EU AGRICULTURE AND INNOVATION: WHAT ROLE FOR THE CAP?

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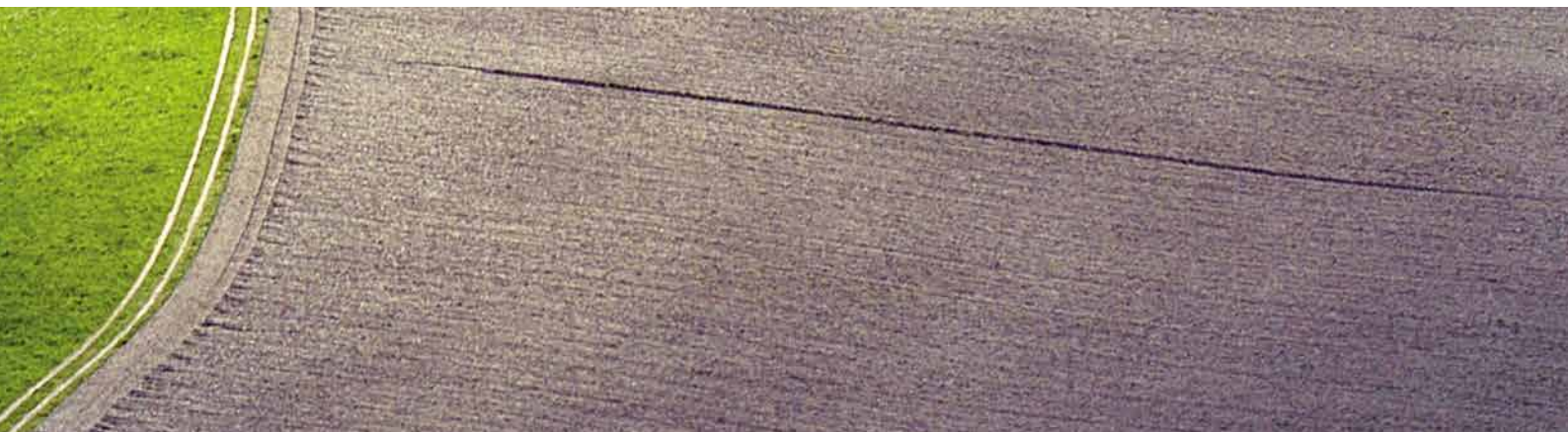

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EU AGRICULTURE AND INNOVATION: WHAT ROLE FOR THE CAP?

One of the current European public debates concerns the future of the Common Agricultural Policy (CAP), the most integrated European policy created over the last 60 years. Given the challenges of sustainable food and nutrition security, innovation should be an important aspect of that debate.

Our organisations, Wageningen University & Research (Wageningen UR) and Institut National de la Recherche Agronomique (INRA), believe that a broad dissemination of results from our research contributes to creating benefit. This benefit is created not only through novel applications of technologies but also by working on societal challenges through dialogue with society and contributing to government policy and legislation.

We are both concerned and thrilled about the future of the CAP. Concerned because of the need to take the right science-based decisions to ensure the long-term future of European agriculture as one of the most innovative, socially responsible and sustainable sectors in the world. And thrilled, because contributing to this promising long-term future provides our institutions with great challenges for partnerships with governments, farmers, consumers, private business, NGOs and scientific peers.

The authors of this policy brief, experts in European research and innovation policy as well as in agricultural policy, have tried to take a critical look at the current CAP and more specifically how it supports innovation for European agriculture, food and rural areas. They have come up with suggestions to take on board in the public debate on the future CAP. Even it is not easy to have à clear picture of the total amount of regional, national and European public funds made available for innovation in agriculture, food and rural areas, we think that the share of the CAP budget specifically devoted to innovation (today, at best a few percentage points of Pillar II expenditure) is too limited. It should at least be doubled in the next CAP.

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We look forward to the responses in the public debate on the thoughts reflected in this policy brief.

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MANAGEMENT SUMMARY

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Innovation is an important topic in agriculture. This report analyses the role of the Common Agricultural Policy (CAP) in supporting innovation in the fields of agriculture, food and rural areas.

The challenges for our food systems, including agriculture, are well known. Food security and safety remain important issues. Climate change affects agriculture. The ecological impacts of farming and food systems have to be reduced by increased resource efficiency in a circular economy. A lifelong healthy lifestyle requires a healthy diet and a green environment. Rural areas face numerous challenges. In addition, European agriculture and food should remain competitive, notably in terms of total factor productivity **[Chapter 2]**.

Fortunately, several areas can contribute to innovation. Genetics can help by breeding plant varieties and animal races that are more resistant to abiotic and biotic stresses. Digitisation and big data lead to precision farming. Energy and bio-based transitions provide opportunities to increase efficiency. Eco-system services open up new horizons in markets as well as practices. A food system redesigned on circular principles reduces waste and losses. Social innovation and innovations related to the design of public policies are relevant too **[Chapter 3]**.

Innovators and farmers (both as bottom-up innovators and as entrepreneurs who adopt exogenous innovations and take risks) are obviously key actors in the innovation process. Governments also have an important role to play for two main reasons. Many challenges are of a public nature and there are market failures as (small) operators in the food chain are not able to reap all the benefits of their innovations, also as these benefits quickly spill over to others. In addition, the challenges faced by European agriculture, food chains and rural areas require systemic innovations, open innovation devices, and bottom-up approaches. Transformative capacity is lacking and has to be enhanced. The powerful actors in the food chain (input suppliers, food processors and retailers) compete strongly, but do not take enough responsibility for internalising the sustainability aspects with the smaller and more numerous actors at both ends of the chain, i.e., farmers and consumers.

To analyse how the CAP contributes to this innovation process, we use a theory of innovation, of functions of innovation systems, and of innovation regimes that mainly follows Hekkert et al. (2007). The functioning of an innovation system thus comprises seven functions, i.e., 1) entrepreneurial activities, 2) knowledge development, 3) network formation and knowledge diffusion, 4) guidance of the search, 5) market formation, 6) resource mobilisation, and 7) support from advocacy coalitions **[Chapter 4]**.

The spectrum of innovation options is very wide in a context where there is no consensus on the future of farming, agri-food and rural areas in the European Union. In addition, many of the challenges have a local (environmental) dimension, and successful innovation can be highly dependent on local conditions.

The first pillar of the CAP, which represents more than two-thirds of CAP expenditure, does not target innovation. By contrast, several measures of the second pillar specifically address innovation, in particular: M1 (knowledge transfer and information actions), M2 (advisory services), M9 (setting-up of producer groups and organisations), M16 (cooperation) and M19 (Leader programme), as well as the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) which is the main new feature of the 2015-2020 CAP in relation to innovation **[Chapter 5]**.

Assessing the effectiveness of an innovation system is a challenge whatever the application domain. The many elements mean that it is particularly difficult to analyse the efficacy and efficiency of CAP support for innovation: innovation in agriculture, food and rural areas is supported not only by the CAP, but also by other public policies at regional, national and European Levels. Regional and national Agricultural Knowledge Innovation Systems (AKISs) differ considerably from one country (region) to another. Many Rural Development Programs (RDPs) are still in the process of full implementation. With these caveats, we used the framework devised by Hekkert et al. (2007) to arrive at the following observations **[Chapter 6]**.

Function 1 (entrepreneurial activities). Entrepreneurs are essential to turn new ideas into concrete actions. Because innovation development is risky and costly, the CAP should support risk-taking over a transitional period, notably when the innovation targets public goods. Living labs are a way to reconcile the various actors involved in common innovation projects. These open innovation arrangements should in particular favour the involvement of new entrants (young farmers, start-ups, new inhabitants, young consumers).

Functions 2 (knowledge development) and 3 (knowledge exchange). These two functions are essential. They are specifically targeted by several measures of Pillar 2, notably the EIP-AGRI. The success of the EIP-AGRI is uneven depending on the country (region) under consideration. In particular, knowledge development and exchange function well within operational groups, but results are not disseminated sufficiently outside these groups. A full mapping of themes designed and experimented in the different operational groups and thematic networks is needed. This mapping will ensure that the themes cover the different innovation priority areas, notably those corresponding to public goods. Secondly, developing a database and

a modelling framework allows analysis of the extent to which innovations experimented in a given operational group depend, or not, on local conditions and hence whether they can or cannot easily be extended to other environments. Modelling will also help in monitoring. The design for societal impact in systems that lack transformative capacity underpins the need to provide actors with independent advice from a public service that could also be delivered by independent and certified consultants.

Function 4 (guidance of the search). The public good nature of challenges and priority areas for innovation implies that the government should guide the direction of the search process that is essential in innovation. We suggest that larger programmes are designed which concentrate on three axes, i.e., 1) climate change, environmental issues and resource efficiency, 2) collaboration on innovation in the food chain, and 3) territorial innovation. Focusing on these three axes should also facilitate monitoring. This should be reflexive, which means a participative process to gain an insight into the progress of the innovation programme, its intended and unintended effects, in relation to and interaction with the local environment. These three axes should be coherent with other government actions within and outside the CAP that constrain and/or incentivise farmers: subsidies, taxes and agri-environmental contracts. It does not make much sense, for instance, to ask farmers to innovate to save energy if at the same time it is subsidised.

Function 5 (market formation). Creating and expanding markets is an important role for an innovation system. This is especially true for the CAP, where innovations are very much targeted at public challenges. Market formation should not be limited to products, but should include markets for ecosystem services (agri-environmental contracts, tourism, etc.). In particular, CAP support should increase for market creation for products of agricultural system diversification, based on their environmental benefits. In the same way, markets for services should be created, notably for environmental services through market-based payments (e.g., in contracts with cities, nature conservation organisations, water authorities, enterprises, etc.).

Function 6 (resource mobilisation). Resources can be human, material and financial. It is very difficult to have a clear picture of the total amount of regional, national and European public funds made available for innovation in European agriculture, food and rural areas. However, it is likely that the share of the CAP budget specifically devoted to innovation (and market creation for these innovations) remains very limited. Besides shifting budgets within the CAP, it is important to attract new resources, notably through public-private partnerships and the use of financial instruments. Green finance is an opportunity.

Function 7 (creation of legitimacy / counteract resistance to change). The seventh function aims at making an innovation part of the incumbent regime, possibly by changing it. In this respect, the consensus on CAP objectives does not create sufficient legitimacy for a new trajectory for EU agriculture, food and rural areas. This is because the objectives remain very general, and do not translate into a clear hierarchy of priorities, notably in terms of innovation areas that should be targeted preferentially. More emphasis is needed on open innovation systems with co-creation approaches, following the logic of living labs. Public-private partnerships and the involvement of non-governmental organisations and new players like cities can help innovators to scale-up and modify institutional arrangements that discriminate against innovation. Such an approach can build upon the Leader programme and EIP-AGRI initiatives.

In addition to these findings from matching the CAP with the functions of an innovation system as defined by Hekkert et al. (2007), we observe, based on contacts with French and Dutch authorities, that there is a need to reduce transaction costs. More farmers should participate in the EIP-AGRI operational groups. Larger programmes of farmer organisations, production organisations (cooperatives) and funding partners such as venture funds or innovation hubs could reduce transaction costs by organising several operational groups on a theme that includes not only pioneers but also active innovators, and they could also organise dissemination. The alignment of CAP EAFRD procedures with those of the single-audit system of the ERD could help too.

In conclusion, our analysis suggests that in the renewal of the CAP, with regard to innovation, the following six topics (which partly overlap and reinforce each other) should be addressed **[Chapter 7]**:

- Acccelerate innovation with increased budget;
- Better access to instruments by individual farmers and reduce transaction costs;
- Create markets for environmentally-friendly and healthy products and services (including agri-environmental contracts);
- Design for societal impact and develop reflexive monitoring;
- EU-level AKIS development with attention to all seven functions of an innovation system;
- Food system approach is needed.

