European Commission

Harnessing Research and Innovation for FOOD 2030: A science policy dialogue

Conference outcome report
16 Oct 2017, Brussels

#FOOD2030EU

Research and Innovation

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Conference outcome report - 16 Oct 2017, Brussels

European Commission
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Bioeconomy

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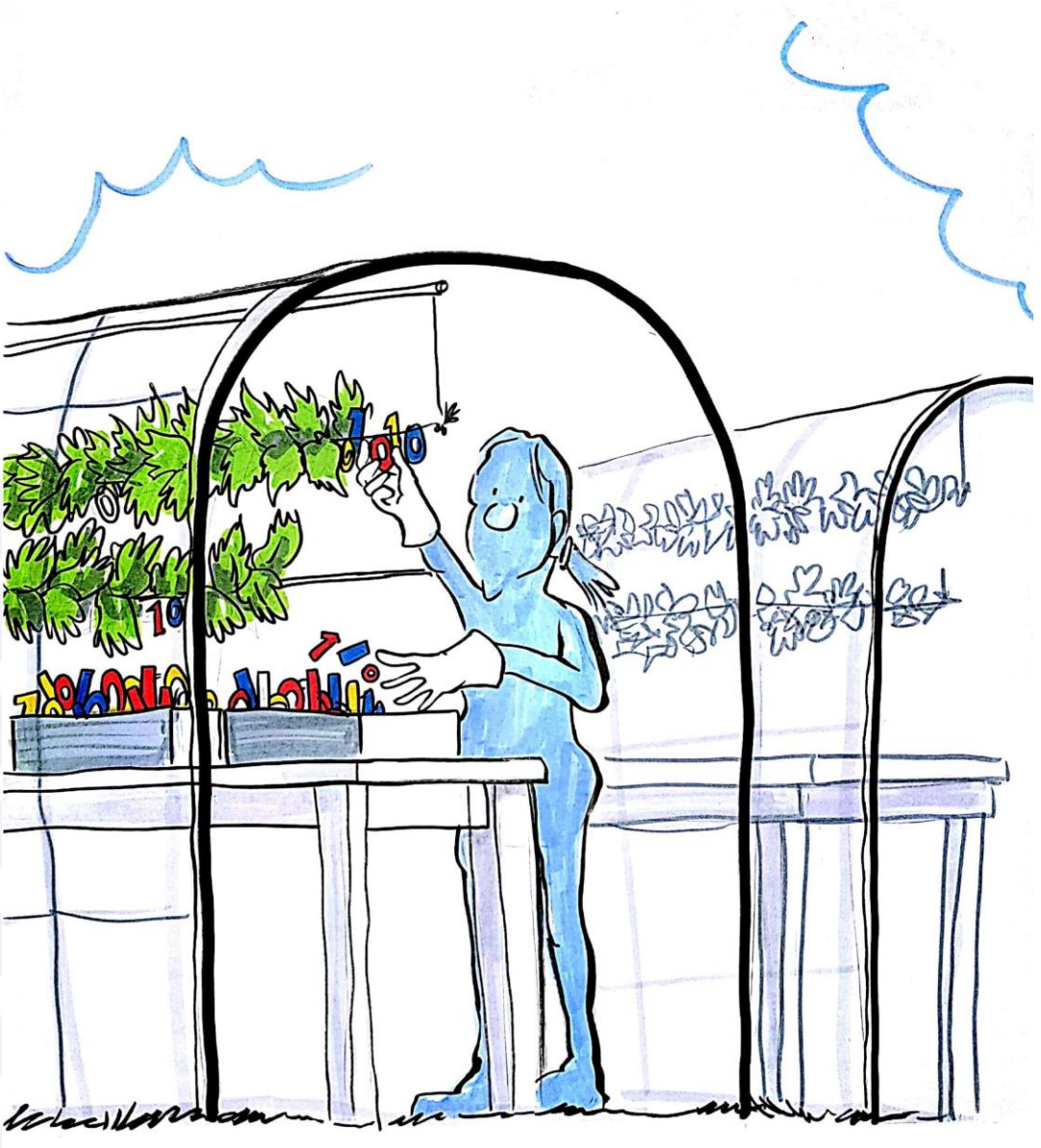

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Executive Summary

The conference entitled 'Harnessing Research and Innovation for FOOD 2030: A science policy dialogue' held in Brussels on the occasion of World Food Day on 16th October 2017 highlighted successful European research and innovation (R&I) outcomes relevant to Food and Nutrition Security and provided inspiration for further development of priorities which will play a key role in achieving the objectives of FOOD 2030. R&I will play an increasing crucial role in future-proofing our food systems as the compounded, multifaceted effects of climate change, urbanisation, population growth and resource scarcity converge, intensify and impact the everyday lives of people.

Main conclusions on need to adopt a systems approach to R&I:

- Aggregating research within the 'food systems context' is a crucial element that needs to be defined in a precise way with clear boundaries [von Braun].

- The food system must include science by default by providing room for breakthroughs allowing academic freedom, long-term funding, and allowing people to think different [Fresco].

- The role of R&I in food systems is crucial to support long-term EU targets, MS and regional priorities, relevant to natural resource management priorities, climate action, soil, air, water and biodiversity [Haniotis].

- R&I in food systems needs to tackle the complex phenomenon of migration for the long term [Amaral].

- R&I has the opportunity to strengthen policy coherence and coverage in food systems, as well as the targeting of actors with influence [Maguire].

Main Conclusions from panellists:

- Catalysing positive change in food innovation ecosystems will require integrated approaches to connect multiple actors of value networks.

- New ways of engaging and empowering consumers and primary producers in innovations in food systems are needed.

- FOOD 2030 should cover issues and target companies needing disruptive, as well as incremental innovations, the latter of which currently predominate.

- FOOD 2030 should address the lack of venture capital/entrepreneur openings in EU.

- There is an urgent need for infrastructure to perform nutrition and health surveys of all population groups, including European residents of ethnic minority, central eastern European countries and vulnerable subgroups.

- There is a need for more face-to-face interactions with policy makers and implementation mechanisms for research results to have measurable impact.

- The understanding of the relationships between 'diversity' and 'resilience' in food systems needs to be broadened and defined.

- Integration of different forms of knowledge (i.e., evidence-based, experimental, embodied experience), underpinned by different values (i.e., socio-environmental justice, economic competitiveness etc.) must be strengthened in R&I for food systems.

- Different policy areas and value chains can be combined through FOOD 2030 for better value-based governance systems and to achieve a positive impact.

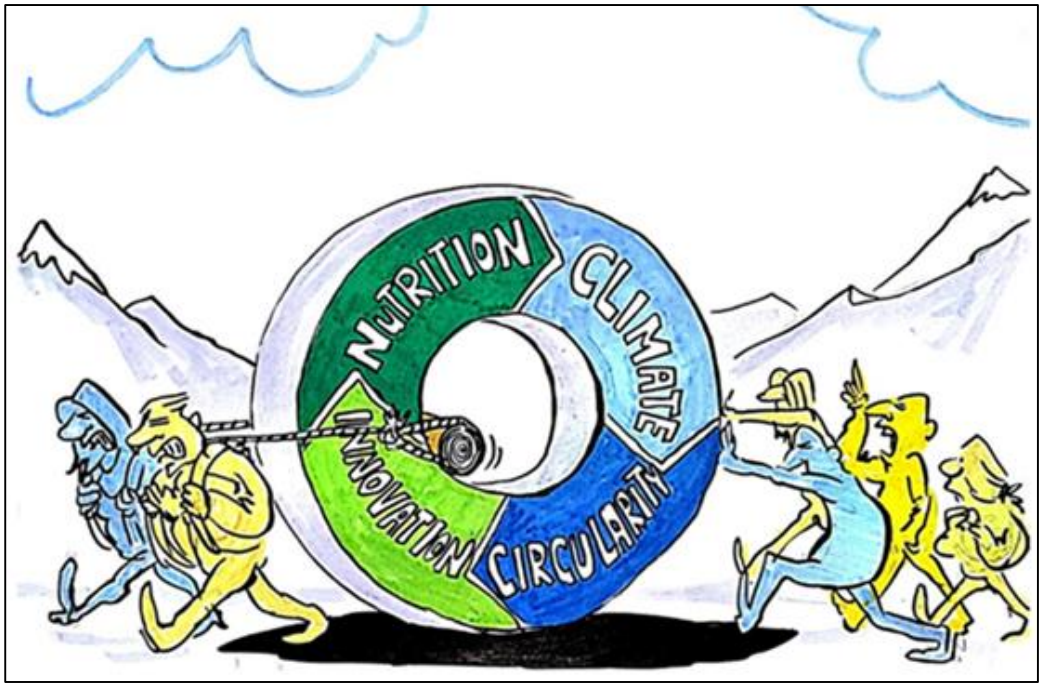
- Social innovation/research has an important role in food system transformation, for example for avoiding, reducing and adding value to food waste.

- For the development of new products or by-products related to the circular economy it is important to go beyond the classical sectors and have a close look at the demand side. Cooperation with industry in this frame is also needed.

Introduction

FOOD 2030 is a European Union (EU) R&I policy framework that strives to future-proof our nutrition and food systems for sustainable and resilient food production and consumption, links land and sea and connects a wide diversity of food systems actors.

The 2015 World Expo in Milan initiated the first phase of FOOD 2030 which catalysed debate within the European Commission (EC) and with key stakeholders on how R&I can future-proof our food systems. The result of this first phase culminated in a first High-Level Event (HLE) held on 12-13 October 2016 and the publication of the EC Staff Working Document entitled 'European Research and Innovation for Food and Nutrition Security'.[1] FOOD 2030 was subsequently referred to in the 2016 EC Communication 'Next steps for a sustainable European future: European action for sustainability'[2] of First Vice-President Timmermans, as a possible tool to help address global hunger.



The FOOD 2030 conference, held on World Food Day 2017, built on the First FOOD 2030 HLE and acted as an important milestone in the preparation of the Second FOOD 2030 HLE to be held in Plovdiv under the Bulgarian Presidency in June 2018.

The conference provided an opportunity to disseminate successful European R&I findings and case studies relevant to future-proofing our food systems. It also

[1] SWD(2016) 319

[2] COM(2016) 739

contributed to the ongoing science-policy dialogue by providing a stakeholder platform to assess the current state of European research, innovation and investment, and explore future needs relevant to the Food and Nutrition Security priorities in particular:

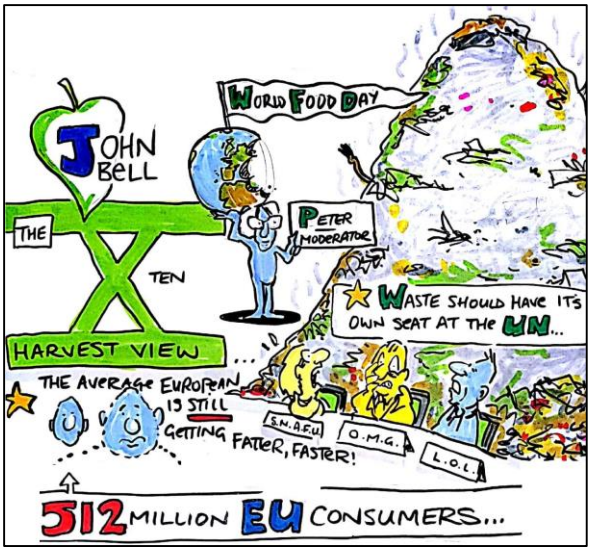
- Food system innovation and empowerment of communities;
- Sustainable and healthy nutrition;
- Climate-resilience and environmental sustainability; and
- Circularity and resource efficiency.

This outcome document provides an overview of the main points raised during the conference and key messages from members of the FOOD 2030 Expert Group that were appointed to act as *rapporteurs*. Additional information on figures of participation, interactivity as well as the conference agenda are found in the annex.

Part 1 - Keynote speakers

This sections provides and overview of the main issues raised by keynote speakers that presented their ideas during the various plenary sessions.

1.1. FOOD 2030 Policy framing, John Bell



John Bell, Director for Bioeconomy at the Directorate-General for Research and Innovation, highlighted in his opening speech that FOOD 2030 will play an important role in delivering food and nutrition security (FNS). A future looking, more coherent and coordinated approach to food systems R&I throughout the EU structures will bring massive benefits to food systems transformation and help address political commitments such as the Sustainable Development Goals (SDGs) and Common Agricultural Policy (CAP) reform.

FOOD 2030 is an EU proposal for R&I that has received solid support at the level of the EU institutions and this conference provides an opportunity to broaden the consultation process to the actual FOOD 2030 stakeholders. Giving access to sufficient, affordable and nutritious food, through a Food Systems approach, is at the heart of the 2030 agenda for sustainable development.

There are important challenges to tackle related to reducing food system-related greenhouse gas (GHG) emissions; meeting increasing protein demand; reducing hunger and obesity and ending food poverty; all by 2030. The outcome of this event will feed into the next FOOD 2030 HLE to be organised under the Bulgarian Presidency in Plovdiv in June 2018. This will mark the next political opportunity to register and move forward on the FOOD 2030 concept and process. It will be a crucial window of opportunity as it coincides with the proposals for the next EU Multi-annual Financial Framework (MFF), and the new Framework Programme for Research and Innovation (FP9).

1.2. Science for Food System Transformation, Louise Fresco

Louise Fresco, President of Wageningen University and Research, opened her intervention with the statement that food production should be sustainable, that we should all produce more with less, based on ecological principles. Policy makers and researchers have to fix their view on several levels of food systems. Level 1: Integrated: In this system we strive to improve production, using skilled solutions (genetics, robotics, big data, and photosynthesis). Level 2: Interconnected: We have to look at the food chain as a cycle. Moving beyond traditional methods, use new technologies and sources (waste, new proteins), look at health. Level 3: Inclusive: The system has to nourish 512 million persons and has to allow them to make the right choice, it especially has to use education to help persons with lower incomes to make informed choices and the system has to empower people by the use of new technologies (sensors, early warning systems). Maintaining diversity is important, so we need to see at which level to intervene (cities, national, supranational, etc). Level 4: 'Science inside': The system has to provide room for breakthroughs allowing academic freedom, long-term funding, and allow people to think different. She concluded by saying that only an integrated, interconnected, inclusive food system will allow us to tackle the challenges of the future.

