China Research and Innovation co-funding mechanism:
<https://ec.europa.eu/programmes/horizon2020/en/news/eu-china-research-and-innovation-co-funding-mechanism-first-call-launched-china>

¹⁴⁷<https://ec.europa.eu/research/environment/index.cfm?pg=prima>

European Forum for Agricultural Research for Development (EFARD), the Global Agricultural Research Partnership (CGIAR), and the Scaling Up Nutrition (SUN) Initiative.

- **ASEAN¹⁴⁸: Reinforcing international cooperation on sustainable aquaculture production with countries from South-East Asia:** With 90 % of all world aquaculture production in Asia, and Europe importing close to 70 % of its seafood (in particular from South-East Asia) both regions wish to cooperate in developing sustainable solutions for aquaculture production to meet the challenge of global seafood security. ASEAN is the Association of Southeast Asian Nations composed of Brunei, Cambodia, Indonesia, Laos, Malaysia, Burma, Philippines, Singapore, Thailand, and Vietnam. Scientific cooperation is part of the partnership between the two regions since the 16th ASEAN-EU Ministerial Meeting in Nuremberg, Germany in 2007. During the EU-ASEAN consultation on aquaculture that was held in Jakarta in August 2014, two main objectives were highlighted: 1) Reconcile concerns for seafood security, quality and safety; and 2) Identify joint research, education and business opportunities for mutual benefits. This will contribute to common standard setting and legislation, creation of long-term business opportunities and consolidation of education and training networks spanning the EU and this region.
- **Mediterranean Sea Research and Development Programme¹⁴⁹:** The BLUEMED initiative, jointly developed and agreed between Cyprus, Croatia, France, Greece, Italy, Malta, Portugal, Slovenia, and Spain, facilitated and supported by the European Commission, aims to advance a shared vision for a more healthy, productive, resilient, as well as a better known and valued Mediterranean Sea. The BLUEMED Initiative considers fisheries and aquaculture as key sectors of the blue growth path, with related actions in its Strategic Research and Innovation Agenda.
- **AORA - Atlantic Ocean research and development programme:** The Galway Statement on Atlantic Ocean Research Cooperation, signed in May 2013 by the EU, Canada and the United States of America, launched an Atlantic Ocean Research Alliance. This Alliance will reinforce cooperation in research and innovation between the EU, the US and Canada by developing joint initiatives on the sustainable exploitation of the Atlantic Ocean. Aquaculture has been identified as one of the five areas of cooperation with a focus on promoting the Ecosystem Approach.
- **Atlantic Ocean research and development programme from the Arctic to Antarctica¹⁵⁰:** In the 2012 Joint Communication to the European Parliament and the Council 'Developing a European Union Policy towards the Arctic Region', the Commission and the High Representative point out that the EU will 'support research and channel knowledge to address the challenges of environmental and climate changes in the Arctic'. The challenge is to include the Southern Hemisphere so as to create and reinforce links around the whole Atlantic basin research community. Fish farming, as well as sustainable fisheries have been identified as areas of major interest for the Southern Atlantic in particular by certain coastal states.

¹⁴⁸ <http://ec.europa.eu/research/iscp/index.cfm?pg=asia>

¹⁴⁹ https://www.researchitaly.it/uploads/12471/BLUEMED_SRIA_March2015.pdf?v=7fb440d

¹⁵⁰ <http://www.atlanticresource.org/aora/>

- **Baltic Sea Research and Development Programme - BONUS¹⁵¹**: The Joint Baltic Sea Research and Development Programme (art. 185) is an integral part of the EU Strategy for the Baltic Sea region. As an enclosed sea which is subject to severe environmental pressures, ensuring sustainable fisheries and aquaculture in the Baltic is particularly sensitive. Topics within BONUS calls include themes addressing fisheries, aquaculture management, stock assessments and resolving spatial heterogeneity and temporal dynamics of the Baltic Sea.

5. Analysis of Food and Nutrition Security Research & Innovation Stocktaking

Although much progress has been made in supporting R&I for FNS in Europe, the current stocktaking exercise shows signs that within the existing EU R&I policy there is need to deal more effectively with the complexity of the FNS challenge by:

Implementing a food system approach: Until recently most R&I actions have successfully dealt with individual compartmentalised parts of the food system (ex: agricultural and fisheries production, food safety, pesticides, nutrition). Such an approach is necessary and adequate to furthering our understanding and handling of individual processes. Selected R&I actions adopted a more integrated approach by implementing system-based approaches. SCAR's plea for a 'systemic approach' recognises that many of the drivers of FNS are becoming increasingly urgent and interconnected. It also means that the policy narrative for R&I in FNS would benefit from adopting a systems approach linking a) land and sea, b) all elements of the food system, c) local to global value chains. In addition R&I would benefit from embracing inter and transdisciplinary approaches and engaging a wide diversity of disciplines (including the social sciences and humanities) and actors (including researchers, policy makers, industry and civil society).