CHAPTER 01 INTRODUCTION

For a long time, increasing agricultural production and agricultural land and labour productivity has been the primary objective of agricultural research and innovation in the European Union (EU). This specific objective for research and innovation was in line with the initial objectives of the Common Agricultural Policy (CAP), laid down in Article 39 of the Treaty of Rome. In particular, it was related to its first objective ("to increase agricultural productivity through the rational development of agriculture, towards the optimal utilisation of the factors of production"[1]). Thanks to mechanical and biological advances, agricultural price support and global economic growth, success was achieved in the 1960s and 1970s. The EU shifted gradually from a net import to a net export position for many agricultural and food products of the temperate zone. This change led to an increase in intervention stocks and associated budgetary costs, as well as international pressure from trading partners for CAP reform, because of distortions in international agricultural markets. This international pressure, led by the United States (US) and channelled into the framework of the GATT (General Agreement on Tariffs and Trade), was one of the main factors for the 1992 CAP reform design (Guyomard et al., 1994). Since that date, the CAP reform has been applied in a series of successive steps. Apart from the technical details, this continuous process of reform follows rather simple principles, namely: a reduction in farm-gate price support, export subsidies and import taxes and partial compensation for the resulting decrease in farm incomes by direct aids. The last ones are either independent of product choices made by farmers (decoupling) or conditional on increasingly environmental requirements (cross-compliance and greening). Multi-annual contractual measures in the form of Agri-Environmental and Climatic Measures (AECMs) target environmental objectives.

Today, there is a wide consensus that EU agriculture is not sustainable, notably from an environmental and health point of view. Farms are now larger than ever and more specialised in a reduced number of products. Farming practices and systems are very simplified and rely intensively on fossil energy and chemical inputs (mineral fertilisers, synthesis pesticides, concentrated and compound feed, etc.). The result of all these changes is the decline in agricultural soil fertility as well as the increase in agricultural soil erosion, the deterioration in water quality, the loss of biodiversity in agricultural ecosystems and the rise in GreenHouse Gas (GHG) emissions of agricultural origin. Air pollution due to agriculture represents an increasing and still underestimated threat, not only for ecosystems but also for human health. Concerning health, a key issue is the emergence of pathogen resistance to chemical treatments used for plants and livestock. Because animals and humans share the same pharmacy, when an antibiotic becomes useless in animal health, it also becomes inefficient in human therapy. An additional key concern is malnutrition in the form of undernutrition and increasing over-nutrition.

There are also signals that suggest that EU agriculture is not sustainable from an economic and social point of view, ei-

1 https://ec.europa.eu/romania/sites/romania/files/tratatul_de_la_roma.pdf

ther. Agricultural prices and incomes [2] in the EU are more and more variable because of international agricultural policy deregulation, climate change, increased variability in yields, etc. EU agricultural productivity is gaining renewed interest not only for international reasons (its capacity to feed more than 9 billion people worldwide in a context of climate change) but also due to competitiveness issues of the EU agricultural and agri-food sector. According to the European Commission (2016), annual agricultural Total Factor Productivity (TFP) growth decreased over the 2005-2015 period (0.8%) compared to the previous decade 1995-2005 (1%). More significantly, the EU-15 "old" Member States (MS) have experienced a much sharper drop, from 1.3% in 1995-2005 to 0.6% in 1995-2005. The most recent figures provided by the EC show that between 2006 and 2016, agricultural TFP grew annually by 0.7% in the EU-28, 0.5% in the EU-15 only but 1.6% in the new MS of the EU-N13 (EC, 2017) [3]. Social unsustainability takes various forms. Not only are farmers' incomes still lagging behind salaries in the whole EU economy (European Commission, 2017, Figure 6), but they are also more volatile and there are strong differences from one farm to another. Farmers are often fairly old: 31% of EU farmers are over 65 years old and 24% are aged between 55 and 64 years (European Commission, 2017, Figure 10). They now represent a small minority group within the total population of most EU rural areas. Moreover, there is an increasing gap in comprehension between agriculture and farmers on the one hand, consumers and citizens on the other hand (Lamine, 2015). Farmers feel that their work is not properly acknowledged, and their efforts are not fully recognised with the constant constraints that are placed upon them.

To be able to address all these sustainability challenges, more research and innovation are needed. The need is even greater since research and innovation should target sustainability regarding not only farming systems but also food chains, diets and maintenance of rural areas. However, addressing these challenges and defining how research and innovation could help to meet them, is much more difficult today than in the 1960s when the CAP was introduced. There are two main reasons for this: (i) the objectives to achieve are more numerous and potentially contradictory, and (ii) there is no consensus on how to reach these goals. In addition, CAP tools aiming at supporting research and innovation have to be considered in relation to the food and nutrition security agenda, as discussed, in particular, during the Food 2030 Conference (EC, 2016), as well as in relation to national and regional efforts and measures. In practice, there is no one-stop-shop solution for addressing all these challenges. Research and innovation should simultaneously consider different ways that can be mobilised for improving the sustainability of EU agricultural systems, food chains and rural areas, from agro-ecology to precision farming, from local and short food chains to export markets. In addition, the way research and innovation are being organised is also changing. Today, there is a broad consensus that the top-down linear model of centralised innovation, from upstream basic research to concrete innovations implemented in commercial farms after a phase of experimentation, is obsolete and outdated. At the very least, it is inadequate. Indeed, solutions are partially in the sole hands of farmers (bottom-up solutions adapted to local conditions). Solutions are also found in co-design with the multiple actors involved: farmers, agri-food chain partners, consumers, taxpayers, citizens, policy makers, etc. In addition, research is essential to support this multi-dimensional innovation transition related to production practices and systems because it provides new sources of knowledge and explains processes, dynamics and systems. It aims at saving natural resources while taking labour constraints into account, mobilising crop and animal gene resources, in particular the articulations between genotypes, practices and the environment, exploiting the potential offered by digital tools and precision agriculture, etc. This complexity requires a food system approach. Changes at farm level should be accompanied by changes in, for instance, food processing, retail and policy.

For many years, the innovation regime supported through the CAP has been the model of centralised innovation. In this regime, new knowledge was developed through research, distributed by advisory and education systems and put into practice by the farmer. Since the launch of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) by the European Commission in 2012, the regime is starting to change. However, there is still a need to better address the main challenges facing EU agri-food systems and rural areas and to provide better support for innovation through public policies, more specifically through the CAP.

The general objective of this paper is to analyse why and how innovation should be supported in the post-2020 CAP, and to provide policy recommendations to do so. The paper is structured as follows. Chapter 2 presents the main challenges facing agriculture, agri-food and rural areas in the EU. Chapter 3 details the principal areas where innovation is required for addressing these challenges. Chapter 4 has a more analytical character and defines innovations, innovation systems and innovation regimes. In particular, it describes the key functions for successful innovation systems. Chapter 5 presents the specificities of EU agriculture, food and rural areas in relation to innovation, and describes how the current CAP supports innovation. Chapter 6 proposes a critical analysis of this support, following the analytical framework developed in Chapter 4 in terms of functions of innovation systems. Chapter 7 reassembles complementary policy recommendations for increasing the efficacy and efficiency of innovation support within the CAP.

2 https://ec.europa.eu/agriculture/sites/agriculture/files/statistics/facts-figures/agricultural-farm-income.pdf

3 However, the EC (2017) notes that between 2014 and 2016, agricultural TFP grew annually by 2.4% in the EU-28, 2.0% in the EU-15 and 4.8% in the EU-N13. The 2014-2016 period is obviously too short to appreciate the robustness of this TFP growth over the most recent years (https://ec.europa.eu/agriculture/cap-indicators/context/2017/c26_en.pdf).

CHAPTER 02 CHALLENGES FACED BY THE EU IN THE AGRI-FOOD SECTOR AND IN RURAL AREAS

Following several authors [4], we identify five major global challenges in which our food systems play an important role. In random order, these are:

1. FOOD AND NUTRITION SECURITY AND SAFETY, ASKING FOR RESOURCE EFFICIENCY.

The world population may rise to nearly 10.5 billion by 2100. The demand for food, in particular for animal proteins, will therefore probably increase by even more than the growth in population suggests. This is because of the so-called westernization of food diets worldwide (see, for example, Guyomard et al. 2012). It will not happen automatically nor in a sustainable way, if current production trends are maintained. Improved resource efficiency is needed and Europe has to play a role in an open global trade system. The EU has a high percentage of good agricultural soils, an exceptional level of know-how, sufficient water availability and an attractive climate.

2. CLIMATE CHANGE INFLUENCING WATER AVAILABILITY, ENERGY USE AND ANIMAL PRODUCTION.

Rising temperatures and changes in weather patterns may cause flooding, droughts and disease, all of which influence food production and food safety. They also lead to income risks for farmers. Agricultural policies will have to be in line with climate policies (COP21 Paris Agreement), enabling farmers to adapt and play a role in mitigation and adaptation, by helping them manage risks, be more innovative and make the right decisions. Taking into account the magnitude of this challenge, it is neither realistic nor fair to make farmers alone responsible for producing food that is climate-change proof. As already pointed out in the introduction, it is intended that part of the solution should come from food chain partners and consumers, who need to shift to a more sustainable consumption pattern with proteins that are more plant- and less animal-based.

3. ECOLOGICAL IMPACTS HAVING TO BE REDUCED BY INCREASING RESOURCE USE EFFICIENCY IN A CIRCULAR ECONOMY.

The agricultural sector and food systems also face major challenges related to the environment and biodiversity. The chemical revolution of the 20th century has led to an agricultural system which is essentially based on high inputs of fossil energy, synthetic fertilisers, pesticides and antibiotics. These have brought and continue to bring many advantages. In many cases, however, the effect on the environment of their excessive use (water and air quality and even public health) is not sufficiently considered when deciding whether to use these inputs. Intensive use of soils and monocultures without proper soil management leads to problems such as depletion of organic matter and soil biota, over-compacting

4 The text of chapters 2 and 3 is partly from Fresco and Poppe (2016). See also: SCAR (2016), De Schutter (2017), Détang-Dessendre and Guyomard (2017), European Commission (2017).

caused by heavy machinery, erosion, and the spread of certain bacteria, fungi and weeds. More attention needs to be paid to issues related to biodiversity, landscape and nature management.

4. A LIFELONG HEALTHY LIFESTYLE REQUIRING HEALTHY DIETS AND A GREEN ENVIRONMENT.

The majority of chronic diseases such as type 2 diabetes, cardiovascular diseases, certain types of cancer and obesity are linked to food intake and lifestyle. Many EU consumers eat more meat than is advisable and do not eat enough fruit and vegetables to get the intakes they require. These challenges are not a direct result of problems created by agriculture, but agriculture can be part of the solution. Agriculture in and around cities (peri-urban) can contribute to a healthy environment and lifestyle (smart cities). Digital innovations in food products (including the breeding of crops and personalised nutrition) can make healthy diets more available and affordable. Moreover, the emergence of resistance of bacteria and parasites to antibiotics and anthelminthic treatments is a key feature in public health. As humans and animals share the same pharmacy, part of the solution lies in animal husbandry.

5. RURAL AREAS FACING DIFFERENT CHALLENGES.

Current trends in demographics, urbanization and an increase in farm size are resulting in an empty countryside. Also, within rural areas, the population clusters in cities and large towns. This leads to questions on vital infrastructure (such as broadband for precision farming and electricity for the machines of the future). It also provides opportunities to refocus regional strategies on bioeconomy, energy production and conservation of biodiversity.