1.3. R&I in support of a modernised Common Agricultural Policy, Tassos Haniotis

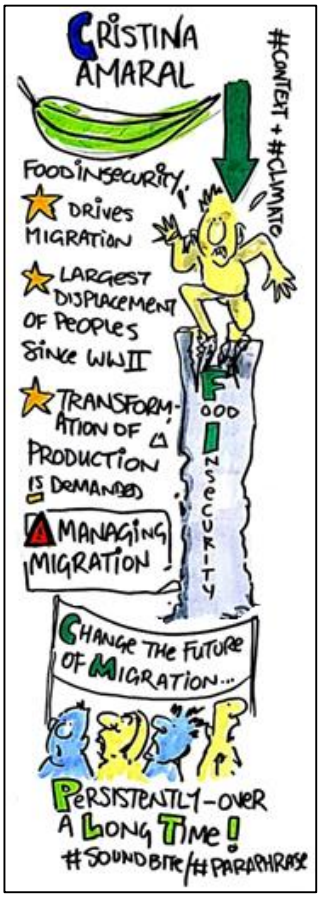
Tassos Haniotis, Director for Economic Analysis in the Directorate-General for Agriculture, described the CAP and how this policy is deeply embedded in the history of European integration. The policy has undergone significant reforms since the mid-1990s and under the current reform cycle it must be adapted to an increasingly broad and complex range of externalities and objectives while maintaining its main purpose of guaranteeing farmers incomes and rural livelihoods. One major challenge is how to improve the integration of the CAP with other policies such as climate and environment to research,

innovation and technology, from the bio-economy and the digital economy to trade.

He stressed the dilemma facing the new CAP having to focus upon sustainability and addressing the tensions between economic competition and the short and long term environmental costs. However a more policy coherent and knowledge based innovation driven agriculture which can address these issues is a viable solution. Turning these tensions into synergies requires the CAP to adapt to the challenges and seek added value and a systemic approach within food, fuel, and fibre systems.

The role of R&I here is more than crucial: Through the translation of long-term EU targets, into MS and/or regional priorities, with respect to natural resource management priorities on climate action, soil, air, water and biodiversity. An expansion of the range of best practices that are regionally pertinent and specific along with better integration of sustainable practices into the virtuous cycle of Research-Innovation-Advice services are the key to serve broader policy priorities.

1.4. Investing in food systems & rural development to change the future of migration, Cristina Amaral



Cristina Amaral, Director of the Liaison Office with the EU and the Kingdom of Belgium of the Food and Agriculture Organization (FAO), began her speech focusing on the global and international dimension of the food and nutrition security challenge and highlighted the important link of the FOOD 2030 conference to the UN World Food Day event, the same day in Rome.

Then, a video message was shown from José Graziano da Silva, Director-General of the FAO that introduced the theme of World Food Day 2017 'Migration' and its slogan 'Change the future of migration. Invest in food security and rural development'. The video presented the link with FAO's work and focused on the current relationship between migration, food security and agriculture. The message at the same time identified root causes that are forcing people to migrate, including conflicts, hunger, poverty and the impact of climate change.

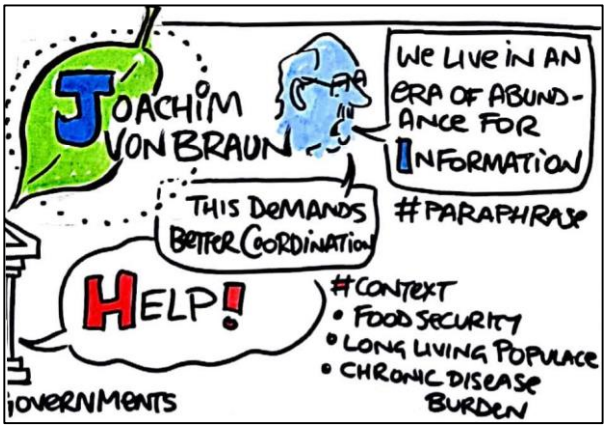
Cristina Amaral focused in her speech on three central messages. Firstly, she raised the issue that after steadily declining for over a decade, global hunger is on the rise again and the number of chronically food insecure people had increased to 815 million in 2016. Secondly, more people have been forced to flee their homes than in any other time since the Second World War due to conflict and

political instability. And thirdly she highlighted the fact that so far the impact of migration on rural areas and rural livelihoods, and the urgent need to invest into these areas, have been largely neglected by past development actions. She highlighted the urgent need to make this a priority.

She highlighted that there is no single solution to the complex phenomenon of migration and a long-term approach will be needed. A key element in the process will be to improve the food and nutrition security in migrants' home countries and invest in rural development and agriculture to address some root causes of migration. Creating conditions that allow for sustainable and resilient livelihoods of rural people, especially for women and youth, are a crucial component of any plan to achieving the Sustainable Development Goals.

Migration and mobility policies need to be underpinned by sound evidence and analysis from reliable and comparable data. Research can provide an important contribution to the elaboration of the right migration policies. In this regard, Cristina acknowledged the contribution of the European Commission's Framework Programmes for Research and Innovation, and also acknowledged the FOOD 2030 initiative with its focus on food and nutrition security and the EU commitment to SDGs and the Paris Climate Change agreement. While more innovation will (hopefully) assist in reaching this goal, she made clear that it is not only the lack of technologies but political will and cooperation that are needed to tackle this problem.

1.5. The Food Systems approach – Europe and emerging African and Global perspectives by the Inter Academy Partnership, Joachim von Braun



Joachim von Braun, Director of the Centre for Development Research (ZEF) in Germany, highlighted the international dimension of any food systems debate. Food is a globally traded commodity. Efficiency gains or shifts in consumer preferences in one part of the world may affect prices and availabilities in other parts. Therefore, in 2017 many reports analysed the future of food systems globally. Unlike reports in previous years they adopt more and more a systematic approach, so they don't look at individual sectors alone and call e.g. for a boost of agricultural production. These recent reports look at the other factors of the food equation, calling for nutrition sensitive agriculture, addressing the need to reduce losses in the food system and addressing obesity risks in developing countries where the diet is solely based on sugar and cheap carbohydrates and lack diversity. Joachim von Braun also explained the reasons behind this increased attention by science and policy to the food systems approach,

including sustainability concerns around food and agriculture and transformative science and technologies which are driving this growing interest.

The Inter Academy Partnership study on Food and Nutrition Security and Agriculture[3] 2017/18 could have a profound impact around the globe on how food systems are discussed at the science/policy interface. All world regions are engaged in the debate and are about to publish their regional report before the first half of 2018 when the global report is finalised. The approach is science based with a strict peer review process for all regional reports and the global synthesis report.

Furthermore, he introduced the conceptual framework for aggregating research within the food systems context as a crucial element that needs to be defined in a precise way by defining its boundaries. Following this, he introduced the main themes of focus in the European report[4], including productivity, waste reduction, bioeconomy, digitalisation, climate change, livestock and improved plant breeding, land use, water soils, personalised nutrition among several other themes. Joachim also highlighted the priority setting process that took place when deciding on these themes in a collective of numerous key players. The emerging strategic dimensions include research agendas which need to recognise importance of basic research, multidisciplinary research and long-term commitment to research, as well as the critical interface between research on nutrition-sensitivity of food systems and on environmental sustainability and focus on food and nutrition security of vulnerable groups in Europe.

The African report is an example that will be inspired by African science policy agendas, including the Malabo declaration or the Comprehensive African Agricultural Development Programme and also the EU-African Union High Level Policy Dialogue on Food and Nutrition Security and Sustainable Agriculture.

Finally, he called for strengthening the science agenda to support the pertinent targets under the SDGs on ending hunger, enhanced sustainable agriculture, healthy diets, and reduced waste. Finally he called for a science-based CAP reform when considering rebalanced priorities – from agriculture subsidies towards public goods and good nutrition through innovation with sustainability and a reform of international food and nutrition governance, considering an 'International Panel on Food Nutrition Agriculture'

1.6. Food in a green light - a systems approach for sustainable food, Cathy Maguire

Cathy Maguire, from the European Environment Agency (EEA), launched at the conference EEA's new report entitled 'Food in a Green light – A systems approach for sustainable food'.

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[3] http://www.interacademies.net/2952/31342.aspx

[4] www.easac.eu/fileadmin/PDF_s/reports_statements/Food_Security/EASAC_FNSA_report_complete_Web.pdf

Before addressing this new food dedicated report in detail, Cathy Maguire shortly introduced the latest EEA SOER 2015 assessment report[5] with a more general perspective on the state and prospects of the European environment. The SOER 2015 clearly demonstrated that while the present environmental policies deliver for the environment, economy and people's wellbeing, important challenges remain ahead. The report highlighted that living well within ecological limits will require fundamental transitions in the societal systems of production and consumption that are the root cause of environmental and climate pressures, including the food system and that such transitions will entail profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking.

Since the 2015 SOER report EEA has been exploring different systems and analytical approaches via several dedicated assessments. The 'Food in a green light' report[6] follows the 'Seafood in Europe'[7] (published in October 2016). The 'Food in a green light' report is a first attempt to frame and analyse these issues in an integrated way, and takes a food system approach to analyse European production, consumption and trade of food and associated environmental and human health aspects. It analyses the challenges ahead and identifies opportunities to respond.

Current policies and initiatives mainly target primary producers and consumers and while these actors are the largest in numbers, they do not necessarily have the most power or influence to bring about change in the food system. Also, at present the main focus is on improving resource efficiency of the food system and consumer awareness and while this can improve environmental performance, it will not deliver the transformation needed to meet sustainability goals.

Cathy Maguire identified the challenges ahead from a global and EU perspective. Achieving more sustainable outcomes involves moving from a sectoral approach to a food systems approach, strengthening of policy coherence and coverage and well as the targeting of actors with influence. And last, but not least, it includes governance arrangements that involve stakeholders and address complexity. In the report three areas were highlighted where opportunities exist to transform policy and practice: Changing mind-sets and underpinning values and practices related to food, seizing current opportunities without merely focusing on future and long-term goals, and knowledge development enabling to move towards food systems approach.

[5] https://www.eea.europa.eu/soer

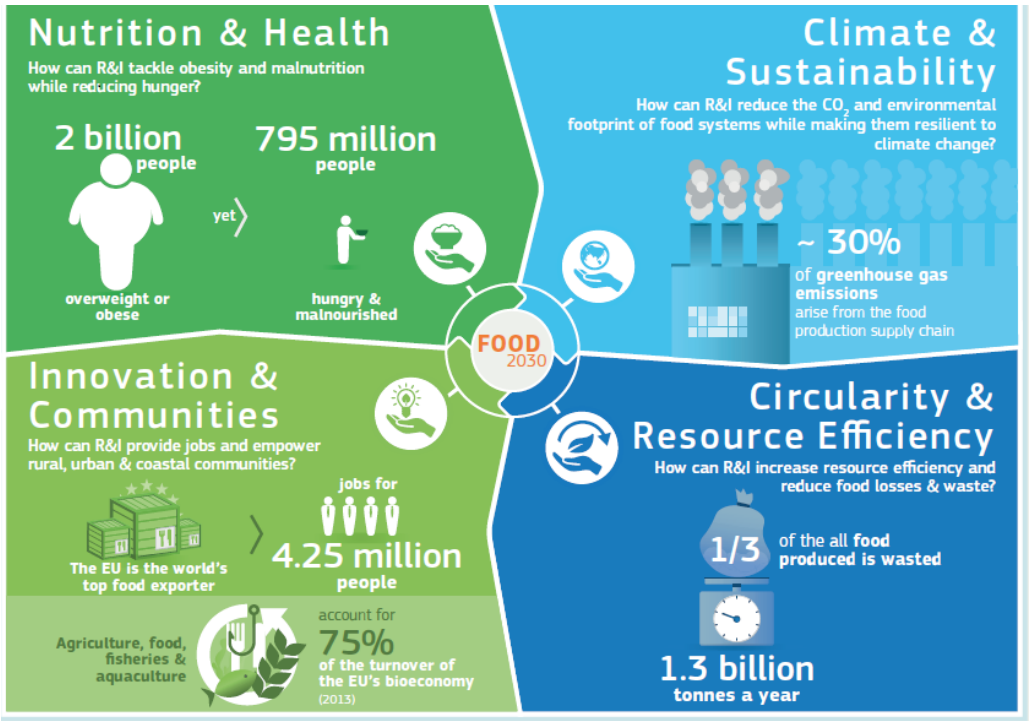
[6] https://www.eea.europa.eu/publications/food-in-a-green-light

[7] https://www.eea.europa.eu/publications/seafood-in-europe-a-food

Part 2 – FOOD 2030 Priorities

The second part of the conference outcome report provides an overview of the main points raised during the four conference sessions, tackling each of the four FOOD 2030 priorities:

- Food system innovation and empowerment of communities
- Sustainable and healthy nutrition
- Climate-resilience and environmental sustainability
- Circularity and resource efficiency



The following sections have been written by four members of the FOOD 2030 EC Expert Group that were also appointed as 'rapporteurs' for the conference. These experts provided background knowledge and personal insights on each of the priorities, reported on the presentations and discussions held during their respective session and extracted lessons learnt and where relevant, ideas for looking ahead.

2.1. Fostering Innovation in Food & Nutrition

By Prof. Dr. Klaus Menrad, Chair of Marketing and Management of Biogenic Resources at HS Weihenstephan-Triesdorf in Germany, and member of the FOOD 2030 EC Expert Group.

2.1.1. Introduction

The EU food industry is characterized by a low R&I intensity with annual investments of 0.20% of the industry's turnover[8] which is significantly lower than in USA and Japan. There is a general agreement among scientists that incremental innovations predominate over radical innovations in the food industry[9,10,11,12]. This high relevance of new products with a rather low degree of novelty can be explained by the "consumer inertia" effect[13] saying that consumers have a higher probability of choosing a product that they have purchased in the past. Additionally consumers often are not able to formulate an explicit need for new products.[14] In this sense the feedback from users of products often leads to modifications within the existing product concepts what might be supported by the mainly small and medium-sized structure of the EU food industry. Furthermore, innovations in traditional food products are often only accepted if they provide tangible benefits for consumers while at the same time not harming the intrinsic traditional character of the product.[15]

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8 FoodDrink Europe (2017). Data and Trends of the European Food and Drink Industry 2017. http://www.fooddrinkeurope.eu/uploads/publications_documents/DataandTrends_Report_2017.pdf

9 Baregheh, A., Rowley, J., Sambrook, S., Davies, D. (2012). Innovation in food SMEs. Journal of Small Business and Enterprise Development Vol. 19 No. 2, pp. 300-321.

10 Alfranca, O., Rama, R., von Tunzelmann, N. (2004). Innovation spells in the multinational agri-food sector. Technovation Vol. 24, pp. 599–614.

11 Menrad, K. (2004). Innovations in the food industry in Germany. Research Policy, Vol. 33, No. 6-7, pp. 845-878.

12 Garcia Martinez, M. and Briz, J. (2000). Innovation activities in the Spanish food and drink industry. International Food and Agribusiness Management Review, Vol 3, pp. 155-176.

13 Cuerva, M.C., Triguero-Cano, A., Corcoles, D. (2013). Differences in innovation between food and manufacturing firms: An analysis of persistence. Agribusiness Vol. 29, No. 3, pp. 273-292.