Strengthening R&I policy coherence and coordination: Given that various FNS-relevant R&I actions are scattered amongst different EC services¹⁵², different programmes and funding instruments (ex: Horizon 2020, AR4D, ESIF, EFSI) would benefit from more efficient coordination. At Member States and regional level, there is also potential for improving coherence and pooling data, as in most countries the governance of food systems is spread over a number of different entities, each managing different parts of the R&I food chain. This finding was highlighted in the 2015 fourth SCAR foresight exercise which provided recommendations for addressing member state FNS R&I, particularly on the need for better policy coherence across the R&I landscape.

Reinforcing R&I MS policy alignment: The building of the European Research Area (ERA)¹⁵³ has attempted to bring about greater alignment and integration of National programmes and research priorities in Europe with varied success. There are currently several Members State-led Joint Programming Initiatives relevant to different FNS issues: FACCE, HDHL and OCEANS. A recent evaluation of these joint initiatives indicates that there is still a need for appropriate tools and incentives to help support an innovation culture both within

¹⁵¹ <http://www.bonusportal.org/>

¹⁵² RTD, AGRI, SANTE, GROW, CNECT, JRC, MARE, HOME, REGIO, etc.

¹⁵³ ERA: http://ec.europa.eu/research/era/index_en.htm

R&I programmes, and food related policies and regulations¹⁵⁴. In addition, SCAR is now committed to tackling food systems via the establishment of a dedicated food systems strategic working group. Further potential R&I alignment work with international funders beyond Europe is being fostered via the International Bioeconomy Forum, with an initial focus on microbiome research.

Boosting R&I investment and market uptake: The Innovation Union (IU) scoreboard¹⁵⁵ for 2015 shows the EU as only fourth after South Korea, US, and Japan while a wide variation exists between Member States. According to the study 'The competitive position of the European food and drink industry', the EU food and drink industry is facing a decrease in competitiveness and is lagging behind comparable economies.

Improving R&I take up of emerging technologies and new ways of doing science: FNS R&I is an ideal place to mainstream the Fourth Industrial Revolution, often characterised as a fusion of physical, digital, and biological technologies¹⁵⁶. In addition to boosting innovation across food systems, such approaches and technologies also bring about new business models and ways of engaging with society, which is a means to foster consumer trust in science, policy and industry.

Improving data gathering and monitoring in Member States: There is no central inventory of FNS R&I initiatives across the Member States. This fact was highlighted in the 2015 fourth foresight exercise of the EU Member States Standing Committee on Agriculture Research (SCAR), which also provided recommendations for addressing FNS R&I, particularly on the need for better policy coherence across the R&I landscape. Through SCAR a recently established food systems strategic working group will map relevant R&I in the Member States after defining the scope of food systems.

Measuring FNS R&I output and impact: Although the output of public R&I investments is better documented, there is much less data around to monitor and assess the impact of R&I overall, including for FNS, for jobs and growth, or for specific societal challenges (e.g. prevalence of food-related non-communicable diseases, reduction of food poverty), overall, or for specific areas of food systems. This complicates measuring the efficiency of public investments, monitoring progress, or the establishment of R&I agendas. Using the indicators of the SDG framework could be key for measuring this impact.

¹⁵⁴ http://ec.europa.eu/research/era/joint-programming-documents_en.htm

¹⁵⁵ http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards/index_en.htm

¹⁵⁶ <http://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond>

6. Conclusions and Next Steps

Food and nutrition security is about ensuring that everybody is able to access sufficient, sustainable, affordable, healthy and nutritious food in the short and long term. In this context, the challenges facing Europe in a changing world are enormous. In the last decades global pressures on the environment have grown at an unprecedented rate and Europe's natural capital –is being significantly degraded, including by unsustainable activities related to food systems¹⁵⁷: Essential resources such as biodiversity, soil and water are limited or in degradation. Climate change-resilient, circular and sustainable production systems need to be developed and sustainable and healthy consumption patterns should be promoted.

Even though Europe has the advantages of a favourable climate, a rich marine environment and the knowledge and skills of its farmers fishermen scientists and industrialists, the challenges outlined in section 1 of the paper are currently not being met with the necessary investments in research and innovation (public or private) to meet the required solutions. As outlined in section 5 above, this paper identifies some bottlenecks and opportunities which have to be addressed in order to meet the challenges ahead.

The paper has described the challenges of FNS in both a global and EU context and how they are being addressed by a wide range of different R&I priorities, policies, strategies, programmes and initiatives. It also describes the vast scope of FNS and how these activities can be best grouped and followed under the thematic headings of nutrition, climate, circularity and innovation, and suggests an R&I structure of research, innovation and investment, open science¹⁵⁸ and international collaboration under which R&I in these themes can be addressed.