Additionally, the EU farm and food sectors have to face two major overarching challenges: i) the necessity to reduce inequality between EU regions, between urban and rural areas within states and between individuals, and ii) the need to maintain competitiveness of the sector, especially in terms of factor productivity.

Referring to the Sustainable Development Goals (SDG) and the EU policy objectives, the recent Communication from the European Commission on "The future of Food and Farming" (2017) recognizes these challenges in general. This paper does not analyse to what extent the CAP addresses them currently or in the future, but analyses i) to what extent innovation could help to address these challenges, and ii) how the CAP should support innovation aimed at addressing these challenges.

These major challenges are all reasons for public intervention in innovation. Even if some of them are also taken up by businesses, market failures remain. Actors in the market, such as farmers, underinvest in innovation, as they do not reap all the benefits. Several of the challenges are linked to systemic failures or a lack of transformative capacity of the food system. We will explain this further in Chapter 4. It is hard to imagine that this can all be achieved by only addressing farmers, who are merely a part of a food chain in which most of the power lies with the retail, food industry and input industry. This means that in order to direct the role of the CAP in innovation, choices need to be made. Before we arrive at these choices, it makes sense to look first at some of the innovation areas based on developments in technology and research.

CHAPTER 03 INNOVATION AREAS THAT ADDRESS THE CHALLENGES IN THE AGRI-FOOD SECTOR AND IN RURAL AREAS

The challenges that we identified in the previous chapter require innovation. Such innovation processes can make use of new insights from research or from other industries. We group these insights into seven interconnected innovation areas, also in random order. These are:

1. GENETICS, WHICH HELPS TO BREED BETTER PLANT VARIETIES AND ANIMAL RACES.

New plant breeding techniques are becoming available which blur the difference between traditional breeding and genetic modification. Furthermore, unwanted genes, which lead, for example, to susceptibility to diseases or to allergies, can be removed. Tolerance to abiotic factors (e.g. drought) could be achieved too. Similar techniques apply to animal breeding. Precision breeding for precision foods and specific consumer types is within reach, especially through the enhancement of nutritional quality.

2. DIGITISATION AND BIG DATA LEADING TO PRECISION FARMING.

Information and Communication Technologies (ICT) make it possible to set up new systems for farming. A revolution comparable to the introduction of the tractor and chemical products in the 1950s is happening, with a deluge of data as a result of the use of sensors, satellites, robots and all types of machinery. This may raise productivity, make farming more climate-smart and help to solve environmental issues. It also improves food traceability (with blockchain technology or otherwise), oversees animal welfare and helps consumers opt for more healthy and sustainable personal diets, in their smart kitchen. At the same time, developments in ICT are not neutral. Depending on who owns the data and how the exchange of data is organised, the food chain can be governed in many different ways.

3. ENERGY AND BIO-BASED TRANSITIONS PROVIDING OPPORTUNITIES.

There is a trend towards low-carbon industrial processes replacing petro-chemicals and fossil fuels. The demand for non-fossil biological materials will increase and these can only be produced via agriculture, forestry, marine activities and recycling. In the process of moving to a post-fossil-fuel, carbon-neutral world, resource efficiency is essential.

4. ECO-SYSTEM SERVICES OPENING UP NEW HORIZONS.

Agriculture contributes to providing eco-system services in many regions, such as preventing erosion and wildfires, maintaining the landscape and biodiversity or water management. As these services are threatened, not least by agriculture itself, there is more and more interest in valuing them and using the CAP budget or other funds to pay for them. This is an area of innovation which includes organisation, such as collaboration of farmers with new business models, or developing new label and sustainability schemes.

5. THE REDESIGN OF FOOD SYSTEMS ON CIRCULAR PRINCIPLES.

Partly based on a better understanding of biomaterials and manufacturing processes, cascading is becoming an important principle in the allocation of biomaterial. This means that agriculture must be linked to bio-economy chains, to supply them through smartly designed systems with minimum losses of produced biomass. This includes the problem of food waste: in the EU-28, around 20% of produced food does not arrive on a plate for human consumption due to losses and waste [5].

The following two innovation areas are characterised as overarching topics. They focus on the process rather than addressing one particular topic or a cluster of specific topics:

6. AGRICULTURAL PRACTICES AND OPEN INNOVATION.

An important source of inspiration for innovation processes are agricultural practices themselves. In the past, many innovations in agriculture originated from innovative farmers. It was never a linear top-down innovation process. Farmers are better educated than before and many challenges, especially regarding more sustainable production, have an important local aspect. It is therefore important, in this period of change, to use the innovation capacity of farmers themselves. This requires a more open innovation process, which includes new actors by using techniques such as living labs. The European Commission recognised this by setting up EIP-AGRI and adopting open science principles.

7. SOCIAL INNOVATION WILL AFFECT AGRICULTURE.

Innovations do not necessarily originate from research. Changes in consumer demands or in attitudes to food or to working in farming also create innovations. Especially in and around cities, there is a need for a peri-urban landscape where farmers offer services in areas such as leisure, care and nature management, as well as producing food. Urban farming and home delivery of food are also on the rise, making cities and regional authorities stakeholders in innovations. Citizens are becoming increasingly involved in co-creation processes, including with social media. Innovation also takes place in governmental policies, for example in procurement of products, school fruit schemes and local food policies.

These seven innovation areas described in this chapter help the food and agriculture sector to innovate and meet the challenges defined in the previous chapter. However, it is too easy to argue that challenges for society form the business opportunity of tomorrow, and that innovation areas are available to provide the solutions. Many of the sustainability challenges are at odds with the current way the food system works. The challenges exist because the current food system generates negative externalities and it is not to be expected that the system itself will be able to fully solve that problem. As described in Chapter 2, not only are there market failures in innovation that need to be addressed, in the sense that innovators cannot reap all the benefits from their innovation (leading to underinvestment), but there is also a need for systemic innovation. The food system has to be innovated in the way it works. This raises the question of the transformative capacity of the system and if it is strong enough to create a more resilient food system. Asking the question also provides the answer. As the system does not change fast enough, it creates another reason for government intervention, that of improving the transformative capacity of the food system in order to create systemic change.

5 According to the EU project "Fusions": www.eu-fusions.org

CHAPTER 04

INNOVATION AND INNOVATION SYSTEMS

SECTION 4.1.

ACADEMIC THINKING ON INNOVATION SYSTEMS AND REGIMES

Innovation refers to the evolutionary, revolutionary and disruptive renewal of products, processes, markets and organisations. It is regarded as the source of economic and societal development (Schumpeter, 1942; Christensen, 1997; OECD, 2005; Hekkert and Ossebaard, 2010). Without innovation, society in principle does not develop, and as a result social problems are not resolved. However, innovation for economic purposes does not automatically counteract or worse, contradict innovation for resolving societal challenges such as the sustainability goals (Porter and Kramer, 2011; Schmitt, 2014). Hence, economic and technical innovation should become more in balance with social objectives. This requires social innovation, a term that has several definitions in the literature. We refer to social innovation as the process of innovation in terms of interaction between multiple actors, organisations and regions towards sustainability considering people, planet and profit, and including socially disadvantaged actors, parties and regions (Klievink and Janssen, 2014; SCAR-AKIS, 2016). Innovation occurs due to a successful combination of new technical devices and practices ("hardware"), new knowledge and modes of thinking ("software"), and new social institutions and forms of organisation ("orgware") (Smits and Kuhlmann, 2004; Leeuwis and Aarts, 2011). Innovation is more than bright ideas or inventions, yet they often form an important starting point.

Our society has become more and more complex and along with this we see the increased integration of technical, economic and societal innovation processes, which lead to interdependent and interactive innovation systems. An innovation system can be regarded as a coherent set of institutions, regulations and power, including trust and traditions between different actors and organizations (Hermans et al., 2013). Early work on innovation systems emphasised the interconnectedness of innovation processes, actors and learning processes to explain its large influence on economic development at national level (Nelson et al., 1982; Lundvall, 1992; Freeman, 1995; Edquist, 1997) [6]. In particular, since the Lisbon Strategy [7], the EU has embraced the concept of Regional Innovation Systems (RIS) which is reflected, for example, in EU structural funding instruments.

In an RIS approach, innovation is the result of interacting sub-systems on inter-regional, national and global levels.

6 The history of agricultural innovation system thinking, however, is slightly different (Hermans et al., 2013). It stems from theories on extension and education. It has developed from linear top-down thinking about innovation to a more horizontal model in which different actors can also fulfil different functions (Klerkx et al., 2012). Nowadays, both research areas have grown towards each other because the general innovation literature does not only look at national innovation systems, but now sector-specific innovation systems and Technical Innovation Systems (TIS) are also being taken into account in research (Cooke et al., 1997; Edquist and Hommen, 2008; Bergek et al., 2008; in: Hermans et al., 2013).

7 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/00100-r1.en0.htm

Cooke (2004) distinguishes between the governance and business innovation dimensions. In RIS governance can be either: i) focused on local business and local policy (grassroots system); ii) focused on both public and private interactions at local, regional, national and supranational level, when appropriate (network system); iii) dominated from outside, mainly at national level (dirigiste system). In RIS the business innovation dimension can be either: i) dominated by larger multinational corporations and dependent SMEs (globalised system); ii) well balanced between larger and smaller firms, both on regional and interregional scales (interactive system); iii) dominated by small indigenous firms and few larger and externally controlled firms (localist system).

The two dimensions interact, leading to a typology to frame regional diversity into nine different possible interactions. Yet this also indicates potential difficulties and mismatches between interregional interaction, preventing optimal exchange and learning for innovation, a particularly relevant factor for the European patchwork. How policy and industry interact in the different regions influences how knowledge processes intervene as triple helix components in innovation processes (Etzkowitz and Leydesdorff, 1995, 2000). We distinguish between various innovation regimes, which are characterised by different knowledge processes (Lans et al., 2006; Joly et al., 2013):

> CENTRALISED INNOVATION AND KNOWLEDGE TRANSFER:

a linear approach in which new knowledge is developed through research, distributed through advisory and education services and then practically implemented by entrepreneurs. This regime can be documented through the Technology Readiness Level (TRL) scale, showing the distance to market. The nine-level TRL scale measures the maturity level of a technology, thereby providing a common understanding of the status of this technology. Each level characterises progress in the development of a technology, from "basic principle observed" (level 1) to "actual system proven in operational environment" (level 9), as defined in Horizon 2020. Initially developed in the space industry sector in the mid 70's, it was consolidated in the mid-90's (Mankins, 1995) as discipline-independent (Mankins, 2009). It was then successfully adapted and implemented in various economic sectors, such as health and human services, the energy sector and the environment (Ekins and Salmons, 2010). It is a useful tool for innovation in agriculture;

> DISTRIBUTED INNOVATION AND KNOWLEDGE CIRCULATION:

also described as open source innovation in which newly developed knowledge or technology is circulated between multiple actors to add value for further development. Applied research, for example, can be seen as a factor of distributed innovation;

> INNOVATION BY COLLECTIVE EXPERIMENT AND KNOWLEDGE CO-CREATION:

in this regime, knowledge is actually being co-produced bottom-up by multiple actors. Examples are citizen science and Wikipedia. The difference between this and distributed innovation is that in distributed innovation there is one actor who introduces the basic knowledge, while collective innovation is characterised by co-invention.

The three regimes and knowledge processes occur and operate both separately and in interaction. They serve different objectives, hence there is no chronological order relating to the regimes nor is one regime preferred over another. Many fundamental or basic scientific research programmes are examples of centralised innovation. Their first aim is to develop evidence-based scientific results, curiosity driven and unhindered by different stakes and demands. Once this new knowledge is developed theoretically, it can be tested in practice. Centralised innovation is societally useful, for example, when results of new knowledge are expected to be dangerous or hazardous for human health or safety. However, researchers or other actors could decide to open up their basic ideas or preresults to a broader public, to share ideas and experiences on both a scientific and a more practical level, to further codevelop the final product. This could be the case in the gaming industry for instance, where initial ideas are shared with potential end users to codevelop a user-oriented product. When end users define an innovation challenge in their (daily) practice and seek colleagues and/or other actors such as researchers, advisors or teachers to help them develop an answer, we speak of innovation by collective experimenting. Operational Groups (OGs) under the European Innovation Partnerships (EIP) are designed to support this bottom-up type of knowledge and innovation co-creation.