14 Von Hippel, E. (1988). The sources of innovation. Oxford University Press, Oxford.

15 Guerrero, L., Claret, A., Verbeke, W., Enderli, G., Zakowksa-Biemans, S., Vanhonacker, F. et al. (2010). Perception of traditional food products in six European regions using free word associations. Food Quality and Preference, Vol. 21, No. 2, pp. 225-233.

Additionally, innovations in traditional food products would barely succeed in attracting new customers.[16]

Despite the presence of large multinational companies, the food supply chain of the EU is characterized by the strong presence of Small and Medium Sized Enterprises (SMEs) in food production and food processing[17] which face specific challenges to succeed in competitive food markets (both locally and internationally). Thus innovations in e.g. modified products, food processing techniques, logistics, marketing or business models are strongly required for SMEs in order to remain competitive. Although scientific studies indicate that innovations have a positive effect on the productivity, export position and turnover of SMEs active in the food industry[18], only half or less of the food SMEs in different EU countries carry out product or process innovations and only one third (or below) have their own R&I activities[19,20,21]. Thereby the lack of co-operation between market-based actors of the food value chains (mainly customers, food retailers, suppliers, and other food companies)[22,23,24] is a key bottleneck for the development of innovations. Previous studies show that food SMEs engage in different types of innovations with product innovation receiving the majority of resources.[25,26,27] In terms of developing innovations in food

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16 Vanhonacker, F., Kühne, B., Gellynck, W., Guerrero, L., Hersleth, M., Verbeke, W. (2013). Innovations in traditional foods: Impact on perceived traditional character and consumer acceptance. Food Research International, Vol. 54, No. 2, pp. 1828-1835.

17 FoodDrink Europe 2014

18 Logatcheva, K., Bakker, T., Oosterkamp, E., van Galen, M., Bunte, F. (2013). Innovation in the Dutch food industry: The role of the SMEs. LEI Report 2013-025. LEI Wageningen UR, The Hague.

19 Cuerva, M.C., Triguero-Cano, A., Corcoles, D. (2013). Differences in innovation between food and manufacturing firms: An analysis of persistence. Agribusiness Vol. 29, No. 3, pp. 273-292.

20 Capitano et al. 2010

21 Menrad, K. (2004). Innovations in the food industry in Germany. Research Policy, Vol. 33, No. 6-7, pp. 845-878.

22 Lefebvre, V.M., Raggi, M., Viaggi, D., Ljungström, C.S., Minarelli, F., Kühne, B., Gellynck, X. (2014). SMEs' preference for innovation networks: A choice experimental approach. Creativity and Innovation Management, Vol. 23, No. 4, pp. 415-435.

23 Bigliardi, B., Colacino, P., Dormio, A.I. (2011). Innovative characteristics of small and medium enterprises. Journal of Technology Management & Innovation Vol. 6, No. 2, pp. 83-93.

24 Zeng, S.X., Xie, X.M., Tam, C.M. (2010). Relationship between cooperation networks and innovation performance of SMEs. Technovation Vol. 30, No. 3, pp. 181-194.

25 Minarelli, F., Raggi, M., Viaggi, D. (2015). Innovation in European food SMEs: determinants and links between types. Bio-based and Applied Economics Vol. 4, No. 1, pp. 33-53.

SMEs market-based actors (e.g. customers, suppliers, competitors, firms of other sectors) play a more distinct role than science-based actors (e.g. universities, research institutes, training institutions, consultants),[28,29,30,31] but such market-based actors have been rarely participating in EU-FP7 projects in the food area.[32]

Based on a choice experiment Lefebvre et al. 2014 showed that food SMEs have a higher preference for innovation networks composed of manufacturers and other members of the food value chain compared to networks with research institutes. Additionally, food SMEs prefer networks where information is shared confidentially among network partners compared to networks where information is shared openly, and they choose a network that is able to provide them with complementary resources and allows them to protect their core assets. This implies that policy activities which aim to foster innovations through building networks should take these needs and preferences of food SMEs into account.

2.1.2. Policy relevance for Innovation

The character of innovations – not only in the food industry – has changed significantly in recent years with the concept of Open Innovation (OI) gaining increasing popularity in academia, policy and industry. Although there are several definitions of the term[33] all definitions have in common that innovation activities are carried out in co-operation with external partners of various fields and that companies should "purposively manage" these knowledge flows which

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[26] Baregheh, A., Rowley, J., Sambrook, S., Davies, D. (2012). Innovation in food SMEs. Journal of Small Business and Enterprise Development Vol. 19 No. 2, pp. 300-321.

[27] Menrad, K. (2004). Innovations in the food industry in Germany. Research Policy, Vol. 33, No. 6-7, pp. 845-878.

[28] Minarelli, F., Raggi, M., Viaggi, D. (2015). Innovation in European food SMEs: determinants and links between types. Bio-based and Applied Economics Vol. 4, No. 1, pp. 33-53.

[29] Bigliardi, B., Colacino, P., Dormio, A.I. (2011). Innovative characteristics of small and medium enterprises. Journal of Technology Management & Innovation Vol. 6, No. 2, pp. 83-93.

[30] Zeng, S.X., Xie, X.M., Tam, C.M. (2010). Relationship between cooperation networks and innovation performance of SMEs. Technovation Vol. 30, No. 3, pp. 181-194.

[31] Menrad, K. (2004). Innovations in the food industry in Germany. Research Policy, Vol. 33, No. 6-7, pp. 845-878.

[32] European Commission (2014). An ex-post evaluation of the rationale, implementation and impacts of EU Seventh Framework Programme (2007-2013). Cooperation Theme 2: Food, agriculture and fisheries, and biotechnology. Report to the European Commission.

[33] Chesbrough, H. (2006). Open innovation: a new paradigm for understanding industrial innovation. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.). Open innovation: Researching a new paradigm. Oxford, Oxford University Press, pp. 1-12.

can be imported or exported by the company.[34] In addition, nowadays technologies and findings of research activities are only one driver of innovation activities with business model innovations, design-driven innovations or user-driven innovations gaining increasing relevance also in the food industry. This changing character of innovation activities requires new or adapted capabilities in companies (such as e.g. entrepreneurial spirit, empathy with customers and other external partners, flexibility to continuously adapt to changing environments, managing circular processes) to successfully benefit from the concept of OI. However, a study of the OECD shows that only 5 to 20 % of SMEs are actively using OI approaches.[35] With respect to the food industry, there are single examples of mainly large companies using OI-approaches documented in scientific literature[36], but "in the majority of food companies their new product development processes are still based on internal innovation".[37]

In order to align EU innovation policy with the characteristics of the increasingly open and dynamic innovation environment, significant modifications have been made in the R&I supporting instruments of the EU in recent years. Within the flagship of the Framework Programs for Research and Technological Development, in which nearly 5 billion € were spent or will be allocated to the food system between 1988 and 2020[38], FP7 made a strong request to foster innovation activities and include them in the proposals. With respect to agricultural and food research, the topics covered in the calls were in key target areas of technical innovations of these value chains. Horizon 2020 strengthened this approach and implemented several instruments to improve industrial leadership of the EU and react to the growing societal challenges also in the food and nutrition area. According to the ex-post evaluation report of FP7, only few results could be achieved in particular related to innovation activities of food SMEs. Although SMEs constituted 24% of the participants in food-related research projects, their "participation was often not focused on the generation of commercial impact from results"[39] but they were mainly used for service

[34] European Commission (2017). Europe's future: Open innovation, open science, open to the world. Reflections of the RISE Group. Brussels.

[35] Houssain, M. (2015). A review on literature on open innovation in small and medium-sized enterprises. Journal of Global Entrepreneurship Research Vol.5, No. 6, pp. 1-12.

[36] Sarkar, S., Costa, A.I.A. (2008). Dynamics of open innovation in the food industry. Trends in Food Science & Technology Vol. 19, pp. 574-580.

[37] Tsimiklis, P., Makatsoris, C. (2015). An Open innovation framework for collaborative food product design and manufacturing. Journal of Innovation Management Vol. 3, No. 4, pp. 134-163.

[38] European Commission (2016). European research & innovation for food and nutrition security. Luxembourg: Publications Office of the EU.

[39] European Commission (2014). Performance of SMEs within FP7: An interim evaluation of FP7 components. Brussels.

activities in the projects.[40] In this sense SMEs of the food value chain are so far hardly the beneficiaries of innovative ideas/outputs from the research projects funded under the EU Framework Programmes. The participation of SMEs in all Horizon 2020 projects as well as some innovation-related activities (like patent applications, prototypes etc.) has increased compared to the FP7 programme[41], but the interim evaluation of Horizon 2020 does not yet allow any specific conclusions for food-related R&I projects.

Within Horizon 2020 the European Institute of Innovation & Technology started its food-related activities in 2017 (EIT Food) and the agricultural European Innovation Partnership (EIP-Agri) which began in 2014 has steadily grown in recent years. In addition, the RISE group suggested implementing a European Innovation Council (EIC) for 2018 which is intended to attract and support talented innovators, shall promote open, collaborative and crowd-source modes of innovating as well as develop instruments that can support "breakthrough projects" until the up-scaling phase.[42] Furthermore, the recently published Lamy report recommends doubling the budget for R&I programs after 2020, to define R&I missions addressing global challenges, to involve citizens in the programs as well as to simplify the EU funding landscape for innovations.[43] These initiatives and recommendations need to be considered in the further elaboration of the FOOD 2030 initiative in the coming months.

The policy community has been the largest group of direct users in terms of EU contribution to research with 27 % of total expenditure of all projects funded from FP5 through Horizon 2020.[44] This shows the high relevance of related R&I activities funded by the EU not least since all business and innovation activities in the respective value chains and industrial branches are at least partially governed by EU policies (like e.g. CAP, Marine Policy). In addition agriculture, fisheries and food production rely strongly on natural ecosystem functioning and natural resource management which is also governed at least partially by EU policies.

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[40] European Commission (2014). An ex-post evaluation of the rationale, implementation and impacts of EU Seventh Framework Programme (2007-2013). Cooperation Theme 2: Food, agriculture and fisheries, and biotechnology. Report to the European Commission.

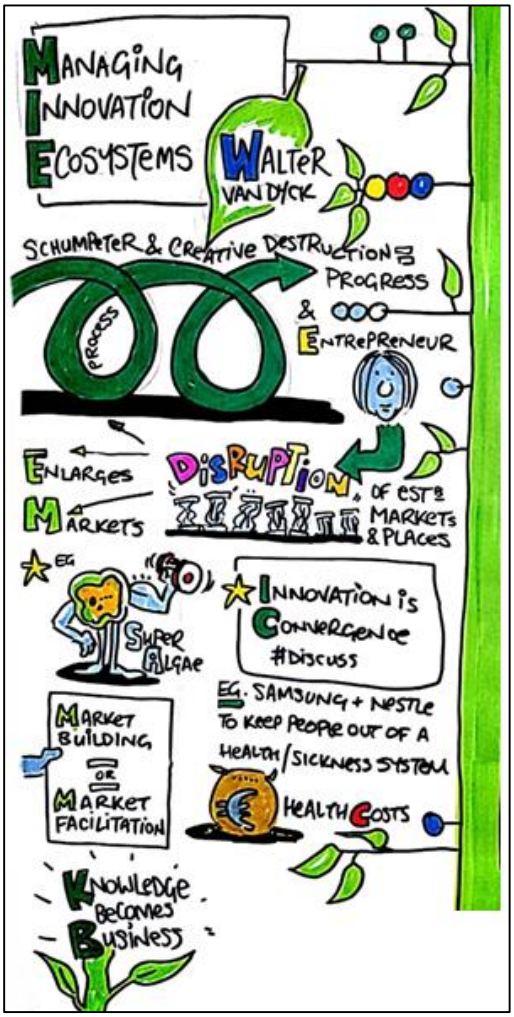
[41] European Commission (2017). Interim evaluation of Horizon 2020. Brussels.

[42] European Commission (2017). Europe's future: Open innovation, open science, open to the world. Reflections of the RISE Group. Brussels.

[43] Lamy, P., Brudermüller, M., Ferguson, M. et al. (2017). LAB-FAB-APP. Investing in the European future we want. Report of the independent High Level Group pm maximizing the impact of EU Research&Innovation programmes. Directorate-General for Research and Innovation, Brussels.

[44] European Commission (2017) Meeting Societal Challenge 2: Approaches to examining how Framework Programmes address Societal Challenge 2: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy.

2.1.3. Innovation session - presentations and panel discussion



The first presentation for this session on fostering innovation was given by **Walter van Dyck**, Vlerick Business School (Belgium) who emphasized the key role of entrepreneurs for disruptive innovation activities in which a new idea or technology will overtake the existing solutions and often expand the current markets. He characterized "disruption" as a process that gradually modifies the existing innovation system and its targeted markets. Additionally, food innovation ecosystems are increasingly characterized by convergence of industry sectors and co-operation of actors of different nature. In this context he highlighted the example of Nestlé and Samsung which collaborate on digital nutrition and health. In addition he emphasized the increasing role of private-public partnerships for innovations in the food value chain using the Dutch fieldlab experiment as an example in which food companies, the Netherlands Organization for applied scientific research (TNO) and universities work together in close neighbourhood. He concluded that open innovation in platform-based entrepreneurial innovation ecosystems is the future also in the food industry of the EU.

The following speaker was **Carmen Lamacchia** who presented the food start-up company *New Gluten World,* which was supported by the EU SME Instrument for several years. The basic technology which is used by this company was discovered by Carmen Lamacchia in 2009 and allows changing certain characteristics of gluten inside the kernel of cereals using humidity and high temperatures so that people suffering from celiac disease can consume cereal products instead of often costly gluten-free food products. She emphasized that it took six years to transfer her invention into a start-up company but after collaborating with one of the largest cereal traders in Europe, the company gained a lot of media attention. She decided to apply to the EU SME Programme in order to speed up program development of her discovery, finance clinical trials and scale-up the technology. After one year experience with this EU instrument Carmen Lamacchia was enthusiastic and convinced that the support of the EU has helped to boost the future of this food start-up company.

This showcase project illustrates the long-term character of a lot of food-related technological innovations which often need a combination of public and private funding instruments. Additionally it shows the systemic character of food innovations which will be further strengthened through the FOOD 2030 activities.

A panel discussion followed which included the two speakers along with **Luis Mira da Silva** (Inovisia, Portugal), **Harry Barraza** (Arla Innovation Centre, Denmark) and **Jochen Weiß** (University of Hohenheim, Germany). Concerning radical innovations in the food industry the panellists emphasized the important role of digital technologies, automatization and blockchain technologies. The panellists agreed that innovations in the agro-food value chain are becoming more and more a multi-actor events for which a more efficient organization of the innovation ecosystem is needed. Due to the fragmented structure of the EU food industry and agricultural sector, intermediates are required which support food SMEs which often do not have any knowledge and capacities to innovate. Thereby innovation partnerships of food industry companies should be created case by case since different partners are needed in differing stages of innovation processes. In this context the rich culture and diversity in food products and eating patterns between EU member states was regarded as a specific asset which can be further enhanced in food innovation activities. However, it was also stressed that around 80 % of food start-ups were located in the USA and that a more favourable environment for such start-ups is needed in the EU.