The paper recognizes that the current research and innovation policy landscape lacks a complete food system approach and is scattered across different sectors and stakeholders, with weak FNS R&I policy coherence and coordination encompassing food security, public health and environmental protection. There is a lack of FNS integration and policy alignment, including data and knowledge pertaining to the amount of R&I investment at the Member State level which may lead to the sub-optimal use of resources. The actual impact of research and innovation policies on investment, especially by the private sector, needs analysis especially concerning low market uptake of R&I and the slow adoption of emerging technologies and new ways of doing science. In addition, a centralised data repository for funding initiatives is lacking concerning FNS R&I in Member States along with better ways to measure FNS R&I output and impact.

We have now reached a point where decisions need to be made to address some of the threats and weaknesses identified. The FOOD 2030 High Level Conference of 12-13 October 2016, taking place just prior to World Food Day 2016, will be an important milestone to engage in a forward-looking conversation with FNS R&I policy makers, industry, researchers, and society on how to best pool and organise EU R&I resources in order to future-proof European food systems to achieve food and nutrition security for all, in a global context.

The conference will offer a useful stage to this forward looking approach but it merits an even wider debate and in this context it is suggested that further developments could include the

¹⁵⁷ <http://www.eea.europa.eu/soer-2015/synthesis/report/0c-executivesummary>

¹⁵⁸ http://ec.europa.eu/research/innovation-union/pdf/expert-groups/rise/study_on_open_science-impact_implications_and_policy_options-salmi_072015.pdf#view=fit&pagemode=none

possible preparation of a green paper and a wider consultation process over the coming period. This could be supported by the Horizon 2020 call for proposals for the FOOD 2030 Coordination and Support Action¹⁵⁹ and further by working more closely with Member States for better FNS R&I policy alignment, for example through the new SCAR 'Food Systems' strategic working group. This will also entail some form of public consultation exercise. Forthcoming policy developments surrounding the existing and new multi annual financial framework will be closely monitored along with related policy reviews of the CAP, CFP, public health, competition, etc., and how they will help shape a new FNS R&I landscape and agenda.

7. List of Acronyms

CAP	Common Agricultural Policy
CF	Cohesion Fund
CFP	Common Fisheries Policy
CoR	Committee of Regions
COSME	EU programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises
DCI	Development Cooperation Instrument
DG AGRI	Directorate-General for Agriculture and Rural Development
DG CONNECT	Directorate General for Communications Networks, Content & Technology
DG DEVCO	Directorate-General for International Cooperation and Development
DG ENV	Directorate-General for Environment
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
DG JRC	Directorate-General Joint Research Centre of the European Commission
DG RTD	Directorate-General for Research and Innovation
DG SANTE	Directorate-General for Health and Food Safety
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
EDF	European Development Fund
EEA	European Environment Agency

¹⁵⁹ <http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/sfs-18-2017.html>

EESC	European Economic and Social Committee
EFSA	European Food Safety Authority
EFSI	European Fund for Strategic Investment
EIB	European Investment Bank
EIP	European Innovation Partnership
EIT	European Institute of Innovation and Technology
EJP	European Joint Programme
EMFF	European Maritime & Fisheries Fund
EP	European Parliament
EPSC	European Political Strategy Centre, European Commission
ERA	European Research Area
ERAC	European Research Area Committee, formerly CREST
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
ETP	European Technology Platform
EU	European Union
FNS	Food and Nutrition Security
FP	Framework Programme for Research and Technological Development – examples FP5, FP6, FP7, Horizon 2020
GPGP of the DCI	Global Public Goods and Challenges of the Development Cooperation Instrument
H2020	Horizon 2020
HLPD	High Level Policy Dialogue
InnovFin	EU Finance for innovators
IU	Innovation Union
JPI	Joint Programming Initiative
KIC	Knowledge and Innovation Community
LEIT	Leadership in Enabling and Industrial Technologies

MSCA	Marie Skłodowska-Curie actions
MSFD	Marine Strategy Framework Directive
PC	Programme Committee of Horizon 2020
PPP	Public-Private Partnership
PRIMA	Partnership for Research & Innovation in the Mediterranean Area
R&D	Research and Development
R&I	Research and Innovation
RIS3	Research and Innovation Strategies for Smart Specialisation
RRI	Responsible Research and Innovation
SC2	Societal Challenge 2 of Horizon 2020
SCAR	Standing Committee on Agriculture Research
SME	Small and Medium Sized Enterprises
SRIA	Strategic Research and Innovation Agenda
STOA	Science and Technology Options Assessment, European Parliament
WFD	Water Framework Directive