SECTION 4.2.

THE SEVEN FUNCTIONS OF INNOVATION SYSTEMS

To identify and analyse the functioning of an innovation system, Hekkert et al. (2007, 2010) developed a framework that distinguishes seven different functions, which we will use later in this paper to comment on the role of the CAP in support of innovation and innovation systems.

TABLE 4.1. THE SEVEN FUNCTIONS OF INNOVATION SYSTEMS

	FUNCTION NAME AND DESCRIPTION	INDICATORS (Hekkert et al., 2007, 2010; Hermans et al., 2013)
F1	ENTREPRENEURIAL ACTIVITIES: Entrepreneurs translate the possibilities of new knowledge, networks, and markets into specific actions to generate, and benefit from, new business opportunities.	• (number of) diverse companies experimenting • (number of) entrepreneurs who incorporate innovation in their strategy or business plan • degree of entrepreneurial involvement, appropriate for the particular innovation phase • changes in entrepreneurial involvement over time
F2	KNOWLEDGE DEVELOPMENT: Learning through research and development is essential for innovation, including search learning and learning-by-doing.	• (number of) R&D projects, patents and investments in R&D • increase in performance by learning • diversity and quality of knowledge development in the innovation process • (number and types of) actors and parties involved
F3	KNOWLEDGE EXCHANGE AND NETWORKS: Next to F2, exchanging knowledge and information between multiple actors and forming diffusion networks, these are needed to be able to put the knowledge into practice.	• (number of) exchange/network events • intensity organising the knowledge diffusion network • involvement of relevant actors and cross connections • intensity of the network and knowledge exchange over time
F4	GUIDANCE OF SEARCH: F4 refers to the actions and interactions undertaken to manage expectations, needs and visions about the innovation product being developed.	• (number of) specific targets to promote the use of the new knowledge/development • (number of) articles/messages in media that raise expectations about the knowledge/development • (number of) positive and negative messages stating the debate • the extent and direction given to the search process • the intensity of creating common ground and a common vision
F5	MARKET FORMATION: The creation of incentives or protective elements to launch innovation, such as temporary niche markets or competitive (tax) advantages.	• presence of a market (demand) for the innovation • (number) of niche markets that have been introduced • (number of) specific tax measures • new policy measures (e.g. environmental standards) • (number and types) of actors and networks creating a market • the extent to which a market has been created
F6	RESOURCE MOBILIZATION: F6 relates to both financial and human capacity required to innovate, such as investments in research in relation to F2.	• perception of accessibility to sufficient resources by actors involved • types of resources available for the development • degree to which the availability of resources is either an obstacle or an incentive for innovation • the evolution of the availability of resources over time (and what caused this)
F7	CREATION OF LEGITIMACY/COUNTERACT RESISTANCE TO CHANGE: Innovation involves the risk of decreasing shares of established products, services, etc. or disruption. Therefore, advocacy and actions to counteract resistance against the innovation are required.	• rise and growth of interest groups and their lobby actions • the number of mechanisms for counter-resistance • the effectivebess of counter-resistance (benefiting or hampering the innovation system) • the evolution of counter-resistance over time

SECTION 4.3.

THE ROLE OF THE GOVERNMENT IN INNOVATION

The seven functions of innovation systems already suggest that the government has important roles to play in innovation systems. One of these roles within the innovation system is to steer and maintain the balance between economic growth and solving societal issues in a balanced way, as previously mentioned. Over the past decades, the use of joint problem solving, where each party has its responsibility and takes on an economically and socially responsible "licence to produce", has increased. Policy makers, entrepreneurs, knowledge workers, NGOs and citizens are increasingly working together in public-private collaboration to produce sustainable agriculture while preserving nature and natural resources. The current EU CAP supports this, and the Commission's Communication on "The Future of Food and Farming" (2017) emphasises this point as important for the next decade. Within the EU, governments create opportunities so that everyone has equal opportunities to learn, to do business and to live their lives. The government is therefore also required to create the preconditions and conditions, together with the other actors involved, to make innovation possible. This also includes innovation in regulation itself. Agreements must be made between different countries, both within and outside the EU, to achieve responsible innovation. Industry cannot do this alone.

One of the main reasons for government intervention in innovation is the fact that the level of innovation is sub-optimal due to market failures (Pomp, 2003). Such failures occur because (i) firms only take their own interest into account and not the possible knowledge spillovers, (ii) innovative companies do not receive all the gains derived from the innovation, as consumers and other customers profit from their investment, (iii) R&D and innovation are risky, because not every R&D project succeeds. When companies are not able to cover these risks well enough, uncertainty puts a brake on innovation. In these cases, the innovation efforts lag behind what is socially desirable. In agriculture and food in particular, with their small and medium enter-

prises, this is an important consideration for government intervention. In other cases, thanks to innovation, a company gains a market share over other companies, which reduces the profit of competitors. Because of this business stealing effect (Pomp, 2013), companies can then innovate more than is socially desirable. In addition to market failure, there is systemic and transformative failure. In essence this implies that market failures can exist within a certain (food) system, but that these systems as such are not resilient, run a risk of collapsing and have to be transformed into another state (Ge et al., 2016). This is linked to an imbalance in private versus public-driven innovation. Private parties mainly invest in economic-driven innovation. The government strives for sustainability and takes the necessary measures. Companies must be encouraged to invest in sustainable developments, to achieve societal goals that make them and society better off. Sometimes it requires organisational innovations (and changes) in the food chain, to be able to transform the food system.

Government involvement in innovation raises the question: which government(s)? Should innovation be encouraged by the EU instead of by an MS? There could be a number of reasons to have the EU involved, especially in agriculture and food. Firstly, because the member states benefit from spillovers and also because there is a level playing field within the EU. Furthermore, different agricultural sectors can benefit by connecting to European knowledge and innovation infrastructures. In the common market, the production of certain products is more and more concentrated (such as sugar), as are research and innovation for these products. This makes it attractive, certainly with the current communication technologies, to link producers in other regions to the hot spots of innovation. It makes AKISs more efficient, especially since the agricultural sector is part of the food chain. Many input suppliers, food processors and retailers operate across national borders. It is inefficient to nationally finance the same innovation projects within one country that are also conducted and nationally financed in other Member States, with the same international companies as partners. By pooling resources, as is done within the ERA networks and the JPIs for research, budgets can be used more efficiently and strategically.

CHAPTER 05 CAP INSTRUMENTS ON INNOVATION

SECTION 5.I.

INNOVATION PROCESSES IN AGRICULTURE, AGRI-FOOD AND RURAL AREAS

The centralised innovation regime remains dominant when considering agriculture, agri-food and rural areas. There is, however, increasing recognition that innovation needs to go beyond biological and technological questions at farm level, to innovate in scales of thinking and to take action in order to address societal challenges, such as climate change or biodiversity preservation. This is true at both EU (Dwyer, 2013) and world levels (McIntyre et al., 2009). The necessity to shape agricultural and agri-food innovation processes relies on the current well-recognised fact that biological and technical progress often has negative side effects, notably on the environment and on our health. Many of the challenges facing EU agriculture, agri-food and rural areas are societal challenges, which correspond to public goods. In this respect, the concept of innovation systems and that of functions of innovation systems appears very relevant. According to Hekkert et al. (2007) innovation systems encompass "all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation". The analytical framework of functions of innovation systems can be used to describe the different elementary processes that are highly important for well-performing innovation systems. This analytical framework will be used in the Chapter 5 to analyse innovation systems in EU agriculture, agri-food and rural areas. It assesses how innovations and innovation systems could be supported by public policies, more specifically by the CAP. First, it is important to underline the main characteristics and possible specificities/specifications of EU agriculture, agri-food and rural areas as far as the latter contribute to shaping what would be an optimal design of innovation systems and functions of innovation systems. Characteristics and possible specificities/specifications are listed below.

1. Many challenges facing EU agriculture, agri-food and rural areas are public goods, both globally (e.g., biodiversity preservation or climate change) and locally oriented (e.g., preservation of water quality). Public goods are largely ignored by the different actors in agri-food chains, from farmer to consumer, when they make their production or consumption decisions. Public policies have to play a key role to ensure that functions 4 (guidance of the search), 5 (market formation), 6 (resource mobilisation) and 7 (creation of legitimacy / counteract resistance to change) of the Hekkert et al. classification, are well fulfilled in order to preserve these public goods.

2. The wide spectrum of options is to be explored in a context where there is no consensus on the future of farming, agri-food and rural areas in the EU [8]. This second dimension has two main consequences. Firstly, it means that innovation should be co-constructed in open innovation devices, including all stakeholders from farmers to consumers. Co-constructing is necessary to increase the

8 See, for instance, the 4th SCAR Foresight on the productivist and suffiency paradigm (SCAR, 2015).

rate of adoption and diffusion of innovations, accepted by the whole society, which contributes to improving function 4 (guidance of the search) and function 7 (counteract resistance to change). The second consequence is that all scenarios have to be explored, taking into account all their likely effects, positive and negative, direct and indirect, intentional and unintentional.

3. Related to the previous point is the fact that part of the solution to the sustainability challenge is in the hands of farmers themselves through innovative farming practices and systems. This means that one should not only consider top-down innovations but also bottom-up innovations, proposed by farmers and other actors involved. Bottom-up approaches require that notably functions 2 (knowledge formation) and 3 (knowledge diffusion through networks) in the Hekkert et al. (2007) typology perform well. In addition, innovation systems in EU agriculture, agri-food and rural areas may also include resources which are not strictly linked to traditional actors. Digital technologies are largely exogenous innovations. They represent opportunities (Chapter 3) and new resources for action. They can also represent drawbacks for farmers, for example because they can require huge investments and new competencies, taking over famers' jobs and questioning traditional ways of farming. In any case, they represent a formidable challenge for traditional actors in agriculture, agri-food and rural areas because of the risk of imposing, of being introduced as undesirable "solutions" and of depriving farmers of the fruits of the digital revolution.

4. Farms in the EU remain largely family-based and small economic dimension. This fourth dimension means that farms often do not have sufficient financial resources to adopt radical innovations, especially when these require huge investments. This low investment capacity and resource mobilisation is exacerbated by the dimension of public goods that innovations should target. It is also exacerbated by the fact that efficiency may require a geographical scale for actions, as innovation has a common pool character, for example, by ensuring that all actors in a given area commit to a scheme collectively. Function 6 (resource mobilisation) appears to be key in addressing this fourth characteristic.

5. The success of innovations can be highly dependent on local conditions (Huyghe et al., 2017). These include not only environmental (climate and soil), biotic (pests and diseases) and economic (prices and markets) conditions, but also historical, cultural, ethical and social dimensions. In comparison to many other economic activity sectors, agriculture is very likely to be much more exposed to dependency on local conditions. This fifth point can be illustrated by the annual and spatial variability of agronomic and environmental outcomes linked to the introduction of a new agricultural practice or a new farming system because of changing weather conditions, disease pressure, etc. Agricultural intensification, through the increasing use of chemical inputs, reduces variations between years and locations and makes a unifying, top-down approach attractive. This implies that more environment-friendly farming systems based on agro-ecology principles (Wezel et al., 2009) are very likely to increase this dependency on local conditions, because of the reduction in the anthropisation of the environment and the increase in the use of natural biotic regulations. This fifth dimension should be addressed by function 1 (entrepreneurial activities) and 7 (counteract resistance to change).