Another question discussed with the panellists referred to how EU Innovation Policy can support food SMEs in future so that they can better benefit from the new forms of innovation approaches. Due to the multi-faceted character of innovations in the food value chain, the panellists addressed different issues in this regard.

One referred to (potential) mistrust between large and small companies of the food industry, but also to other co-operation partners in innovation projects, which need to be overcome for a fruitful partnership. In this context intermediates have an important role but also training activities in particular for food SMEs are needed so that they become familiar with new scientific, technical and management opportunities. Management training was also regarded as fruitful for scientists who intend to establish a food start-up in order to reduce mistakes in the founding period and to support such companies to survive long enough after market introduction of products. The panellists also argued in favour of a more flexible regulatory framework for new food products since often regulatory innovations are required after disruptive innovations in this sector of economy.

Another important issue during the panel discussion referred to the role of consumers in the innovation processes of the food industry. The panellists agreed that the behaviour of private and/or other consumers (like e.g.

restaurants, canteens, public institutions) is vital to innovation projects since their buying and eating behaviour finally determines success or non-success of such activities. More R&I efforts are needed to bring citizens and consumers in the focus of innovation activities and develop "future markets" of the food industry together with consumers. Currently consumers often have doubts about new technical and scientific developments related to food production and processing and thus they often do not readily accept new food products. Therefore the panellists stated a lack of knowledge concerning the social acceptability of (technical) change in food systems and emphasized to foster related research and more general social-innovation thinking in food-related innovation ecosystems within the EU.

Pluri-disciplinary and multi-actor approaches with stakeholders of different stages of the value chain as well as from the external business environment (such as regulators, education specialists, NGOs etc.) are needed to cover the different aspects of system-oriented R&I activities of the agro-food value chain. The specific challenge in the dialogue between science, society and policy is to include "underrepresented and weak" groups of stakeholders. These stakeholders might not even have a specific interest in the related issue/activity but could give particular insights to the question at hand (e.g. obese consumers who are not specifically interested in nutrition aspects, "traditional" small-scale farmers who would benefit most from technical or organizational innovations). Including such groups in a dialogue can only be successful if they are addressed in their local and known environment and if some individual benefits of such an activity can be offered to them. Therefore there is a need for developing new forms of interactions with such groups and lay people in general as well as including the outcomes of such approaches in economic and political decision-making on local, national and EU level.

Finally, the panellists discussed which specific aspects should be considered in the further development of FOOD 2030 in the coming months. An important request was to facilitate the connection and co-operation between the multiple actor groups which are more and more involved in food-related innovation activities from idea creation to market introduction. Thereby flexible instruments are required since different actors play a role in the different stages of an innovation project of the food industry. In addition, the at least partially existing public mistrust in science and new scientific findings related to the food industry should be tackled as well as changing the mind-set of (large) industrial actors which often are not interested in co-operations with small companies of the food industry. Nutrition-related education of consumers and training of food SMEs were regarded as important long-term activities which should be included in FOOD 2030.

2.1.4. Conclusions & Lessons learnt from the session

Changing food innovation ecosystems require integrated approaches to connect multiple actors of value networks

As shown during the conference there have been significant changes in the food innovation systems in the recent decade. Important developments are the convergence of different industries as well as emergence of open innovation

including external partners. Additionally drivers of innovations are not only scientific or technical developments but also design, market, and business model driven innovations. These changes require developing and establishing integrated approaches to connect multiple actors of the food value chains with each other. In this context different instruments have been put into place in recent years in the EU contributing to this purpose (such as e.g. EIT Food or EIP Agri) but better integration and co-ordination of these activities might be required for the future. Additionally analogous instruments are to be elaborated connecting partners on national or local level with each other

New ways of engaging consumers in innovations in food systems are needed

The panellists' and participants' comments sent over Sli.Do often highlighted the key role of consumers in the innovation processes of the food value chains who finally have to accept and buy the new or modified food products. Involving consumers in product development processes or other innovation projects in the food industry is not a new idea but it can be observed that failure rates of food products introduced in the market have not substantially decreased in recent years. In this sense new ways of engaging with consumers seem to be necessary both for incremental innovations and for disruptive breakthroughs.

FOOD 2030 will cover issues and target companies needing disruptive and incremental innovations

The presentation and discussions during this Conference highlighted the relevance of disruptive, often science-driven innovations in the food industry for future growth and competitiveness in this field. However, FOOD 2030 initiated by the EU has the challenge to take all types of innovation activities of the food industry into account. In this context it has to be considered that the vast majority of EU food companies are often traditionally-working SMEs for which mainly incremental innovations are necessary to remain competitive on their markets. Thus new ways of innovating in traditional food companies have to be elaborated including co-operation with external partners. In addition, training activities for food companies and education initiatives for consumers are required to create a fruitful environment for future innovations in the food value chain of the EU.

2.2. Sustainable & Healthy Nutrition

By Prof. Dr. Lorraine Brennan, Associate Professor at the UCD Institute of Food and Health in Ireland and member of the FOOD 2030 EC Expert Group.

2.2.1. Introduction

Many nutrition related issues highlight the importance of the theme 'Sustainable and Healthy Nutrition' as one of four key FOOD 2030 priorities, among others the fact that Europe is severely affected by non-communicable diseases (NCD). Indeed, of the six World Health Organisation (WHO) regions, the European region is the most severely affected by NCDs which in turn are the leading cause of disability and death. Recent figures quoted by the WHO report that the four major NCDs together account for 77% of the burden of disease and 86% of premature mortality[45]. Key risk factors for these NCDs include excess body weight, over consumption of energy, saturated fats, sugars and salt and under consumption of fruits, vegetable and wholegrains. Concomitant with this, recent reports highlight that more than 50% of the European population are overweight or obese. In addition to this the Europe also faces the double burden of malnutrition where overweight/obesity co-exist with nutrient deficiencies.

Another highly relevant issue is healthy aging, since the number of Europeans over 65 is expected to double in the next 50 years while over 80s will almost triple. In addition despite having significantly enhanced food safety, 23 million Europeans fall ill every year due to foodborne diseases which advocates for continued investment in food safety related issues.

In this respect research strategies are needed to provide the evidence base for improving the overall quality of the European diet and for tackling the challenges ahead. To achieve this further R&I is needed in order to ensure that our future food systems are dealing with the most pertinent issues that will result in an improvement of the situation for all European citizens. The FOOD 2030 conference highlighted some on-going research in the Nutrition and

[45] http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/nutrition

Health field and provided inspiration for further development of R&I priorities which will play a key role in achieving the objectives of FOOD 2030.

2.2.2. Policy relevance for Nutrition

Data collected in R&I projects, such as those presented at the FOOD 2030 conference, are essential in providing the evidence to inform EU policies and their national interpretation. From the projects showcased here, it is clear that data from the ODIN project are essential for informing public health strategies relating to vitamin D and prevention of vitamin D deficiency. ODIN also filled critical gaps in our knowledge in relation to vitamin D requirements for certain population groups which in turn feeds into policy areas such as European Food Safety Authority (EFSA) dietary reference values. The I.Family project reports on intake and physical activity patterns in children. Such R&I improves data collection methodologies but also allows for monitoring and assessment of risk of inadequate or excessive intake of food constituents such as nutrients or food chemicals. Furthermore, they can provide an evidence base of 'when' and 'how' to target specific populations. Such data are key to the workings of organisations such as EFSA. On the other hand, the Hearthealthyhoods project helps informs policies relating to the built environment at a city level. The project demonstrates how R&I can empower local communities to become advocates for policy change at a local level.

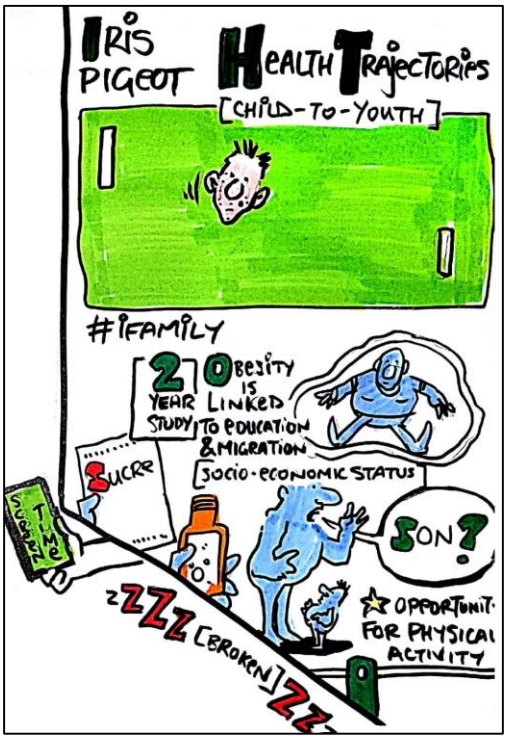
Other R&I projects have helped inform EU policies e.g. on food labelling, dealing with food safety issues including allergens or communication of food risk. Successful R&I has also provided the evidence needed (mechanistic and whole body) to substantiate EU nutrition and health claims, including heath claims for specific ingredients.

EU Public Health policies advocate achievement of healthier diets through population reductions in fat, sugar and/or salt intake. R&I has been instrumental in developing the evidence base to support these policies. Projects such as EATWELL have been instrumental in providing rigorous evaluations of healthy eating policies that then provide the evidence base for the development of policies such as the WHO European Food and Nutrition Action Plan (2015-2020). For example EATWELL demonstrated that at the EU level voluntary reformulation has worked well with respect to reduction in trans-fat and salt. Many R&I projects have been instrumental in providing recommendations on advertising controls, importance of nutrition labelling and the potential of school food provision- all of which now appear in the WHO's Action plan for Europe.

Furthermore, R&I has been influential in developing technologies and strategies to create foods with a healthier profile, yet are economically viable, safe to eat and acceptable to consumers. Such R&I also helps identify obstacles and barriers to attainment of these dietary goals. Examples of such projects include but are not limited to the FOFIND, PROCURED, PLEASURE, and FoodProForHealth projects. R&I will also be essential for dealing with future EU policies. R&I has highlighted the value of nutrition and lifestyle behaviour in reducing disease risk and in part helping increase longevity. Further R&I is needed to improve quality of life in these extra years and to help shape future policies to safeguard the needs of older people.

Finally, R&I has allowed the EU shape, and respond to, global policies and goals such as the UN Sustainable Development Goals, e.g. target 3.4 of UN SDG3 which aims to 'ensure healthy lives and promote well-being for all at all ages' or target 2.2 of SDG2 which aims to 'end hunger, achieve food security and improved nutrition and promote sustainable agriculture'.

2.2.3. R&I successes presented during Nutrition session

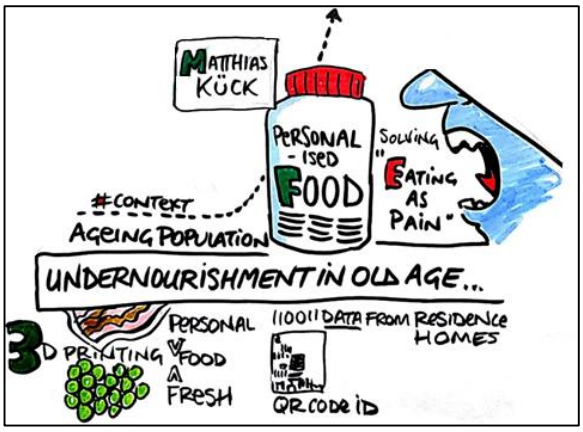


This section provides an overview of the five successful EU R&I projects that were showcased. Two challenges within the R&I priority of nutrition and health include obesity and healthy ageing. Dorian and I.Family provide examples of EU-funded projects which have successfully addressed aspects of these challenges. **I.Family** has established how families, friends and environments influence health and behaviour, with a focus on children. This multi-disciplinary project has documented regional differences in body weight status and in physical activity patterns and has created a solid evidence base including genetic studies, biomarker collection and phenotypic behaviours. Key findings include that girls are more likely to be overweight/obese and that the energy density of children's diets is high. Less than a third of children are meeting physical activity recommendations of 60 minutes per day. The importance of the built environment was also highlighted. The project reveals that in addition to improving knowledge, any tailored intervention to address obesity should account for affordability, accessibility and availability. Data collected also support polices for regulation of food marketing. The breath of data collected has the ability to empower behaviour change and to inform tailored policy taking into account the regional differences across the EU. Further, this pan-EU cohort allows for longer term evaluation of the effectiveness of any such behaviour changes.

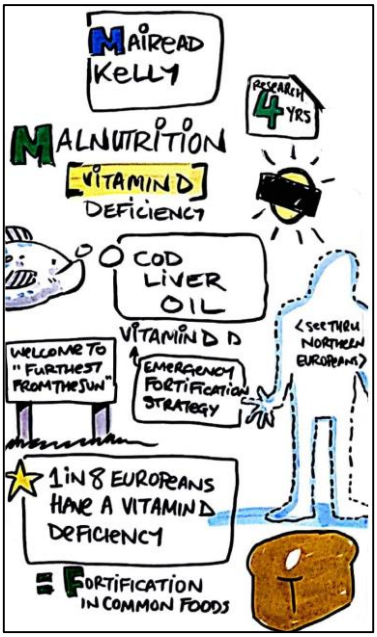
The **Dorian** project, by interrogating large cohort studies, has demonstrated that late pregnancy BMI is an independent predictor for non-communicable diseases typically associated with unhealthy ageing (e.g. cardiovascular disease, type 2 diabetes). Through a combination of animal and human models underlying potential mechanisms were presented. Furthermore, using a series of cellular, animal and human data, it highlights the potential for primary prevention of maternal obesity. However, more work is needed to develop primary prevention strategies based on the results. Key questions that remain to be answered: does reversal of maternal obesity reverse the consequences,

what are the key windows to intervene and is the gut microbiota a viable target? Furthermore, the need for personalised approaches is evident.

The Performance and ODIN projects have demonstrated how personalised food production and/or food fortification may be used to address malnutrition and micronutrient deficiencies.