SECTION 5.2.
THE CAP IN BRIEF

The CAP consists of two pillars. Pillar 1 includes income support and market and price policy, and accounts for more than two-thirds of the whole budget. According to "European Parliament - At your service"[9]: "Single farm payments have been replaced by a system of multi-purpose payments, with seven components: 1) a basic payment per hectare; 2) a greening component, providing environmental public goods that are not remunerated by the market; 3) an additional payment for young farmers; 4) a redistributive payment whereby farmers may be granted additional support for the first hectares of farmland; 5) additional income support in areas with natural constraints; 6) coupled support for production, granted in respect of certain areas or types of farming for economic and/or social reasons, and 7) a voluntary simplified system for 'small farmers', offering payments of up to 1,250 euros. The first three components are compulsory for EU Member States while the last four are voluntary."

Pillar 2 corresponds to the so-called Rural Development Policy. The six priorities of the current Rural Development Policy for 2014 to 2020 are as follows (again quoting "European Parliament - At your service",[10] "1) promoting knowledge transfer and innovation in agriculture and forestry: developing the knowledge base in rural areas, fostering links between agriculture, forestry and research; 2) increasing the viability and competitiveness of all types of agriculture, promoting innovative farming technologies and supporting sustainable forest management; 3) promoting the organisation of the food production chain, animal welfare and risk management in farming; 4) restoring, preserving and enhancing agricultural and forest ecosystems (biodiversity, water and soil); 5) promoting the efficient use of resources (water and energy) and supporting the transition to a low-carbon economy (renewable energy use, greenhouse gas emission reduction, carbon sequestration and

9 http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_3.2.5.html

10 http://www.europarl.europa.eu/atyourservice/en/displayFtu.html?ftuId=FTU_3.2.6.html

storage), and 6) promoting social inclusion, poverty reduction and economic development: facilitating job creation, promoting local development and improving access to information and communication technologies."

The second pillar of the CAP is financed by the European Agricultural Fund for Rural Development (EAFRD). The Rural Development Policy is implemented under Rural Development Programmes (RDPs) by Member States or Member State regions. An RDP addresses the specific needs of Member States or regions, corresponding to the European rural development policy. The programmes are based on a combination of (some of) the following EU measures, which are detailed in Regulation (EU) No. 1305/2013. We restructured the respective text from "European Parliament - At your service" as follows:

• in favour of knowledge production and transfer: i) transfer of knowledge and information measures (training, information campaigns, etc.); ii) advisory services, farm management and farm relief services;

• in favour of competitiveness: i) physical investment (processing of farm products, infrastructure, improving the performance and sustainability of farms, etc.); ii) restoring agricultural production potentially damaged by natural disasters and catastrophic events and introducing appropriate prevention actions; iii) development of farms and businesses (business start-up aid for young farmers, non-farm business operations in rural areas, etc.); iv) quality systems applicable to farm produce and foodstuffs (new ways for farmers to participate in quality systems); v) payments for areas facing natural or other specific constraints;

• in favour of environment-friendly and animal welfare practices: i) investment in the development of forests and improving their viability (afforestation and creation of woodland; establishment of agro-forestry systems, prevention and restoration of damage to forests from forest fires, natural disasters and catastrophic events, including parasite infestations and diseases, as well as threats from climate change; investment to improve the resilience and environmental value of forest ecosystems and their potential for mitigating climate change; investment in forestry technologies and in processing, mobilisation and marketing of forest products); ii) preservation of farming practices which have a beneficial effect on the environment and climate and foster required changes (agri-environment-climate measures). These measures have to be included in rural development programmes. Commitments must go beyond the mandatory standards; (iii) subsidies for organic farming (conversion or support payments; iv) payments linked to Natura 2000 and the Water Framework Directive; v) payments for forest, environmental and climate services and forest conservation; vi) animal welfare payments;

• in favour of collective actions: i) encouragement of cooperation between farmers and forestry operators and those involved in the food production chain (establishment of centres and networks, operational groups of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI); ii) setting up producer groups and organisations;

• "risk management toolkit": crop, livestock, and plant insurance; mutual funds for adverse climate events, animal and plant diseases, pest infestations and environmental incidents; income stabilisation tool, in the form of financial contributions to mutual funds, providing compensation to farmers for a severe drop in their income;

• in favour of territorial development: i) local development support under the Leader initiative; ii) basic services and revitalisation of villages in rural areas (broadband, cultural activities, tourist facilities, etc.).

Furthermore, the EAFRD finances the European Rural Development Network (ERDN). "The network serves as a hub for the sharing of information about how Rural Development policy, programmes, projects and other initiatives are working in practice and how they can be improved to achieve more." [11]

SECTION 5.3.

THE IMPORTANCE OF CAP INSTRUMENTS FOR INNOVATION

Stimulating innovation, exchange of knowledge and practices and innovation support, are important topics in the recent Communication of the European Commission on "The Future of Food and Farming" [12]. In stimulating bottom-up innovation as a separate status, it is not so much about defining specific substantive topics. Rather, it is about promoting the process whereby farmers come up with solutions themselves for the transition towards sustainable agriculture. The main aim of the innovation tools is therefore to adapt the working practices and attitudes of agricultural entrepreneurs, so that agricultural practices as a whole are transformed towards more sustainable and societally responsible production methods. Innovation provides creative destruction (Schumpeter, 1942), required for agriculture to continuously adapt to the dynamics of societal challenges, wishes and requirements. Enhancing the innovation competence of agricultural entrepreneurs is therefore likely to lead to a reduction in dependency on subsidies, an advantage for both the EU and the country budgets.

11 https://enrd.ec.europa.eu

12 https://ec.europa.eu/agriculture/sites/agriculture/files/future-of-cap/future_of_food_and_farming_communication_en.pdf

Support for research to enhance innovation is possible through framework programmes such as Horizon 2020. Topics are designated for this purpose where researchers can react with research proposals. However, this form of management does not fit in optimally with farm practices, where goals and results cannot be defined in advance but are being shaped during the process. EIP-AGRI has been designed for that purpose. Based on the interactive innovation model, EIP-AGRI aims at "fostering innovation by favouring cooperation and knowledge flows between all research and innovation actors" [13] , in particular by giving farmers a pivotal role. The instrument was introduced in 2012. The core entities of all EIPs are Operational Groups (OGs) in which farmers, entrepreneurs, chain partners, (representatives of) citizens, knowledge workers (research, advice, education) and policy makers combine their competences and organise themselves around a specific concrete topic. The focus is on bringing together various players for agro-innovation through the multi-actor approach and knowledge exchange between these actors and projects. EIP-AGRI OGs can be funded under the RDPs and are project-based. A first evaluation of the EIP (Coffey et al., 2016) suggests that its bottom-up approach is clearly valued by the farmers and rural development agencies. It is highly likely that it will lead to a large number of innovative solutions. They tackle a certain (practical) problem or opportunity, which may lead to an innovation and contribute to achieving the programme's objectives. The EU countries or regions decide on the precise conditions for supporting innovation projects through their RDPs, which operate in a given region or country, for example, from the perspective of smart specialization or certain regional tasks related to the environment or rural development and to designing their subsidy schemes. EIP OGs can benefit from an increased EU co-financing rate [14]. The EIP-AGRI contributes to integrating different funding streams so that they contribute together to the same goal and duplicate results. Rural development will in particular support OGs and Innovation Support Services (ISSs) within a country or region, while Horizon 2020 will fund multi-actor projects and thematic networks, involving partners from at least three EU countries. Other policies may offer additional opportunities.

Innovations can be agronomic, biological, technological, ecological, organisational, social and/or societal. They can be based on new or traditional practices. The link between the OGs and the H2020 research instruments (via focus groups, thematic networks and research and innovation projects) is also made within the EIP-AGRI through the multi-actor projects. Such projects must focus on real problems or opportunities that farmers and foresters are facing. It also means that partners with complementary types of knowledge - scientific, practical and other - must join forces in the project activities from beginning to end [15]. The EIP-AGRI policy has been implemented in 27 Member States; 97 regional development programs and 3,200 operational groups are planned for the period 2014-2020 [16]. "The bottom-up and farmer-led approach is truly distinctive and highly appreciated by stakeholders" (Coffey et al., 2016). However, the implementation of the EIP-AGRI policy varies considerably depending on the country or the region. Although it is probably too early to evaluate the EIP-AGRI success in actually developing innovations (stakeholder satisfaction is an important but insufficient metric for this), it will be further discussed in Chapters 6 and 7, and we will make recommendations aimed at improving its efficiency.

SECTION 5.4.

HOW DOES THE CAP MAP THE SEVEN FUNCTIONS OF INNOVATION SYSTEMS?

Table 5.1 describes how the CAP instruments target the seven functions by Hekkert et al. (2007), a critical requirement to ensure the effective functioning of innovation systems. Innovation encompasses all types of innovation, including new bottom-up farming practices. A cross in brackets indicates that the instrument has at least the potential of fulfilling the function. The principal CAP measures for innovation are underlined.

13 https://ec.europa.eu/eip/agriculture/en

14 https://ec.europa.eu/eip/agriculture/en/about/pooling-funding-streams-boost-interactive

15 https://ec.europa.eu/eip/agriculture/en/news/brochure-%E2%80%9Cmulti-actor-approach%E2%80%9D

16 Presentation by DG AGRI and EIP Service Point, at the PLATFORM conference in Rome, October 2017.

TABLE S.I. THE CAP AND THE SEVEN FUNCTIONS OF INNOVATION SYSTEMS *

F1 ENTREPRENEUR ACTIVITIES	F2 KNOWLEDGE DEVELOPMENTPT	F3 KNOWLEDGE NETWORK/DIFFUSION	F4 GUIDANCE OF THE SEARCH	F5 MARKET FORMATION	F6 RESOURCE MOBILISATION	F7 ADVOCACY COALITIONS
FIRST PILLAR - EU REGULATION 1306/2013 (313 BILLION EUROS FOR 2014-2020)						
MARKET SUPPORT MEASURES						
-	-	-	[X]	-	-	-
COUPLED DIRECT AIDS						
-	-	-	[X]	-	-	-
DECOUPLED DIRECT AIDS						
-	-	-	[X] (2)	-	-	-
SECOND PILLAR – EU REGULATION 1305/2013 (95.5 BILLION EUROS FOR 2014-2020, INCLUDING 239 MILLION EUROS FOR TECHNICAL ASSISTANCE)						
ARTICLE 14 (KNOWLEDGE TRANSFORMATION AND INFORMATION ACTIONS) [M1]						
X	X	X	X	-	X	[X]
ARTICLE 15 (ADVISORY SERVICES) [M2]						
-	X	X	X	-	X	[X]
ARTICLE 16 (QUALITY SCHEMES FOR AGRICULTURAL PRODUCTS, AND FOODSTUFFS)						
X	-	-	X	X	X	-
ARTICLE 17 (INVESTMENTS IN PHYSICAL ASSETS)						
X	-	-	X	-	X	-
ARTICLE 19 (FARM AND BUSINESS DEVELOPMENT)						
X	X	-	X	-	X	-
ARTICLE 20 (BASIC SERVICES AND VILLAGE RENEWAL IN RURAL AREAS)						
X	X	-	X	-	X	-
ARTICLE 27 (SETTING-UP OF PRODUCER GROUPS AND ORGANIZATIONS) [M9]						
X	-	-	-	X	X	-
ARTICLE 28 (AGRI-ENVIRONMENT-CLIMATE: AECMS)						
X	X	X	X	-	X	X
ARTICLE 29 (ORGANIC FARMING)						
X	•	[X]	X	-	X	X
ARTICLE 33 (ANIMAL WELFARE)						
X	•	[X]	X	-	X	X
ARTICLE 35 (CO-OPERATION, THIS MEASURE SUPPORTS NOTABLY THE ESTABLISHMENT AND OPERATION OF EIP OPERATIONAL GROUPS [M16]						
X	X	X	[X]	-	X	[X]
ARTICLES 42, 43 AND 44 (LEADER) [M19]						
X	X	X	[X]	-X	X	X
ARTICLE 51 (FUNDING TECHNICAL ASSISTANCE)						
-	-	X	[X]	-	X	-
ARTICLES 52 AND 54 (EUROPEAN NETWORK FOR RURAL DEVELOPMENT, NATIONAL RURAL NETWORK)						
[X]	-	X	[X]	-	X	[X]
ARTICLES 53, 55 AND 56 (EUROPEAN INNOVATION PARTNERSHIP NETWORK)						
[X]	X	X	[X]	-	X	[X]

* At EU level, agricultural and food innovation is also supported through Horizon 2020, the EU's framework programme for research and innovation. (2) Potentially through cross-compliance and greening.

CHAPTER 06 CAP SUPPORT FOR INNOVATION: ANALYSIS AND RECOMMENDATIONS

Table 5.1 summarises how the current CAP supports innovation. Pillar 1, which represents more than two thirds of CAP expenditure financed by the EU budget, does not target innovation directly [17]. In contrast, several measures of Pillar 2 specifically target innovation, in particular M1 (knowledge transfer and information actions), M2 (advisory services), M9 (setting-up of producer groups and organisations), M16 (cooperation) and M19 (LEADER), as well as the EIP-AGRI. This last is undoubtedly the main new feature of the 2014-2020 CAP in relation to innovation. It is defined by Title IV of EU Regulation 1305/2013, more specifically article 55 (aims), article 56 (operational groups) and article 57 (tasks of operational groups), while article 52 of Title III provides technical assistance to put in place an EIP-AGRI network. However, the establishment and operation of EIP-AGRI operational groups is supported by M16 of article 35. Other measures of RDPs can also have an effect on innovation. This is the case, for example, for AECMs defined by article 28. AECMs can favour the development and adoption of environment-friendly farming practices. In brief, agricultural innovation at the farm level is the main target. There are fewer measures devoted to innovation for food chains and rural areas and they are less well financed.

The second funding instrument specifically supporting innovation is H2020, the EU's framework programme for research and innovation. In addition, each country has its own AKIS. Hermans et al. (2011) have compared the organisation and functioning of AKISs in eight European countries, namely England, France, Germany, Hungary, Italy, Latvia, the Netherlands and Switzerland. They have shown how these eight AKISs vary significantly, not only between countries, but sometimes even within countries that have a highly federalised or regionalised political system. They have also noted that these national / regional systems have generally not changed with the impetus of a clear strategy. Changes have rather been the result of an adaptation to new regulatory, economic and social environments.

There are many elements that make it particularly difficult to analyse the efficacy and efficiency of CAP support to innovation in agriculture, food and rural areas. Innovation in these three closely linked domains is supported not only by the CAP, but also by other public policies at regional, national and European levels. Many RDPs are still in the process of full implementation. The EIP-AGRI is certainly a welcome initiative introduced by the 2014-2020 CAP in place since January 2015. However, there is as yet no synthesis information by topic available from the different operational groups or thematic networks, and nothing about how knowledge developed within the operational groups is disseminated at a larger scale (although a lot of information is available through the EIP-AGRI service point website and national websites). More importantly perhaps, assessing the effectiveness of innovation systems is a challenge whatever the application

17 Direct aid in Pillar 1 may, however, have an indirect positive effect on innovation. It can relax a credit constraint and so make farmers' investment in new technologies easier. By stabilising farm incomes, it can give greater certainty and so may encourage risk-taking behaviour. To our knowledge, there are no studies analysing these potential indirect effects of directs aid on innovation which, as a result, remain theoretical. In the same way, stricter cross-compliance and greening requirements could also have a positive impact on innovation, notably by favouring the development of agricultural practices and systems that are more sustainable from an environmental point of view.

domain. Agriculture, food and rural areas are no exception. As noted by the European Commission (2017), "one can only determine afterwards whether a new idea has led to a real innovation." To a large extent, this is because there is no single pathway leading to a real innovation from a new idea. In addition, pathways are under the influence of a quasi-infinite list of factors linked to history, culture, education, research, market evolution, not forgetting accidental factors.

In what follows, we provide an analysis of CAP support for innovation using the innovation system function approach detailed in Chapter 3. More specifically, we analyse to what extent the current CAP targets the seven functions of well-designed innovation systems and we provide recommendations aimed at improving this targeting. The analysis is based on Table 5.1, which summarises how the different instruments of the two pillars support one or several functions. This exercise is rather precarious for at least three reasons. Firstly, because this assessment is based on "expert" judgement, since there are no evident and quantitative indicators with which to construct Table 5.1. Secondly, and perhaps more importantly, because other European, national and/or regional policies can also support innovation and target one or several functions. Thirdly, and from a more technical point of view, because the different functions interact. This leaves room for discussion on, for example, whether the arrival of newcomers in agricultural innovation is part of function 1 on "entrepreneurial activities" or function 6 on "mobilisation of resources", or more likely both, as well as other functions like function 2 (knowledge development) and function 3 (knowledge exchange).

Recommendations are directed to CAP instruments that directly and specifically target innovation. In accordance with the theoretical framework presented in Chapter 4, which states that innovation should be considered as a dynamic process shaped by innovation systems, recommendations are also directed to a larger set of CAP instruments with a view to public policy consistency.

FUNCTION 1: ENTREPRENEURIAL ACTIVITIES

Agriculture, food and rural areas face huge challenges (see Chapter 2). At the same time, there are today real promises of progress through a proliferation of new possibilities. However, not all of these are at the highest levels of the TRL scale and hence they are not implemented in operational environments. These new possibilities are traditional in terms of domains (agronomy, breeding, mineral fertilisation, animal feed, etc.). They also cover new domains linked in particular to the numerical and digital revolution where one can find incumbent entrepreneurs, as well as new players. Incumbent entrepreneurs seek diversification of their business strategy and activity portfolio. "Pure players", sometimes from outside the agricultural and food world, find a business opportunity in the agricultural and food sector. In a domain such as biocontrol, for example, traditional large stakeholders cohabit with young start-ups in an industry configuration that is not yet stabilised and consolidated.

Entrepreneurs are essential for a well-functioning innovation system. According to Hekkert et al. (2007), their role is "to turn the potential of new knowledge, networks, and markets into concrete actions to generate – and take advantage of – new business opportunities". The status of entrepreneur cannot be imposed by decree. However, public policies have undoubtedly an important role to play to favour the entrepreneurial spirit and increase the number of good ideas that become concrete innovations. In the context of this paper, it is a question of whether this entrepreneurial spirit should be supported by the CAP and how, while taking into account the fact that several other policies, mainly at regional and national level, already target the entrepreneurial function. We recommend an intervention of the CAP based on the following reasoning [18]. Because innovation development and adoption is costly and risky, the CAP should encourage risk-taking over a transitional period, notably when the innovation targets public goods, which correspond to the priority areas for innovation defined in Chapter 2. These aids, aimed at favouring entrepreneurial activity, should be transitional. They could be supplemented during and after the transitional period by additional support targeting market creation and development in order to satisfy the fourth function (see below). There is legitimacy, from a public economics point of view, in permanently supporting innovation targeting public goods that are not taken into account by the market (or only very partially). However, budgetary constraints lead us to encourage the development of market-based payments for ecosystemic systems, financed by the intermediate and/or final user, as soon as the creation of ecosystemic service markets is possible.

Entrepreneurial spirit and activity will be favoured by a well-performing innovation system in which the different processes or functions required for innovation development are successfully carried out. Hence public policies in general and the CAP more specifically should encourage the development of public-private partnerships extended to public-private-people partnerships, i.e., living labs [19]. No one would dispute the importance of innovation for the future of EU agriculture, food and rural areas. However, there is no consensus on the detailed shape of this future, which leads to opposition to some innovation forms. In addition, this op-

18 Favoring the entrepreneurial spirit is obviously not specific to agriculture, food and rural areas. One specificity is however in that in these domains, entrepreneurs, notably famers, are fragmented and of small economic size.

19 In a general way, a living lab is an open innovation ecosystem in which any development in a field of study is co-constructed, tested and applied with real users in a real life environment. Five key elements characterise a living lab, i.e., i) active user incolvement, ii) real-life setting, iii) multi-stakeholder participation, iv) multi-method approach, and v) co-creation. For more details, see, for example, the website of the European Network of Living labs (ENoLL): http://www.openlivinglabs.eu/

position differs depending on the economic or social group. Living labs are a way to reconcile the various actors involved in territories on common innovation projects (see function 7). These open innovation arrangements should in particular favour the involvement of new entrants (young farmers, start-ups, young consumers, new inhabitants of territories).

FUNCTIONS 2 AND 3: KNOWLEDGE DEVELOPMENT AND KNOWLEDGE EXCHANGE

There is no doubt that knowledge development (function 2) and knowledge diffusion through networking (function 3) are essential. As noted by Lundvall (1992) quoted in Hekkert et al. (2007), "the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning". Knowledge exchange is equally important. Indeed, bringing science closer to practitioners is essential. Scientists should also learn from practitioners [20] and sometimes farmers should be involved in "doing" research, especially when innovations are related to new farming practices and systems (co-learning and bottom-up innovations). Within the CAP, several measures of the second pillar target these functions 2 and 3, specifically measures M1 (knowledge transformation and information actions), M2 (advisory services), as well as the EIP-AGRI through operational groups, thematic networks, and innovation support services and brokering. Operational groups are supported by the cooperation measure M16. As mentioned in Chapter 5, in September 2017, 108 RDPs implemented cooperation through this measure, which represents 1.9% of the Pillar 2 budget or 1.8 billion euros for the 2014-2020 period (Van Hoye, 2017). Out of these 108 RDPs, 98 provided support to around 3,200 operational groups. The number of operational groups varies considerably from one Member State to another, from a few units in countries like Lithuania (7), Slovenia (9) or Finland (10) to 435 in Greece, 735 in Italy and 852 in Spain (in comparison: 305 in France and 60 in the Netherlands). The share of cooperation measures in the total RDP budget is 0.3% in Romania but 13.6% in Malta (in comparison: 1.7% in France and 4.4% in the Netherlands). These figures say nothing about the efficacy and efficiency of cooperation measure M16, or more specifically of operational groups. Note, however, the huge variability in the number of operational groups between countries and within a given country between regions. For example, in France, there are 65 groups in the Rhône-Alpes region but only 2 in Champagne-Ardennes or Haute-Normandie, despite these three regions facing sustainability challenges that require knowledge development and diffusion on a similar scale. Note also the (very) limited amount of resources devoted to this measure M16, again with a great heterogeneity between countries / regions.