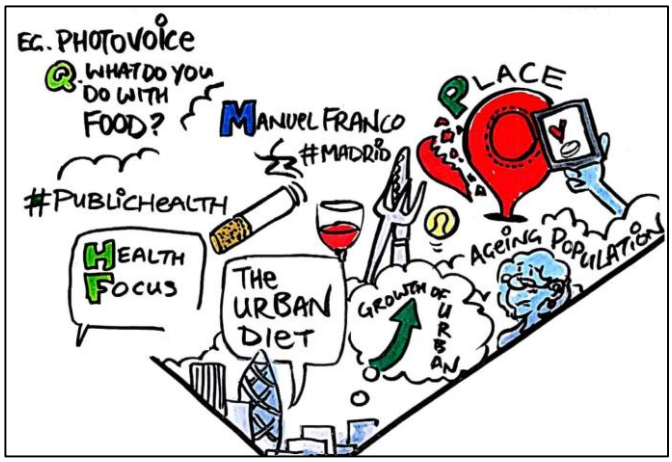
Performance demonstrated the potential of 3-D printing in delivering nutrition solutions to the elderly population with the potential to address dysphagia and thus malnutrition in this population group. The technology developed within the project was capable of automated production of smooth food which could be personalised to the individual level on a daily basis. This project highlights the potential of this approach to target very specific population groups and has the potential to improve their nutritional intake. However, further work is needed in assessing the scale and cost of such an approach and in the examination of the acceptability of the concept with consumers.



The **ODIN** project has demonstrated that food-first approaches to increasing vitamin D intakes across the population are technically feasible, can achieve meaningful increases and prevent vitamin D deficiency without increasing the risk of excessive intakes or toxicity. This is important considering the prevalence of deficiency reported by ODIN across Europe: 1 in 8 (13 %) Europeans have vitamin D deficiency and 2 in 5 (40 %) have low vitamin D status which means that they are at an increased risk of inadequate vitamin D for maintenance of bone health. The dietary modelling work demonstrated that the low dose fortification could shift the population mean intake from 3.3 µg/day to 8 µg/day.

Furthermore, the ODIN project has filled many of the gaps in dietary requirements for vitamin D.

Awareness of the importance of the food environment is increasing and **HeartHealthyHoods** has made important contributions in this area. More specifically, it has developed a multidisciplinary research approach that can examine the urban food environment at a city level and in future has the possibility of informing policy at a city level with the goal to improve population



health. Hearthealthyhoods also undertook a photovoice approach to examine residents attitudes in relation to the Food Environment and dietary habits. Through this process the residents became key players in developing policy recommendations and dissemination of the results highlighting it as a success story for the power of citizen science. Further work on to how to capitalise on research into food environments to develop well-designed urban food interventions and evaluate their effectiveness is critical considering that by 2020 it is estimated that 80 % of Europeans will live in an urban environment.

2.2.4. Conclusions & Lessons learnt from the session

The projects showcased in the Nutrition and Health session identified a number of important obstacles:

- Current funding mechanisms do not support the long term follow up of cohorts making it difficult to support studies that follow children through key transitory periods into adulthood or to examine the impact of public health nutrition interventions.

- There is an urgent need for infrastructure to perform nutrition and health surveys of all population groups, including European residents of ethnic minority, central eastern European countries and vulnerable subgroups.

- Research results are often lost in translation and there is a need for more face-to-face interactions with policy makers and implementation of mechanisms to facilitate such interactions.

The projects showcased within this session highlight that R&I projects with nutrition at the core are transdisciplinary by nature and have provided an evidence base that has impacted on policies and development of new technologies. Continuation of support for projects that have nutrition science at the core is essential for the future success of FOOD 2030. The projects presented in this session feed directly into 3 of the 4 challenges prioritised by FOOD 2030 and help to provide solutions and discussion points for ensuring long term Food and Nutrition Security.

Within the priority of 'Nutrition and Health', all projects presented provide learnings about how to ensure "that nutritious food and water is available, accessible and affordable for all". Similarly all provide experiences about how to "help all citizens and consumers adopt sustainable and healthy diets for good

health and wellbeing". The Performance project demonstrated the potential of 3D printing in delivering personalised nutrition in a specific population group, and has developed a prototype system to help "reduce hunger and malnutrition" while "ensuring high levels of food safety and traceability" right across the food chain. The Hearthealthyhoods, I.Family, ODIN and Dorian projects have worked directly to reduce the incidence of non-communicable diet-related disease while accounting for lifestage. Dorian for example demonstrated that late pregnancy BMI is an independent predictor for NCDs and offers potential future intervention strategies.

Findings from these projects have also informed other FOOD 2030 priorities, with the experiences of ODIN and Performance informing research in the area of 'circularity and resource efficiency of food systems'. Both projects started with a nutrition problem and developed food based solutions demonstrating the importance of linking the different players in the food system. All of the projects have strived to 'empower communities', from the creation of scientific evidence and knowledge to underpin relevant policy to suggesting innovative opportunities for products and services to advance FNS. Hearthealthyhoods engaged in a "citizen science" approach and empowered communities to enter in a dialogue with local policy makers. Collectively, these multi-faceted projects underpin the aspiration of FOOD 2030 to make our food systems more resilient, diverse, sustainable and competitive.

2.2.5. Looking ahead

Key R&I issues within Nutrition and Health that we should focus on include but are not limited to:

- Obesity, including high childhood obesity
- Healthy ageing
- Promotion of healthy and sustainable diets across Europe
- Personalised nutrition and variability in response to diets
- Role of nutrition in prevention of NCD's
- Use of high value foods to meet nutrition needs
- Issues of food safety pertinent to nutrition and health

As already mentioned in the introduction, of the 6 WHO regions, Europe is the region most severely affected by NCD's which in turn are the leading cause for death. Key risk factors for NCDs include being overweight/obese and a poor quality diet. With these facts in mind it is imperative that future R&I should focus on reducing obesity, promotion of healthier diets and understanding the optimal intervention strategies to reduce NCDs. Aging of the European population is another startling challenge and will place considerable burden on healthcare systems unless strategies are implemented to promote healthy ageing. Through a food systems approach interaction back to food production

has the potential to develop high values foods to meet specific nutrition needs which in turn will help to alleviate some of these issues.

In order to achieve success in FOOD 2030 there are a number of factors that need attention:

- A substantive evidence base is needed and therefore, it is imperative that each of the above issues is addressed by quality science which ranges from mechanistic studies to rigorously evaluated public health interventions and policies.

- The identification and validation of better biomarkers to track health and nutrition in response to dietary and/or lifestyle interventions and throughout the lifespan is essential for success.

- The recognition that there is substantial variability in response to interventions across individuals is emerging and the full potential of personalised, more precise, nutrition remains to be explored and incorporated into interventions.

- Claims relating to nutrition or health need to be substantiated by well-designed studies, and biomarkers have the potential to aid in the development of such health claims.

In addition, for each of the R&I issues identified, common challenges will relate to timely delivery and evaluation of the evidence base and associated education of key stakeholders. Delivery of an evidence base to underpin food system changes is challenging within the timeframe of most research funding structures given its transdisciplinary and pre-competitive nature and the fact that many nutrition and health interventions may require many years to see effects. Critical evaluation of the evidence base generated is also essential. Within this, consideration is required not only of behavioural assessments but of the supporting biological mechanisms or biomarkers.

Finally, future-proofing food systems is dependent upon translation of evidence by trusted, suitably qualified individuals to audiences who may have little or no formal nutrition education or exposure. Pan European nutrition education programmes should be developed and supported to train the future generation of healthcare workers.

Science-policy-society interface is important to ensure that decisions and policies are made based on the best available evidence. Measures exist in Europe to engage in this at a national and EU level. Both are important and considering the diversity across Europe it is important and relevant to continue and nurture both approaches.

Within Nutrition and Health the EFSA[46] is the main body that interacts with scientists to develop advice and policies that help protect consumers, animals

[46] https://www.efsa.europa.eu/

and the environment from food-related risk. Food and Nutrition R&I provides key data and scientific opinions that enables EFSA to formulate advice that informs policy and legislation. Its remit includes nutrition, food and feed safety. It has been instrumental in the communication of food related risks by delivering information on food safety issues. Furthermore, from a nutrition R&I viewpoint it plays a key role in dietary exposure assessment, developing dietary reference values for key nutrients and overseeing nutrition and health claims on foods. More recently, EFSA has developed a number of strategies to engage with the society.

Within the EC Joint Research Centre (JRC) foresight exercises are important for input into policy development and a recent one highlighted priorities for food and nutrition[47]. Continued support for such European led exercises will be important. However, individual projects have also the potential to engage at a local level with policy makers and the potential of citizen science in developing policy recommendations should be examined further.

Nutrition sciences for many years have suffered from an image of a "soft science" in Europe. However, in the last 10-15 years the field has undergone rapid change and is now characterised by rigorous interventions and application of advanced "omics" technologies to understand the link between nutrition/diet and health. The knowledge gained in these years has the potential to make significant impact on our future health through prevention rather than treatment. However, for this to become a reality further investment is needed to define the optimal strategies for prevention of disease/promotion of health, to encompass individual responses into recommendations and to develop strategies for shifts in dietary patterns and to move away from a focus on single nutrients.

The startling evidence in relation to Europe's problem with NCDs and its link with obesity and food patterns make it a distinct concern for FOOD2030. Furthermore development of a food systems approach to tackle NCDs has the potential to have major societal impacts.

[47] JRC FORESIGHT STUDY Joint Research Centre Tomorrow's Healthy Society Research Priorities for Foods and Diets

2.3. Climate & Environmental Sustainability

By Prof. Dr. Roberta Sonnino, Director of Impact at the School of Geography and Planning in Cardiff University, United Kingdom and member of the FOOD 2030 EC Expert Group.

2.3.1. Introduction

Global initiatives such as the 17 UN SDGs and the COP21 climate commitments set clear targets for creating more climate-smart food systems in which natural resources (perhaps better understood as global commons) such as water, soil, land and sea are used sustainably within planetary boundaries. Implicit in these targets is the recognition of the need to build *more efficient* and *diverse food systems* that integrate the bio-economy, energy and sustainable healthy diets to develop more resilient pathways to a post-carbon transition. Addressing climate change in such a *systemic* manner will entail linking FNS with environmental integrity and socio-economic welfare and investigating the water-food-health-energy nexus from a holistic perspective to identify trade-offs and potential synergies.

While *climate change* is a catalyst for food insecurity, it *can* also *be a driver of innovation* through public-private partnerships, open science, research breakthroughs and increased global cooperation in knowledge creation, sharing and dissemination. We must *critically act*, improve *science-policy-civil society engagement*, create spaces and platforms to *incubate and nurture new ideas*, increase the *adoption of innovative solutions* but also *identify barriers to implementation* in which knowledge is activated and put into practice.

2.3.2. R&I policy relevance for Climate and Environment

By focusing on the interconnections between climate change, FNS and public health, R&I has the capacity to influence multiple policy areas (such as agriculture, fisheries & aquaculture, energy, trade and development). For example, presently FNS R&I actions are supporting the implementation of relevant EU policies like the CAP, which has developed the EIP-AGRI[48] in an attempt to strengthen the science-policy-farmers interface. The CAP is complemented by various environmental policy instruments like the Water Framework Directive and Marine Strategy Framework Directive, in addition to general food safety law and internal market rules covering the protection of human, plant and animal health. Furthermore, FNS is an integral part of the broader 2012 Bioeconomy Strategy (currently under revision), which has underpinned much of the R&I under Societal Challenge 2 of Horizon 2020. It could also be argued that FNS R&I should play a strategic role in the development of a *European-wide food and nutrition policy* that integrates environmental and health concerns across the whole food system to break from silo mentality and deal with the full complexity of FNS. This is the main

[48] EIP-AGRI: European Innovation Partnership for Agricultural productivity and Sustainability https://ec.europa.eu/eip/agriculture/en

conclusion achieved by the interdisciplinary project TRANSMANGO, which has demonstrated the need to understand the complexity of systemic and nested vulnerabilities (at multiple scales) in agri-food systems to deliver FNS.

Beyond the EU, R&I is crucial to make progress in the implementation of the SDGs, ten of which are connected to FNS. In addition to SDG 2 (which aims to end hunger), the SDGs relating to public health (SDG 3), affordable and clean energy (SDG 7), innovation and infrastructure (SDG 9), responsible consumption and production (SDG 12), climate change (SDG 13), the preservation of marine ecosystems (SDG 14) and life on land (SDG 15) were variously highlighted by the projects as being applicable to the emerging social, ecological and economic outcomes of their research.

2.3.3. R&I successes presented during Climate session

This section builds on findings of the five successful EU R&I projects that were showcased. The FNS EU R&I projects discussed are varied in terms of conceptual framing and empirical focus. They concentrate on various elements of the food system, ranging from demonstrating and developing sustainable aquaculture in Europe to adapting precision farming techniques in relation to irrigation for small-scale farmers, and from developing solutions for the sustainable use of land to keep soils healthy to the creation of integrated knowledge-exchange platforms. The projects seek to enhance FNS in the EU by focusing on its various dimensions, such as demonstrating aquaculture sustainability (**ClimeFish**), improving irrigation efficiency (**MASLOWATEN**; **Mistrale**), increasing soil health through cropping systems (**SoilCare**), implementing smart technology in relation to precision farming techniques (Feed-a-Gene; MASLOWATEN; **Smart-AKIS**) and improving stakeholder communication (Smart-AKIS).

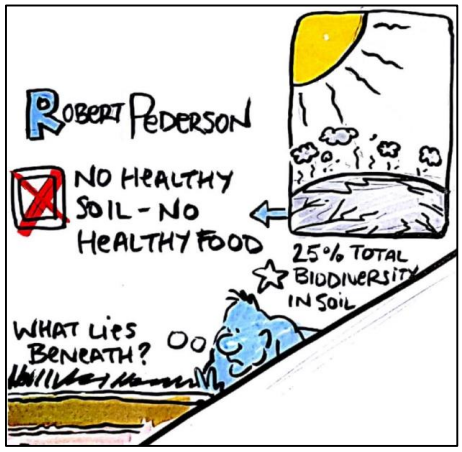
All selected projects have in common the goal of developing *collaborative knowledge* that has policy relevance and social robustness, and propose mitigation and adaption strategies that *advance the FOOD 2030 agenda* of engendering more sustainable, resilient, diverse and competitive food systems.

2.3.4. Conclusions & Lessons learnt from the session

Despite their diversity, three common interconnected lessons emerged from the projects showcased at the conference:

Broadening understanding of the relationships between 'diversity' and 'resilience': The food system is a complex interplay between various relationships, practice and decisions, encompassing how we cultivate, process,

store, distribute, transport, trade, consume, waste and dispose of food. In general, globalised food supply chains ensure that the high demand for food, particularly in urban areas of the global north, is (generally) met in terms of quantity. However, the impacts of environmental degradation, the proliferation of food insecurity and an increase in health-related illness (for example, globally, there are 815 million people undernourished and 2 billion people overweight/obese) has demonstrated the vulnerability, unsustainability and fragility of a highly industrialised, convoluted and unequal food system.