As stated before, the EIP-AGRI is a welcome initiative of the 2014-2020 CAP, aimed at fostering knowledge development and exchange by developing co-learning and communities of innovations and practices. Even if detailed information is lacking, our impression, based on exchanges with stakeholders, is that success is uneven, depending on the country (region), that knowledge development and exchange are functioning well within functional groups. However, innovation does not disseminate sufficiently outside the operational groups already in place. Our recommendation is therefore to supplement available information by developing a full mapping of themes designed and experimented in the different operational groups and thematic networks. This mapping would pursue two main objectives. Firstly, to ensure that the themes cover the innovation priority areas and notably the priority areas corresponding to public goods (see Chapter 2). Because farm-level innovation is the main target of most operational groups and thematic networks, it is likely, at least possible, that resources centred on innovation for food chains and rural areas are not sufficient. Secondly, to allow the development of an analytical framework able to analyse the extent to which innovation developed in a given operational group depends on local conditions and as a result, whether it can or cannot (easily) be extended to other situations. The thematic networks target this dissemination objective. This is necessary, but it is not sufficient. Case studies and exchange methods among actors should be completed by modelling to provide a sound basis for innovation actions. Models should be able to analyse how innovation affects the three dimensions of sustainability, starting from an initial diagnostic. They should also be able to take into account the environment of the farm, the food enterprise or the rural territory in order to link positive and negative impacts of innovation on economic, environmental and social outcomes to local environments and characteristics. Understanding the impacts of innovations on sustainability by modelling makes it easier to transfer best practices from one context to another, from one sector to another, from one region to another. A certain level of abstraction is helpful. It will also help in monitoring.

FUNCTION 4: GUIDANCE OF THE SEARCH

Because innovation processes are costly and resources are limited, there is a need to make a selection from among a quasi-infinite number of options. This is the role of function 4 of innovation systems corresponding to guidance of the search.

No one will dispute that farming systems, food chains and rural territories should be (more) sustainable. As a result, it is difficult to disagree with CAP objectives as they are defined in the Communication of the European Commission in November 2017 (European Commission, 2017, pages 7 and 8). This consensus does not provide guidance of the search for three main reasons. Firstly, because "grasp all, lose all". Secondly, because the different objectives are not quantified. Thirdly, because non-compliance with objectives is not sufficiently discouraged.

20 Practitioners should learn from scientists as well.

The public good nature of challenges and priority areas for innovation implies that guidance of the search in EU agriculture, food and rural territories is first a matter of government influence. Basic economy theory suggests that if the prices of fossil energy and chemical inputs rise relative to those of other inputs, the energy and chemical intensity of farming and food systems will fall because of behavioural changes (induced innovation hypothesis first proposed and formulated by Hicks in 1932, later showcased as relevant for agriculture by Hayami and Ruttan, 1971). This means that if we want to bring about innovations that would reduce the use of energy and chemical inputs, the relative prices of these inputs should increase. Such a change is in accordance with the polluter-pays principle because a large part of diffuse pollution from farming and food systems is directly linked to an excessive use of these inputs. This reasoning leads us to recommend their taxation [21]. This taxation would result in actors modifying their behaviour so that choices are based on all costs, private and public. In order to avoid reducing the competitiveness of EU farming and food sectors, the taxation scheme should be implemented at the European scale (ideally at the world scale). The product of the taxation should be kept within the agricultural and food industry in order to finance other measures (e.g., risk-taking aids proposed above to target function 1 of innovation systems), and to encourage virtuous evolutions, practices and innovations while discouraging bad ones through, for example, a bonus-malus mechanism. This reasoning applies similarly to health and nutrition issues, as well as to rural development issues. Even if many challenges facing rural territories can be considered as local, the objective of territorial cohesion is an EU common good [22].

Without waiting for such a coherent governmental framework of subsidies and taxes, in line with both the polluter-pays principle and the provider-gets principle, the guidance of the search could be significantly improved with clearer common visions on priorities and the overcoming of certain ambiguities. To take only one example, a coherent view on the role of livestock in a circular economy in a scenario of climate change would help to direct and select innovation efforts.

FUNCTION 5: MARKET FORMATION

Function 5 corresponds to market formation and can be viewed as specific guidance of the search through market creation and expansion. Given that several priority areas for innovation are of the public good type (see Chapter 2), it is important not to limit market formation solely to products but to extend it to services by developing market payments for ecosystem services, financed by the intermediate and/or final user.

The CAP should encourage the creation and development of new markets, not only for products but also for services, notably environmental and territorial services (tourism activities, local markets, etc.). In the framework of the second pillar, this function is targeted through article 16 of EU Regulation 1305/2013 related to "quality schemes for agricultural products, and foodstuffs", and article 19 related to "farm and business development" insofar as this article can provide business start-up aids for "investments in creation and development of non-agricultural activities." Support provided by these two articles targets the formation of niche markets but does not necessarily correspond to niche markets for specific applications of an innovation. Function 5 is also targeted by focus groups, operational groups and/or multi-actor projects aimed at developing innovative concepts to market products, explore niche markets and diverse economic activities. In a word, they aim to address new business models.

Our first recommendation here would be to increase CAP support for products of diversification of agricultural systems. Let us consider the specific case of the diversification of cropping systems. Temporal and spatial diversification of crops through rotation, multiple and intercropping schemes should allow farmers to reduce the consumption of fossil energy and chemical inputs, and negative environmental impacts linked to an excessive use of these inputs. Despite its potential benefits, crop diversification has gained little ground so far because of many barriers and bottlenecks throughout the whole agro-food system and the sociotechnical system. Barriers and bottlenecks related to value creation and repartition can be addressed by favouring market creation for product diversification. Achieving this objective by organisational innovations is very likely to be insufficient in most cases. Public policies, and more specifically the CAP, have a role to play by providing positive incentives, i.e., by creating a competitive edge through favourable tax regimes, coupled aids or minimal consumption quotes. This competitive advantage could be temporary, conceived as a support to infant industry and market creation.

Our second recommendation also targets market formation but this time for services, notably environmental services. The development of market-based payments for environmental

21 This recommendation also targets function 7 related to counteracting resistance to change.

22 As noted by Guyomard and Détang-Dessendre (2017), the second pillar of the CAP is largely targeted on agricultural, forestry and, to a lesser extent, food-related activities because of their impacts on landscapes, territories and rural development. However, these knock-on effects are difficult to assess and there is no clear evidence showing that the second pillar has acted to reduce spatial disparities within the EU and to increase rural population welfare. Guyomard and Détang-Dessendre continue by noting that the Rural Development Policy is largely based on a rather out-of-date understanding of the rural development process, still too much thought of as a development based on agriculture and forestry. Insufficient consideration given to other activities present and often today dominant in rural areas impedes an integrated conception of rural development and provides only an imperfect means of dealing with the main challenges these areas face, more specifically value creation and setting, provision of and access to services and equipment for the rural population. Support would grow in consistency and clarity if it were given within the framework of the European Cohesion Policy, targeting transversal objectives with a strong knock-on effect on economic development and/or a strong impact on the living conditions of populations, for example digital access in rural areas or maximised access to public and private services. The risk inherent in this evolution of the Rural Development Policy towards the European Cohesion Policy is that of excessive dilution, with the result that agriculture and forestry are the losers.

services should be encouraged by the CAP, again through positive incentives. Creating markets for environmental services is not always possible, and certainly not immediately. As a result, there is also a need for non-market payments for environmental services financed by the taxpayer, at the EU level when the environmental good is of global importance (such as biodiversity, carbon storage, etc.), and at the EU, national and regional levels when it is of more local importance (such as water quality, open landscapes, etc.).

In addition, the CAP is very often seen as a policy directed to farmers. However, it has not totally neglected the function of market creation. There are examples in the past where the CAP budget has been used for market development, like in organic farming or fruit for schools, as well as in marketing campaigns formilk or fruit and vegetables, for example. This suggests that embedding the CAP in food system approaches can build on historical cases.

FUNCTION 6: RESOURCE MOBILISATION

Resource mobilisation remains a key challenge. These resources can be financial, material and human.

It is difficult to get a clear picture on the total amount of public funds made available for innovation in EU agriculture, food and rural areas. This is partly due to the fact that innovation in these three related domains is funded by regional, national and European resources in a context where agricultural knowledge information systems can differ significantly from one country to another, and in some countries from one region to another. To our knowledge, no information is available on total public and private resources specifically devoted to innovation for EU agriculture, food and rural areas. It should be noted, however, that the share of the CAP budget allocated to innovation remains very limited (see above, functions 2 and 3). Given the importance of innovation for the future of EU agriculture, food and rural areas, we recommend increasing the CAP budget targeted on innovation. This is mainly in order to complete the toolbox of innovation instruments along the lines set out, following the analysis framework of the different functions in innovation systems. We also recommend developing an innovation information system in each MS and at EU level, in order to monitor public and private funds devoted to innovation. This innovation information system should be a prerequisite for assessment impacts, i.e., to analyse how resources translate into concrete innovations and their effects on the sustainability of EU agriculture, food and rural areas.

We are well aware of the budgetary constraint of the CAP. As a result, our third recommendation is to attract new resources. Financial instruments can be mobilised to attract additional resources for EU agriculture, food and rural areas. These new resources must target innovation and investment needs that are currently not met, or only very imperfectly, by current funding channels. In this way, a development strategy can be put in place for financial instruments that remedies shortcomings and best meets unsatisfied needs. Green financing is rapidly expanding. It represents an opportunity for EU agriculture, food and rural areas that can foster the evolution towards more sustainable farming and food systems. Qualifying environmental performance of investments and innovations is essential for the development of green bonds in EU agriculture, food and rural areas.

Another way to attract additional resources is to develop public-private-people partnerships. In relation to the CAP, we believe it is essential to ensure that each regional or national agricultural knowledge innovation system includes modern forms of innovation ecosystems such as incubators, accelerators, etc., and provides new entrants, notably start-ups, with easy access to services while minimising bureaucratic requirements.

FUNCTION 7: CREATION OF LEGITIMACY/ COUNTERACT RESISTANCE TO CHANGE

The aim of the last function is to make an innovation, a new technology and/or a new farming system part of the incumbent regime. It also aims at changing the incumbent regime. Advocacy coalitions can function as a catalyst: as noted by Hekkert et al. (2007), "they put the new technology on the agenda (function 4), lobby for resources (function 6) and favourable tax regimes (function 5), and by doing so, create legitimacy for a new technological trajectory" (see also Sabatier, 1988). From this perspective, it is likely that the consensus on CAP objectives will not create sufficient legitimacy for a new trajectory for EU agriculture, food and rural areas. This is because these objectives remain very general and, more importantly, do not translate into a clear hierarchy of priorities, notably of innovation areas that should be targeted preferentially. The meaning of function 7, compared to function 5 in which common visions are created, is to be able to act accordingly.

Our first recommendation is therefore to prioritise the list of innovation domains facing EU agriculture, food and rural areas and from this prioritised list, to identify a few selected areas on which the CAP should focus, and to act accordingly. The choice of these few selected areas should be based on two main criteria, i.e., the domains where there are significant market failures and where there is a clear benefit to act at EU level. The priority innovation domains defined in Chapter 2 meet both of these criteria. In addition, we recommend developing public-private-people partnerships following the logic of living labs. The ultimate objective of living labs, which are a social and societal innovation (see Chapter 2), is to increase the rate of innovation creation, adoption and diffusion by "direct" users (farmers, agri-business, etc.) and their acceptability by "indirect" users (citizens, consumers, taxpayers) through their systematic co-construction and co-design. Living labs are very rare in EU agriculture, food and rural areas. Because the first non-farmer actors concerned by agriculture are actors in their immediate surroundings (mostly in rural areas, but also increasingly in peri-urban and even urban areas), there is legitimacy to develop territorial living labs and to include them within the EIP-AGRI toolbox.

CHAPTER 07

FINAL RECOMMENDATIONS: FROM AGRICULTURE TO FOOD SYSTEM APPROACHES

The need for innovation in agriculture, as demonstrated in the previous chapters, suggests that the current CAP is not optimally organised to deliver the innovation needed: the CAP itself needs to innovate. The (in) adequacy of the CAP's instruments in relation to innovation relates to three levels:

1. the technical adjustment of innovation-support instruments that are already in place, in which the reduction of transaction costs is an important element;

2. the design of new CAP instruments that are the best adapted to deal with objectives in relation to priority areas for innovation (Chapters 2 and 3) and the seven functions of innovation systems (Chapters 4 and 5) that, for instance, suggest the active creation of markets for (new) products and services (as analysed in Chapter 6);

3. the consistency and completeness of innovation-support policy instruments and other CAP instruments as regards the challenges facing agriculture, food and rural areas in the EU, especially in a food system approach. This is because the innovation challenges are far too great to place solely on the shoulders of farmers, the essence of the problem and the rationale for government intervention is the lack of transformative capacity of the current food system.