Crucially, increasing the resilience of the food system will entail understanding, supporting and growing the *diversity* of production systems but also recognising the essential importance of biodiversity in ensuring the FNS of the human population and in protecting the interconnected ecological systems humans are entangled with. Building resilience requires knowledge and understanding of the various dynamics, processes and functions of ecological systems such as healthy soil, which can help reduce erosion, improve drought tolerance and safeguard long-term land fertility. Despite the vital role of soils for growing food (approximately 90 per cent for the food we produce is grown on soil, which also hosts 25 per cent of our biodiversity), up to 25 per cent of this has already been exhausted and degraded. Against this background, the EU-funded SoilCare project is utilising a trans-disciplinary approach to improve soil quality for crop production by identifying, testing and evaluating soil-improving cropping systems to increase the profitability and sustainability of agriculture.

R&I and technological 'solutions' need to be orientated towards increasing the vitality and diversity of ecosystems (such as soil ecologies made of a multispecies community of biota) to enhance resilience and security of food production and achieve healthy, equitable and sustainable food systems. Central to this is a reconfiguration of the food-feed efficiency dynamic (as discussed by Feed-a-Gene) by utilising precision livestock feeding techniques.

Co-production of Knowledge

There is no 'one-size-fits-all' solution to climate change. The most effective mitigation and adaptation strategies are based on hybrid techniques and the integration of different forms of knowledge (i.e., evidence-based, experimental, embodied experience), underpinned by different values (i.e., socio-environmental justice, economic competitiveness etc.). While global in its impact, climate change is experienced in diverse places (and by human and nonhuman communities) in differential ways, reflecting localised bio-climatic ecosystem dynamics and anthropocentric influences. R&I in relation to precision agriculture can help adapt technology to address place-specific (albeit always interconnected multi-scalar) issues contextualised by territorially embedded

social-ecological processes such as variable soil moisture and increase efficiency. For example, the MASLOWATEN project demonstrated that photovoltaic irrigation systems reduce dependence on fossil fuels in food production; while Mistrale utilises a Remotely Piloted Aircraft System (RPAS) to measure soil moisture using GNSS Reflectometry, comprising various remote sensing techniques, to produce soil moisture content maps that allow farmers and water-managers to optimise water use and productivity.

Since the time frame of climatic changes extends beyond the short-term funding cycles of research grants, there is a vital need for more long-term research to monitor the impact of R&I interventions. Moreover, the complexity of climate change requires connecting the natural and social sciences to develop much needed holistic and integrated measurement systems.

In terms of sharing and disseminating knowledge, it is important to develop multi-actor platforms from the start of projects to integrate knowledge transfer into R&I throughout the life course of the research to increase its transparency and accountability. Furthermore, the interface between multiple stakeholders needs to be strengthened, particularly between institutions such as universities and communities (reducing the gap between consumers and citizens), by establishing new synergies between research and policy-making, by forming new collaborative partnerships between civil society, the private sector and local authorities and by drawing on the expertise and embodied knowledge of a range of stakeholders. This inevitably entails reconfiguring the power dynamics between stakeholders by recognising and drawing on various experiences and knowledge through critical explorations of (possibly conflicting) ideas. Notably, knowledge can be effectively transferred if it is meaningful and useful to those who should implement it. Hence, the active involvement of end users and stakeholders in the set-up of R&I projects becomes key to successful take up of innovation, while abstract top-down mechanisms may be limited in their everyday application.

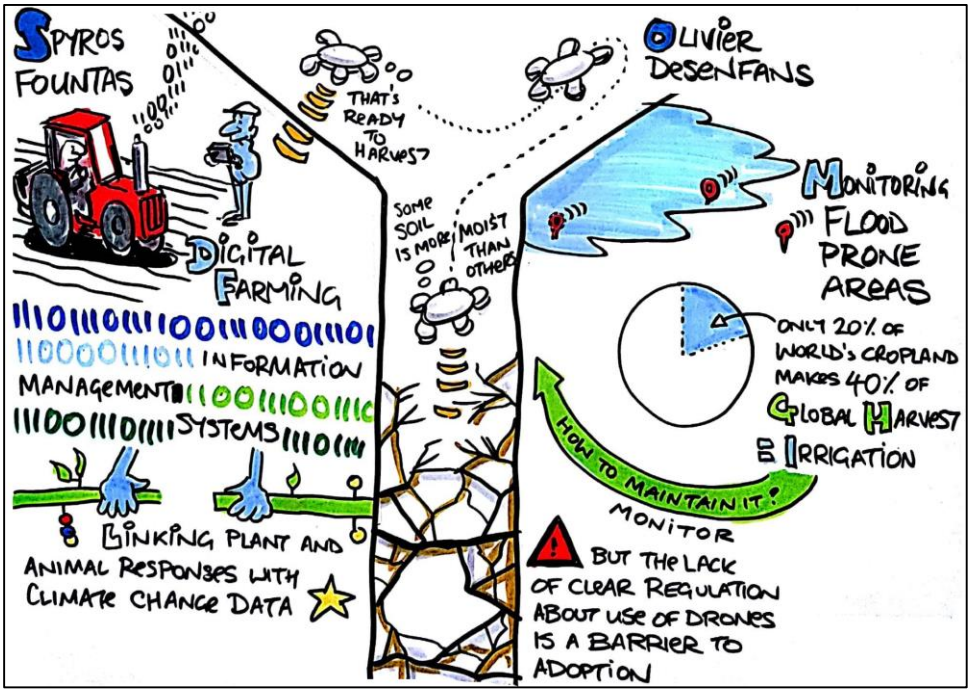
A current limitation in relation to R&I is the (currently) disjointed nature of EU-funded projects. In this sense, the findings of fragmented projects need to be connected and cross-referenced to ensure that outcomes effectively influence policy agendas and to identify scope for further collaborative research across academic disciplines, organisations and/or communities in substantive ways. For example, the session raised the need for greater cross-sectoral research and cooperation to reduce the barriers between agriculture and aquaculture and create platforms to share information between other EU-funded projects (as discussed by the ClimeFish project). Ultimately, greater connectivity will strengthen EU-funded R&I and build a more coherent R&I policy framework.

Empowerment of farmers

R&I will be ineffective at creating positive change in our food systems unless its outcomes and solutions are successfully transferred and applied in practice by the multiple actors operating along the food chain.

Empowering farmers (particularly smallholder farmers, who produce over 70 per cent of the world's food supply and represent 50 per cent of the world's

food insecure) through investing in adaptive technologies and training is crucial to build resilience. Increasing sustainable practices and supporting farmers to adapt to climate change and produce diversified crops to feed their own communities and serve local markets, will help shape more democratic food systems, especially in those regions of the world where access to sufficient and nutritious food is still problematic.



However, technological solutions typically require a large commitment due to the propensity of high initial investment. Therefore, there is a need and responsibility to facilitate uptake of R&I outputs by working with farmers and ensuring information, support and access to finance (particularly for SMEs in the global north and farmers in the global south). Smart-AKIS is an example of a knowledge network that endeavours to mainstream SFT among the European farmer community, produce accessible end-user material under the EIP-AGRI common format and bridge the gap between practitioners and research on the identification and delivery of smart farming solutions aligned to farmers' needs.

Currently, precision farming technological development is dominated by the USA. This highlights the importance of sustaining and increasing investment in EU R&I to ensure that Europe takes a leadership role in transforming and future-proofing our food systems in sustainable ways. Connecting and scaling up R&I can be achieved by utilising open platforms that harness existing EU tools and 'innovation workshops' to foster knowledge exchange, but also generate novel ideas for collaborative projects based on the needs, observations and priorities of farmers, who are the most important players at base of our food systems. This entails actively listening to farmers and drawing on their everyday practices and social innovations to ensure R&I outputs are as applicable as possible to a range of end-users. Indeed, innovation should be seen as a process in which multiple stakeholders are engaged to generate

hybridised co-produced knowledges. Moreover, FNS R&I has a moral obligation to produce robust research data to inform evidence-based policy decisions that translate into effective policy measures and incentives to produce practical, tangible and positive changes to our food systems to make them more resilient and sustainable in the long term.

2.3.5. Looking ahead

Sustained and expanded investment in EU R&I will be critical to develop evidence-based solutions to sustainably feed a growing population in the context of a changing climate and limited natural resources. As identified in the FOOD 2030 High-level Conference Background Document, the challenges set out in FOOD 2030 are currently not being met with the necessary investments in R&I to reach the desired solutions. As climate change negative impacts unfold and intensify, many of the current efficiencies of the industrialised, global food system will be challenged, since the global increase in average temperatures and extreme weather events will require more resilient food production systems and more efficient management of water, soil and external inputs to cope with increasing competition over scarce natural resources. The EU can play a crucial role in increasing resilience and reducing vulnerability to FNS, for example by helping the *transition to renewable energy sources* severing the reliance of agriculture on fossil fuels. This will require investing in projects that help to incorporate diversity and flexibility into food systems that may not be at face-value commercially attractive to private investors.

There is also a need to *boost user uptake of R&I solutions*. Left to the market, Smart Farming Technologies (SFTs) may be out of reach of smallholder farmers or SMEs. The EU has a role in ensuring that price is not an exclusionary factor for those who want to adopt precision farming technology, for instance by adopting adequate policy measures and incentives. In this sense, the Smart-AKIS platform can play an important role in transmitting knowledge relating to SFTs, building smallholder capacity and acting as a conduit to react to end-user requirements and feedback. This links with the 'open science' priority of FOOD 2030, which is based on cooperative work and new ways of diffusing and reusing data and knowledge by using digital technologies and collaborative tools.

There is also a need to *strengthen R&I policy coherence and coordination* and better link European projects and findings together, identifying synergies and potential new areas of collaborative research. The global nature of climate change raises the need for trans-disciplinary and international cooperation in R&I, building upon current collaborative initiatives such as the AORA (Atlantic Ocean Research Alliance and Development Programme). This will require strengthening the capacities of multiple actors and forming communities of practice, building trust between civil society-science-policy makers. At the heart of more climate-smart food systems is the *re-articulation of the relationships between agriculture, sustainability and participatory platforms of engagement*. Indeed, while technological advancements can demonstrate how to produce more food with less materials and resources (sustainable intensification), technology does not eliminate the socio-ecological harms that are embedded within a deeply flawed and unequal food system. As identified by the EU-funded

FOODSECURE project, poverty (therefore, inequality, not unavailability) is the main reason people experience food insecurity in the EU and beyond.

Climate resilience and *equity* must be placed at the centre of food system reform. Indeed, the climate crisis will not be solved by fragmented techno-managerial fixes. Advances made in information and communication technologies need to be available to (and benefit) all. Furthermore, we need to ensure that digital or smart farming does not increase our dependence on high-input monocultures but promotes agricultural diversity and regenerative agriculture by enhancing the multiplicity (and flexibility) of production and processing methods that aim to maintain ecosystem services and increase resilience of our food systems.

Engendering systemic changes in our food systems to make them sustainable, resilient, inclusive, responsible, diverse and competitive requires "reflexive governance" processes that embed science-policy dialogue between multiple actors (public, private and civil society) at each stage of R&I. Participatory forms of research and innovation are needed to link citizens with scientific/academic/policy actors and develop relevant on-the-ground inventive designs and knowledge-sharing exercises. Regardless of how knowledge is characterised (i.e. 'expert', 'scientific', 'community', etc.), more inter- and trans-disciplinarity in research are needed, and improved *knowledge transfer* is essential to take advantage of innovations. In the context of R&I, we need an open debate about what knowledge is, who produces it and who owns it, and the moral and ethical implications of this.

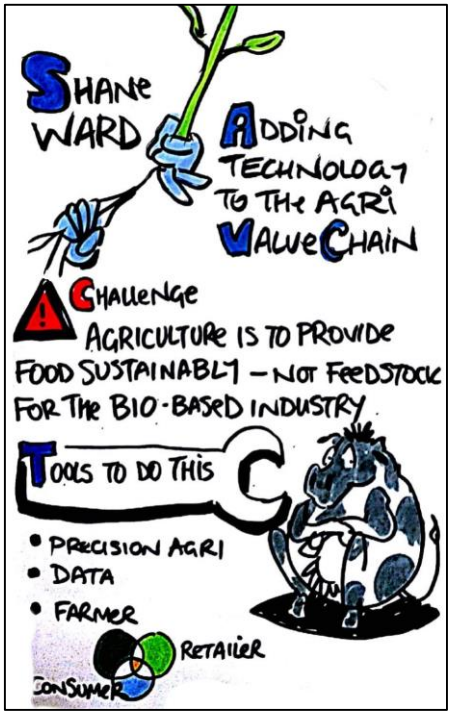
There is general consensus that we need a multi-disciplinary approach to R&I that places emphasis on co-design and co-delivery of innovation breakthroughs. This will require strengthening the capacities of multiple actors and building communities of practice, making links and building trust between civil society-science-policy makers. While this will no doubt be difficult and is ambitious, it is crucial for developing a transformative project that demonstrates how communities can (re)shape multiple dimensions of food systems (and therefore address some of the power imbalances in the food chain) in socially and ecologically just ways. At the heart of more climate-smart food systems is the re-articulation of the relationships between agriculture, sustainability, and participatory democratic platforms of engagement, which demonstrates that the multi-scaled challenges of the current configuration of industrialised global food systems are not isolated problems, but indicative of underlying systemic socio-ecological problems.

R&I will play an increasing crucial role in future-proofing our food systems as the compounded, multifaceted effects of climate change, urbanisation, population growth and resource scarcity converge, intensify and impact the everyday lives of people. Ensuring FNS in the era of climate change is particularly challenging and requires urgent political action and civil society engagement to counter the slow pace of progress made to date. This will entail multi-scalar coordinated action, collaborative partnerships and R&I that take a long-term perspective into account to develop technologies, knowledges and ideas for dealing with the uncertainty, unevenness and abruptness of (various possible) socio-ecological changes.

2.4. Circularity & Resource Efficiency

By Otto Schmid (Dipl.-Ing. Agr.), Team member at the Research Institute of Organic Agriculture (FiBL) in Switzerland and member of the FOOD 2030 EC Expert Group.

2.4.1. Introduction



This part addresses the circularity and resource efficiency aspects of food systems highlighted in the FOOD 2030 conference. The implementation of resource-efficient circular economy principles across the whole food system can contribute to reduce its environmental footprint and to minimise food losses and food waste (the long-time goal being: Zero-Waste, Cradle to Cradle).

In the 7th Framework program (FP7) (2007-2013), one of the main themes was the management and protection of biological resources to secure food and non-food products. A strong financial contribution was given to the development of primary production towards more sustainability and competiveness through the funding of multiple projects. However, at the time, the focus was more directed at the use of biotechnology serving the emerging bio-based industries while food waste and circular economy issues were overall less covered.

The Horizon 2020 program (2014-2020) is addressing this important gap. For instance, one of five priorities in the Workprogramme 2018-2020 focuses explicitly on: "Making the transition towards a circular bioeconomy". More themes have been taken up, relevant for resource use and circularity in the area of societal challenges, such as the reduction of food waste, energy- and water efficient food processing, food packaging and urban waste management.

However, projects in both FP7 and H2020 revealed some limitations in the focus areas and research approaches regarding circularity and resource-efficiency. Namely, the emphasis along the food chain to improve efficiency is mainly on technical solutions with less attention being given to aspects such as the overall sustainability of the food system. Furthermore, very often, a narrow definition of bioeconomy is used taking into account mainly an industrial perspective and being sometimes disconnected from food production and the provision of ecosystem services of sustainable agriculture. Another limitation identified pertains to the farmers' role which is often reduced to the production of "cheap commodities", forcing them to unsustainable practices. Lastly, too much focus is put on resource efficiency as opposed to resource smart or resource

sufficiency disregarding potential rebound effects that can counteract efficiency gains.

Transitioning to a real circular economy will require overcoming significant barriers. There is a low cost paradigm in the whole food supply chain leading to strong price pressure on farmers and fishermen. This is somewhat enabled by the current economic and legal framework conditions allowing unsustainable and inefficient resource use as well as by continuing to use linear economic business approaches as opposed to models that cover the entire chain, i.e. food systems. Long-term sustainability is receiving relatively little attention due to the non-pricing of externalities that leads to low prices of external inputs (e.g. pesticides, fertilizers). Other important barriers to consider are the high level of food losses, knowledge gaps (e.g. socio-economic data) and insufficient cooperation between the main actors.

2.4.2. Policy relevance for Circularity

FNS R&I has played and will play also in the future an important role in informing and shaping of EU Policies for the food sector.

Regarding the CAP, R&I projects helped in minimizing the use of natural (non-renewable) resources (soil, water, genetic resources, biodiversity) trough organic and other agro-ecological approaches, contributing to more efficient recycling of nutrients/minerals/biomass, reducing the use of external inputs for fertilisation as well as pest and disease control, reducing and/or avoiding food waste on the production sites, maintaining landscapes, etc. For the EU-Rural Development Fund, R&I contributed to develop investment models and support policies for circular economy initiatives.

Regarding EU-Environmental Policies (MSFD, WFD, Circular Economy Package, Biodiversity strategy, etc.), R&I helped to develop more targeted instruments and strategies. However, there is still a knowledge gap on accounting the external costs ("true cost" accounting), where socio-economic research is important.

In the EU-Global Food Security Policy area, R&I can contribute to change of WTO rules regarding sustainability criteria in international food and feed trade. More specifically, for the EU-Common Fisheries Policy, R&I was and is important to develop sustainable fishery and aquaculture practises (including reducing fish discards).

In the area of EU-Health policy R&I contributed to awareness rising for more sustainable and healthier diets and consumption with less food waste. This shares common objectives of the EU-Energy policy, where R&I can help to reduce trade-offs related to the use of by-products and waste from food production (see EU Food waste hierarchy/cascade).

One future challenge is the transformation towards a circular bio-economy that needs the combination of many different policy areas and value chains. New governance models need to be developed on international, EU, national and

regional/local level to create synergies between policies and reduce trade-offs. R&I can assess these models and make policy recommendations.

2.4.3. R&I successes presented during Circularity session

This section provides an overview of the seven successful EU R&I projects that were showcased. The FP7 **FUSION** project (Food Use for Social Innovation by Optimising waste prevention Strategies) focussed on the feasibility of social innovative measures for optimized food use and the development of a common food waste policy framework. Interesting finding was an estimate of food waste in the EU (88 Mio. tons per year in the EU 28 corresponding to 20 % of all produced food in EU, equivalent to 6 % of total GHG-emissions). Further, an inventory of 7 interesting case studies of social innovation (e.g. awareness rising in Kindergartens), a report on causes of food waste, policy options to stimulate social innovation initiatives to optimise food use as well as the development of an accounting and reporting standard for food waste were made. These findings were taken up by the on-going **REFRESH** project (Resource Efficient Food and dRink for the Entire Supply cHain). A central aim was to develop a "Framework for Action model" based on strategic agreements across all stages of the supply chain. Interesting first results were: the creation of national platforms (communities of experts) with governmental and industry people; a public award in a food waste solution contest; a consumer food waste behavioural model as well as the development of a compositional waste database. Main problems mentioned in both projects were to get sufficient reliable data to calculate food waste as well as to develop new transformational business models.

The on-going project **SHARECITY** (Assessing the practice and sustainability potential of city-based food sharing economies) documented food sharing activities in 100 global cities as well as in-depth food sharing profiles of some selected cities. Interesting results & outcomes were: exploration of the practice and performance of Information and Communication Technologies (ICT) mediated food sharing in cities; the mapping and clustering of food sharing economies and the development of an on-line assessment tool. One of the main problems mentioned were, how to assess in an appropriate way the sustainability impact of such food sharing initiatives (when lack of data, insufficient methodologies, difficulty to take social values into account, etc.)? Furthermore a difficulty was to upstream food sharing for a circular economy (surplus food re-distribution, community growing, eating together for social integration).

The project **BioSuck**, funded through German Government under ERA-NET-SUSFOOD, was focusing on the development of a traditional vacuum technology for cleaning and separating food waste with much less water consumption combined with simultaneous production of bioenergy (biogas, biochar, bioethanol). It resulted in the development of a practice-focused pilot system, which was integrated into a new decision support system. Furthermore a database (with key figures on the waste stream and bioenergy) and a Life Cycle Analysis of the BioSuck concept was made. However, although technology was developed and a demonstration unit was installed, the barriers for adoption were still too high (high infrastructure costs, legal uncertainties, cost saving not attractive enough). An obstacle was that the cost reduction potential will depend very much on the facility and related framework conditions.

The on-going project **GreenProtein** (Revalorisation of vegetable processing industry remnants into high-value functional proteins and other food ingredients) is focussing on establishing a demo plant for the extraction and purification of functional RuBisCo protein isolate at industrial scale. This project highlights the potential in valorising by-products of food processing for high added value, food grade and fully functional food ingredients. However, a big challenge of the project was to come from a demo-plant level to a pre-commercial level and finally to a commercial application One obstacle is the high moisture of the material (with 90 % water content), which is difficult to handle (high transport costs, microbiology, food safety requirements). Another obstacle might be the consumer acceptance of these kind of products (e.g. made with RuBisCo), which was not researched specifically.

The on-going project **AgroCycle** (Sustainable techno-economic solutions for the agricultural value chain) focusses on the use of agriculture waste, co- und by-products both inside and outside the agricultural sector, leading to the realisation of a circular economy. Different utilisation and valorisation pathways will be assessed on its sustainability impact. Interesting first results were an overview on the regulatory framework and a biomass supply chain evaluation in Europe. A major challenge in this project is to determine which pathways are most effective for creating sustainable agri-food systems (Closed loop agriculture versus wider bioeconomy utilization). Another challenge is where to define the scale (locally versus globally). Further research is needed to develop of a more integrated Life Cycle Assessment, which addresses better social and economic issues of multiple uses of agricultural products and by-products (inclusion of social LCA and Life Cycle Costing methods). A future research question might be the feasibility of "raw material passports" to specify

provenance and quality of material to ensure that valorisation pathways are not damaging the environment.

The FP7 project **ChiBio** developed an integrated biorefinery for processing chitin rich biowaste to fine chemicals from laboratory scale to novel industrial product. The goal was to transform the chemical constituents of EU, African and Asian crustacean shell waste into "drop-in" and novel chemical intermediates to produce bio-based polymers at high atom efficiencies. However a main problem was that the economic viability of chitin biorefinery process is not yet given although the potential is quite high. Further technological development is needed to make the process more cost-efficient (e.g. better methods for enzymatic depolymerisation and microbial transformations into bio-based polymers). This needs more time and research as the lignocellulosic biorefinery approach has shown.

Several issues were raised from the audience (related to food waste). One issue is food safety, which should not be forgotten when dealing with food wastes. Another main issue is that different perceptions exist in different countries regarding food waste (moral ideas, cost situation, cultural traditions, role of state, etc.), which have to be taken into account. Furthermore to reduce food waste, initiatives e.g. documented in SHARECITY project, showed the importance of IT supported information both in combination with local infrastructure (e.g. collection systems) and a specific regulatory framework to achieve food waste reduction. Behavioural studies showed that a significant reduction of food waste is possible. However the social context and the willingness of industries are very important. In addition, several statements from the audience emphasised that the bioeconomy should not be built on food waste as we need to minimize food waste as much as possible. The goal should be to use agricultural land primarily for high quality food. It is important to use as much as possible also by-products as food. It was mentioned that the processing sector is already quite efficient, whereas the situation in the retail sector is very complex and often not resource-efficient.
However, much is dictated by the consumers, due to food habits, consumption and eating behaviours (e.g. only buying chicken legs makes it difficult to farmers to sell the entire animals).
It is important to find a good mix of policy measures and private market incentives/initiatives. It should be avoided that policies even contribute to more uses of resources.

Some participants mentioned the important role of livestock for a circular economy (re-circularity), for soil fertility and for the whole value chain in a sustainable agri-food system. Also future research should focus more on food from insects, e.g. by using food waste as source, but consumer acceptability still has to be improved in Europe; consumer studies and food safety studies could help to make better use of this protein source.

2.4.4. Conclusions & Lessons learnt from the session

The projects selected and presented showed, that there is a huge potential for the food industry to use waste streams from food and beverages industry sectors to produce added value bio-based products: food supplements, feed, sustainable nutrients for agriculture, bio-based chemicals, bio-polymers, bio-based food packaging, etc.

- For advancing FOOD 2030 the combination of many different policy areas and value chains (agriculture, food, feed, energy, etc.) is a must for a circular economy; therefore better value-based governance systems are needed to achieve a positive impact (e.g. city food policies).
- Social innovation/research has an important role for avoiding, reducing or re-valuing "food waste" and can be facilitated by ICT, however ICT alone is not sufficient for transition. More socio-economic research should be integrated in technologically oriented projects, e.g. consumer acceptability of new by-products, creation of incentives, etc.
- It needs much more a systemic approach to solve problems and find solutions, which often are going beyond the sector (e.g. multiple uses for food, feed and energy). And for the development of new products or by-products it is important to have a close cooperation with industry but in the same time also tacking the demand side into account.

Therefore, future circular economy concepts and resource-smart or resource-sufficient food systems have:

- To consider all elements of quite different food systems in a systemic way, including resource use, pricing of externalities, ecosystem services, distribution and consumption, food health and ethical values.
- To evaluate better the economic, environmental and social impact of bioeconomy strategies with further developed sustainability assessment systems, which are better suitable for multiple use of food, by-products and biomass.
- To reconnect bioeconomy approaches to the soil and to the territory.
- To put more emphasis on off-farm nutrient recycling: how can we recycle all the nutrients in crop and livestock products which are being exported to urban areas, and which now disappear (burning of bone meal and sewage sludge for example).
- To connect the resource use and prevention of waste streams much more also to human health: food waste now often occurs because food companies produce heavily processed, refined foods. Humans eat the fats, carbo-hydrates and sugars, animals do get the best part: the minerals, fibres, proteins etc. We take the 'nutrients' out of their matrix and consume these in a 'pure' form. While consumption in the matrix is much better for human

health than the isolated product (see for example fish oil versus fish, or apple juice versus apples).

Europe must fundamentally transform its food system for it to become truly sustainable. We need to understand better how the current system functions (and malfunctions), in order to effectively address it.

2.4.5. Looking ahead

The analysis of the FP7 and H2020 projects related to "circularity and resource efficiency" revealed the following key priority research and innovation areas:

- Increase resource efficiency, circularity (including sustainable use of natural resources) across the food system (for land, water, energy, soil, fertilizers, marine resources, etc.).
- Promote sustainable and efficient use of land, while maintain landscapes, soil fertility and biodiversity.
- Promote sustainable use of the marine fish stocks, coastal areas, and marine biodiversity (including the reuse of fish discards).
- Sustainable and efficient water management (esp. farm level, also across food chain).
- Reduction of nutritional loss in food processing (and unnecessarily creation of by-products).
- Optimal allocation of food and feed streams through re-modelling of food systems.

Some important principles to bring systemic changings in our food systems and towards a circular economy are:

- Not looking at challenges / problems in isolation, but trying to understand why the problems occur; and what can be done to solve the problems in a more fundamental way, rather than focusing on technical solutions.
- Try to reduce the complexity and dependency on technology of the system; go for less complex, less energy-demanding and less resource-intensive approaches.
- In general, when short cycles are functioning well, these should be promoted and optimized.
- Circular economy should have a stronger focus on territorial approaches (e.g. urban food systems).

- In striving for higher efficiency, trade-offs with animal welfare, animal and human health should be avoided.

- Solutions would need to be technically feasible, as well as socially and economically (in the long-term!) viable.

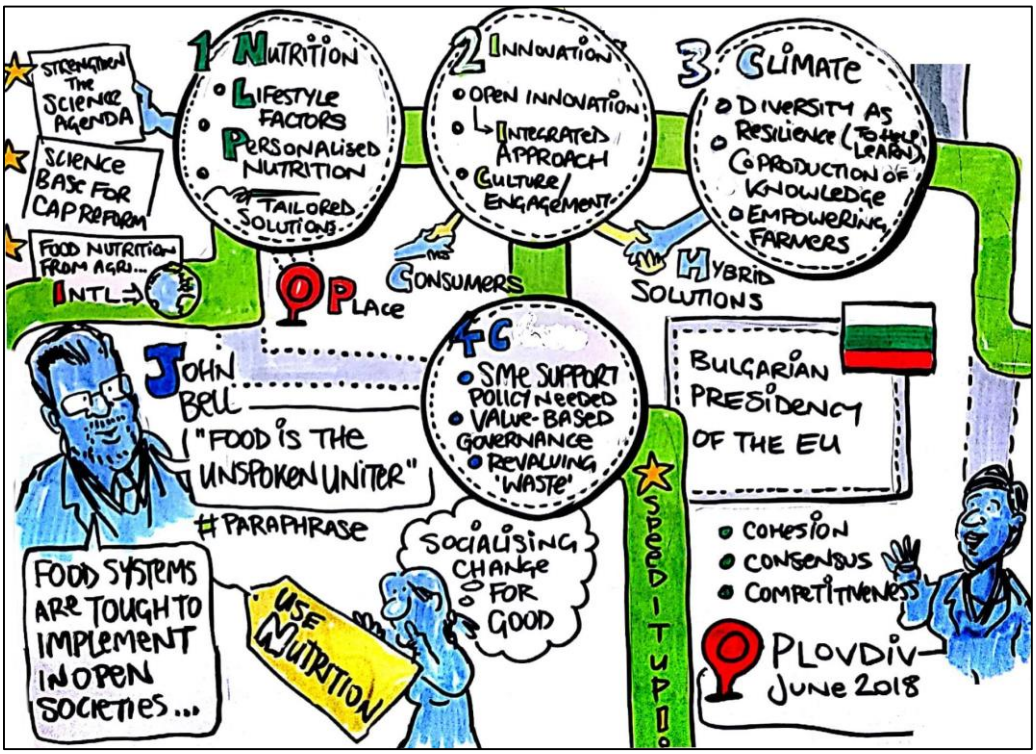
- Governance systems or arrangements should aim at private-public partnerships.

In order to strengthen the science policy-society interface/dialogue the beneficiaries should possibly already be included in the preparation of projects (e.g. by creation of new platforms, innovation incubators and/or brokers, etc.) in order to ensure that the results are useful for them. Hereby it is important to facilitate the dialogue between the main actors in food systems (farmers, consumers, processors, traders, retailers input providers, intermediaries, citizens, policy makers) in multiple ways on different levels and with sufficient resources. In particular, farmers and small companies should get a more prominent role in more decentralised circular economy approaches, showing the potential for income generation, added value and contribution to rural vitality.

The development of a circular economy is strongly linked with better resource efficiency. There is a huge potential for different kinds of innovation and business opportunities, while bringing multiple benefits for society. Research can play an important supportive role, if following a systemic, multi-actor and participatory approach. The two FOOD 2030 Conferences (October 2016 and 2017) were a good opportunity to bring these issues on a policy level and to a wider public.

Conclusions

The FOOD 2030 conference highlighted successful research and innovation outcomes relevant to Food and Nutrition Security and provided inspiration for further development of priorities which will play a key role in achieving the objectives of FOOD 2030. R&I will play an increasing crucial role in future-proofing our food systems as the compounded, multifaceted effects of climate change, urbanisation, population growth and resource scarcity converge, intensify and impact the everyday lives of people. Ensuring Food and Nutrition Security in the era of climate change, migration, and rising global hunger is particularly challenging and requires urgent political action and civil society engagement. This will entail multi-scalar coordinated action, collaborative partnerships and R&I that take a long-term perspective into account to develop technologies, knowledges and ideas for dealing with the uncertainty, unevenness and abruptness of (various possible) socio-ecological changes.



The conference concluded with a final wrap up by John Bell, followed by brief intervention by **Karina Angelieva,** Head of Sector of Education and Research of the Bulgarian permanent representation on behalf of the Bulgarian EU Council presidency. Karina introduced the Bulgarian Presidency Research and Innovation priorities[49] and welcomed participants to join the next major

[49] https://en.vleva.eu/event/EU2018BG-researchandinnovation

milestone of FOOD 2030, that is, the 2nd High Level Event that will take place in Plovdiv in June 2018.

Acknowledgements

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Annexes

Annex 1 – Conference Agenda

9:00	**Registration & Welcome Coffee**
09:30 – 09:45	**Opening by the European Commission**
	John Bell, Director for Bioeconomy, Directorate-General for Research and Innovation
09:45 - 10:45	**Policy Framing Session**
	Science for Food System Transformation **Louise Fresco**, President of Wageningen University & Research
	R&I in support of a modernised CAP **Tassos Haniotis**, Director for Economic Analysis, Directorate-General for Agriculture
	Investing in food systems & rural development to change the future of migration **Cristina Amaral**, Director for FAO's Liaison Office with the European Union and the Kingdom of Belgium
10:45	**Coffee Break**
11:15 - 12:45	**Innovation: Fostering innovation in food and nutrition: Taking stock and looking forward**
	Managing Innovation Ecosystems Keynote speaker: **Walter Van Dyck,** Professor of Technology & Innovation Management, Vlerick Business School
	New Gluten World on the Horizon: Propelling Innovation through Public Funding Showcase speaker: **Carmen Lamacchia**, New Gluten World srl
	Followed by a discussion with panellists: **Luis Mira da Silva**, Inovisa **Harry Barraza**, Arla Innovation Centre **Jochen Weiss**, ETP Food For Life - EIT Food
12:45 - 14:00	**Walking lunch & Visit of the Photo Exhibition 'Food and the City'**

<table>
<tr><td rowspan="4">14:00
-
15:15</td><td colspan="2">Parallel Sessions – part 1
A Science Policy Dialogue: How can R&I shape the future of FNS?</td></tr>
<tr><td>Sustainable & Healthy Nutrition

Room De Gasperi</td><td>Moderator: Stephanie Bodenbach, DG SANTE
• Like mother, like offspring - Does maternal overweight predict health outcomes?
Patricia Iozzo, CNR
• Health trajectories from childhood to youth: What are the drivers?
Iris Pigeot, Leibniz Institute
• Towards 3D printing of food
Matthias Kück, Biozoon GmbH</td></tr>
<tr><td>Climate & Environmental Sustainability

Room Mansholt</td><td>Moderator: Alberto D'Avino, DG AGRI
• Soil care for sustainable crop production
Robert Pederson, Milieu Ltd
• Sustainable fish production under climate change
Michaela Aschan, University of Tromsø
• Is feed efficiency a relevant indicator to assess the role of livestock in sustainable food production?
Jacob Van Milgen, INRA France</td></tr>
<tr><td>Circularity & Resource Efficiency

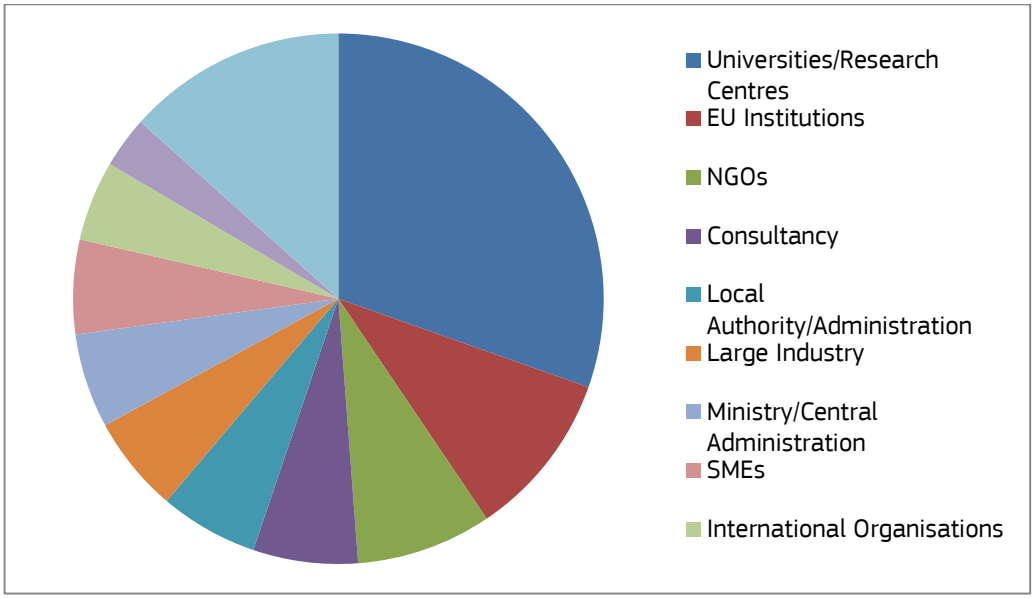
Room Jenkins</td><td>Moderator: Peter Woodward
• Towards a circular economy in food; the role of public-private partnerships
Toine Timmermans, Wageningen University & Research
• Food sharing and sustainability: challenges and opportunities
Anna Ray Davies, Trinity College
• Water savings, cost savings and other benefits by separation of mass flows
Christoph Glasner, Fraunhofer Institute</td></tr>
<tr><td>15:15</td><td colspan="2">Coffee Break</td></tr>
<tr><td rowspan="2">15:45
-
17:00</td><td colspan="2">Parallel Sessions – part 2</td></tr>
<tr><td>Sustainable & Healthy Nutrition

Room De Gasperi</td><td>Moderator: Stephanie Bodenbach, DG SANTE
• Policy relevant food research for improving urban populations diets
Manuel Franco, University of Alcalá
• Innovative solutions for improving vitamin D nutrition and health in Europe
Mairead Kiely, University College Cork</td></tr>
</table>

	Climate & Environmental Sustainability Room Mansholt	Moderator: Mindaugas Maciulevičius, COPA-COGECA • **Innovative irrigation solution based on low water-energy consumption** Luis Narvarte, University of Madrid • **Mainstreaming digital farming for a Climate Smart Agriculture** Spyros Fountas, University of Athens • **Monitoring water-flooded areas for agriculture and environment** Olivier Desenfans, M3 Systems
	Circularity & Resource Efficiency Room Jenkins	Moderator: Peter Woodward • **Challenges in recovery of food ingredients from vegetable industry by-products** Paulus Kosters, GreenProtein BV • **Sustainable techno-economic solutions for the agricultural value chain** Shane Ward, University College Dublin • **Development of an integrated biorefinery for processing chitin rich biowaste to specialty and fine chemicals** Volker Sieber, Fraunhofer Institute
17:00 - 18:00	**FOOD 2030: Looking Ahead** **Global FNS perspectives and future outlook**	
	The Food Systems approach – Europe and emerging African and Global perspectives by the Inter Academy Partnership **Joachim von Braun**, Center for Development Research (ZEF), Bonn University	
	Food in a green light - a systems approach for sustainable food **Cathy Maguire**, European Environment Agency	
	Main messages from the sessions **Innovation** presented by **Klaus Menrad** **Sustainable & Healthy Nutrition** presented by **Lorraine Brennan** **Climate & Environmental Sustainability** presented by **Roberta Sonnino** **Circularity & Resource Efficiency** presented by **Otto Schmid**	
	Followed by a panel discussion with **John Bell**	
	Bulgarian Presidency of the Council of the EU: Research and Innovation priorities **Ivan Dimov**, Deputy Minister of Education and Science, Bulgarian Presidency	
18:00	**Networking Cocktail**	

Annex 2 - Figures of Participation

From more than 810 participants registered to the conference, 489 attended on site and 380 watched the conference through webstreaming. The percentage of *no show* reached an expected level of 28 %. From the total registered participants, 22 % selected the 'Circularity & Resource Efficiency Session', 29 % registered for the 'Climate & Environmental Sustainability Session' and 48 % registered for the session 'Sustainable & Healthy Nutrition'. The variety of actors that registered for the conference is depicted in the following chart:



Regarding an interactive participation of the audience, Sli.do was used in order to get feedback in real-time from participants. There were 335 active users of Sli.do during the conference that posted a total of 604 questions and comments on the following topics:

Annex 3 – Interactivity via Sli.do

Most Relevant Comments & Questions from the Audience received through Sli.do
How to change: discussing innovation &food in uniform panels? Diversity is key to innovation! Where are the women, the social scientists, the non-Europeans?
Can EC and Food2030 support innovations not focused on business development but on developing social innovations and public services e.g. local Food systems ?
We need to shift to more plant-based diets but this will challenge the dairy and meat industry. Business as usual is not an option. How can EU support change?
What about retro-innovation? Revisiting and refreshing traditional solutions with modern science and technology, including local knowledge
Change of consumer behaviour is a must! Social innovation is vital, and same important as technological! We need change society in general, joint action required
Innovation is not only technological. What about social innovation?
How ready are policy makers to adjust rules / regulations to embrace successful disruptive technologies?
If competition determines the success of innovations, how do we make sure that it is a fair competition and not one dominated by large scale companies?
Farmers as the base for food production are excluded from the discussion. If we want farmers to be empowered they need to be part of the story.
Which is the best policy instrument to change consumer choice for a more sustainable diet?
Consumers look for smart and innovative in everything, except for in food.. How to overcome societal Technophobia when it comes to food?
Disruptive innovation may not please big & established industry...will these folks make disruption terribly painful?
How can we increase consumer demand for healthy sustainable food when we can't provide it at eu events?
Is innovation just about 'the market'? What about innovation for the common good? Shouldn't healthy food be a fundamental right?
Why would we need to "produce more with less" since we 1/3 of food produced is wasted?

In 150 years how will humans look back at our treatment of animals? Lab grown meat will revolutionise food productions systems.

Governance systems also need disruption. What kinds of anticipatory governance do we need to do this?

What will digital technology bring for food insecure people with lower income?

Both science push and consumer pull is required. How to boost consumer involvement in e.g. Genome editing research?

Consumer awareness is a whole system and as long as many people can not afford innovative products our discussion is theoretical.

How to address the difference between consumers, voters, citizens, stakeholders, and 'price motivated choosers in front of the supermarket shelf'... ?

How do we shorten the chain between producer and consumer in REAL terms? It looks like talk while small farmers are disappearing while all is left to the LARGE.

How can the Food2030 system align with activities such as the Biobased Industries JTI?

History shows that the free market is not the best instrument for solving global challenges. EU policy should take its role and responsibility.

Is FOOD2030 just an R&I initiative or something which could be adopted by the whole Commission as a comprehensive policy goal in line with SDGs and cop21 etc

Too little focus on what a sustainable diet contains. How to decrease meat and dairy consumption need an action plan!

Does disruptive innovation always contribute to more sustainable and social development and how can we ensure it does?

Prices of unhealthy food (suger, red meat and wine) are too low because of support of the CAP for farmers producing these products. How to change these policies

It seems to me we're missing a research and related discussion on retailers' key role in impacting on consumers' choices

How about food as commons rather than commodity!

What about the new skills we need for innovation and entrepreneurship like empathy? I see it as fundamental for social innovation

Fed up about delegating citizens For issues the majority of them have no clue!

Regarding the call for focusing on start-ups, what could be the specific features of responsible food innovation, and how does it relate to RRI?

What about the relationship between regulator and consumers? The regulator should influence consumers and not the opposite.

Why not to give EU incentives for large companies to partner with SMEs and Start-ups? To speed up pilot tests in an open innovation environment...

Sure this is an EU event, but we should talk about/include international cooperation in the debate if we want to have an impact globally

Is there a need of a new common EU food, nutrition and health policy?

Notes:

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This report captures the main findings of the European Commission (EC) Conference entitled "Harnessing Research and Innovation for FOOD 2030: A science policy dialogue", which was held in Brussels on 16th October 2017 on the occasion of World Food Day. The event, which represents an important milestone in the EC's FOOD 2030 process, served to showcase promising Research and Innovation (R&I) outcomes contributing to sustainable food systems transformation in Europe and beyond. Furthermore, the conference provided a space for multi-stakeholder reflection and dialogue towards envisioning future R&I needs relevant to the urgent issue of ensuring long term food and nutrition security, particularly challenging due to the compounded effects of climate change, resource scarcity and increasing global demand for food. The outcomes will further feed into the deliberations of the FOOD 2030 EC Expert Group and the Second FOOD 2030 High Level Event under the Bulgarian Presidency of the Council to be held in Plovdiv in June 2018.

Studies and reports

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