All three levels are taken into account in our recommendations. The analysis in the previous chapter, the first EIP-AGRI evaluation (Coffey et al., 2016) and our contacts with stakeholders in France, the Netherlands and other EU AKIS actors suggest to us that in the renewal of the CAP with regard to innovation, the following six topics (which partly overlap and reinforce each other) should be addressed:

- Accelerate innovation with more budget;
- Provide better access to instruments by individual farmers and reduce transaction costs;
- Create markets;
- Design for societal impact and develop reflexive monitoring;
- EU-level AKIS development with attention to the seven functions of innovation systems;
- Food system approach is needed.

We conclude the paper by expanding these six topics.

> ACCELERATE INNOVATION WITH MORE BUDGET

As argued in the previous chapters and in line with the 2017 Communication of the Commission on the Future of Food and Farming, societal challenges require more innovation. Resource mobilisation for this is key. In analysing Function 6 (resource mobilisation), we concluded that the CAP could do more in this function. This justifies a larger budget for the different instruments (investment support, farm advisory service, EIP-AGRI, AECMs, and Leader). This can be financed in part by transferring resources from Pillar 1, where most of these payments are currently not linked to services by farmers and are capitalised in land values. However, budget resources are limited and it is therefore important to attract private resources by developing new mechanisms of financing, using public-private partnerships and financial instruments

such as venture capital or leasing of new equipment for precision farming or private-public investments in broadband. Green financing is probably also an option.

> PROVIDE BETTER ACCESS BY INDIVIDUAL FARMERS AND REDUCE TRANSACTION COSTS

The EIP-AGRI is a welcome instrument that could evolve in carrying out this transformative challenge. It is not yet sufficiently mature. As the Commission concludes in its Communication on "The Future of Food and Farming" (2017), important efforts still need to be made. Now that the EIP-AGRI has proved that it can work, it should be scaled up. Even if we agree that there are only 4.5 million professional farmers, of whom about 15% are active innovators (van Galen and Poppe, 2013), there is still only a tiny fraction of the target group actively engaged in the EIP-AGRI. To promote more disruptive innovation (and also if some of the ideas in our next point were to be taken up), it is especially important that farmers in a (small) operational group can have access to a starting subsidy of e.g. 25,000 euros. This would require a procedure that is available all year round, with limited paper work of e.g. one page A4 that describes the problem or idea, and the participants. Providing farmers with this lump sum in advance (at the moment the project starts, not at the end when the costs have already been incurred) would help. There should not be too many questions asked when an innovation does not have guaranteed success. Alternatively, it could be attractive to involve partners with venture funds or innovation hubs, and farmer organisations to reduce transaction costs. Such organisations can stage hackathons and innovation labs that create competition between innovative ideas, and carry out some of the functions of innovation systems (e.g., promoting entrepreneurship, guidance of the search, mobilisation of resources).

Better access by individual farmers could strengthen the functioning of the innovation system to promote entrepreneurial activities (function 1). However, even with easy access many farmers may not take the initiative themselves to become more involved in innovation, not even incremental innovation. For those farmers, OGs might be set up in larger programmes at regional or food chain level to provide better access. This broadens the approach from pioneers to active innovators, and can lead to increased diffusion of innovation. Such programmes would also help in reducing transaction costs at regional level or at the level of the food chain.

An important problem in the current implementation of the EIP-AGRI and even investment support is related to transaction costs. Farmers, as well as governments at European, national and regional levels, are confronted with administrative costs. It is always cheaper to distribute money with a fixed amount per hectare (even when the cross-compliance and greening measures lead to complaints about paperwork and control procedures), but that is no excuse to make innovation support burdensome. Some of these problems are the result of gold plating (adding extra complications at national or regional level), but it also seems to be a characteristic of the CAP: "It appears that a self-sustaining mechanism has arisen within the EAFRD, where interpretation issues are resolved with detailed guidelines. These guidelines give rise to new issues, which lead to new guidelines. This cycle exacerbates the complexity of the system. That complexity in turn leads to discrepancies in interpretation of the EU legislation between the Member States and the European Commission, ending up with support recovery and thereby lack of legal certainty of support for the beneficiaries" (Schoneveld et al., 2017).

We suggest a number of options to tackle this problem of administrative burden and transaction costs. The first is to harmonise the CAP/EAFRD procedures with those in, for instance, the European Regional Development Fund (ERDF), the financing instrument of the European Cohesion Policy, as well as with other EU funds (policy coherence). This gives Member States and regions more responsibility by means of decentralised policy programming, implementation and control. The operational programmes of the ERDF restrict themselves to thematic objectives, priority axes and investment priorities. They are strategic and do not contain information on measures. The two systems have a different management and control system; ERDF is more a single-audit system and not a multi-level audit as in the case of the EAFRD (Schoneveld et al., 2017).

Simplification of the CAP's delivery philosophy is needed here, and it seems that the European Commission has recognised this point in the recent Communication on "The Future of Food and Farming" (2017). The proposals for a new CAP delivery model, with increased subsidiarity to Member States or regions, can reduce transaction costs for the EU, but not necessarily for the Member States or the farmers.

Subsidiarity suggests that regions create their own smart specialisation strategy and that they could receive co-financing from the European Union from several policies, to the extent that they target certain objectives (e.g., small amounts for improving competitiveness given the income level of the region, more for environmental and social objectives, and most for environmental objectives like the mitigation of GHG emissions where the whole Union benefits). This plan should not be influenced by differences in the management philosophy or control system of the different policies. The Berenschot report (Schoneveld et al., 2017) also suggests opportunities for simplification in the current system: risk-based controls (where larger projects and those with a higher risk of fraud are more often inspected than smaller projects), trusted management, single information - single audit principle and accelerated resolution of interpretation disputes.

A second option for reducing transaction costs is to create larger programmes that contain many operational groups on a certain topic. Thematic networks already aim at connecting projects, activities and actors with similar interests to exchange knowledge on specific topics. If a regional authority (such as a water authority), a farmers' organisation, a farm advisory service, a cooperative or an innovation hub had a strategy for smart specialisation, or for tackling a certain

environmental or social challenge, it could set up an innovation programme with many operational groups, and access to other innovation instruments such as extension or investment support. The idea is that the government authorities then only have to evaluate and audit that programme, auditing could be more risk- and sample-based, and organisational costs would be lower if the programme were linked to the normal work of the organisation. This last point is essential. Otherwise, there is only a shift from public transaction costs to private transaction costs without cost gain. As farmers have lower opportunity costs (e.g., in winter time) and more local know-how in control (fewer agency problems), the idea of collective undertakings (such as those introduced in managing AECMs) seems to make sense. Such programmes would be comparable to large research projects in Horizon 2020 like, for example, the "Internet of Food and Farming" project (IoF2020), which manages 30 million euros and runs many trials with farmers and small and medium enterprises. The evaluation of these proposals could take into account the question of whether the interests of farmers are still central in the programme, for example, by using farmers as evaluators. An additional advantage is that these programmes are easier to communicate to the public (see below), and across borders. That links in with network formation and knowledge diffusion in an innovation system (function 3). As at least part of their innovation is perhaps more tuned to incremental innovation and replicating results from successful groups, this type of organisation in a region should not block the option for OGs with easier access (see above).

> CREATE MARKETS

An important function of an innovation system is to be able to create markets. Our analysis in Chapter 6 concluded that in that respect, there are important weaknesses in the CAP. Governmental intervention in innovation is legitimised by innovation areas that have a public good character (see Chapter 2). That only makes sense if markets for the innovated goods and services are created and strengthened. Otherwise, scaling-up innovations (in a food system that can be hostile to such innovations) will fail. Our first recommendation here would be to increase CAP support for products of diversification in agricultural systems that have a better environmental performance. In addition, other support mechanisms could be used (e.g. tax breaks, minimal consumption rates, coupled direct payments, etc.), and competing polluting production systems could be subsidised or taxed less. Our second recommendation is to create markets for environmental services. Firstly, the CAP budget could be significantly shifted from direct payments as such to payments for agri-environmental payments. To really change farm behaviour and investments, these probably need to be long-term commitments, as in the conservation programmes in the United States. Other industries (e.g. infrastructure building and maintenance, or the defence industry) are also used to the government being the main buyer, so governments can act here as a reliable market partner. The CAP could design its instruments in such a way that it tops up agri-environmental contracts from, e.g., cities, regions, water authorities and nature conservation areas, all of which have an interest in influencing the behaviour of surrounding farmers.

> DESIGN FOR SOCIETAL IMPACT AND DEVELOP REFLEXIVE MONITORING

In the current CAP, it is up to the national or regional authorities to decide which topics are eligible for the innovation instruments. This has advantages: bottom-up needs and ideas are central; it provides flexibility and is in line with subsidiarity. However, there are two main disadvantages: the innovations are not necessarily in line with societal needs and even if they are, it is hard to communicate to the taxpayer why this money is spent. We therefore suggest that three axes are chosen for the large programmes that we advocated in the previous point, these are: i) climate change and resource efficiency / environmental issues at farm level, ii) collaboration on innovation in the food chain, and iii) territorial innovation. This assumes that our first suggestions (larger budget and better access for farmers in small operational groups with disruptive ideas) are also implemented.

Asking countries and regions to promote these three axes in their strategic plan, and especially the one on the food chain, is a result of our suggestions in previous chapters that a food system approach is necessary to improve the transformative capacity of the system. Such a choice also strengthens three of the functions of an innovation system: guidance of search (function 4), market formation (function 5), and support from advocacy coalitions (function 7). Such a three-pronged approach will also help with the full mapping of innovation activities undertaken in the different regions (within or outside the EIP-AGRI). This is in line with our finding on knowledge exchange (function 2) that diffusion of innovation outside OGs is underdeveloped.

The design for societal impact in a food system that lacks transformative capacity underpins the need to provide farmers with independent advice from an advisory service. There is a difference between the sales of chemicals and related advice on their application and agricultural advice on sustainability issues. As a farmer recently told us: "I receive many glossy brochures on how to renew my grassland with the latest varieties and machines, but nobody tells me how to maintain it as permanent grassland". That is not to say that independent advice on sustainability issues in the public interest are taken up by farmers who are profit-oriented. If such actions do not contribute to income, adoption by farmers will be low. Given the fact that in most Member States public extension has now been supplemented with (or replaced by) private consultants, there is no need to have public advice about sustainable farming delivered by a public service. The delivery can be outsourced to private consultants, as long as they are independent from sales of inputs. It is essential that advisors work efficiently and that their knowledge is up-to-date. Certification could be a solution.

With these three axes, it could also be easier to organise monitoring whether the money for innovation is well spent. Such monitoring should be reflexive, which means a participative process of gaining an insight into the progress of the innovation programme, its intended and unintended effects on the food system, in relation to and interaction with the environment and including the structural and regime aspects to translate the findings back into the design of the programme. This is in order to preserve the ambitions for system innovation [23]. It helps the guidance of search (function 4). Such monitoring and evaluation is needed because interim and ex-post evaluations of new CAP instruments, like greening or the EIPR-AGRI, are scarce. Monitoring of innovation in the Farm Accountancy Data Network (FADN) has been proposed (Van Galen and Poppe, 2013), but still has to be installed. As a result, there is also no insight into the number of farmers who are are credit-constrained in their innovation and would really benefit from CAP support in this regard.

> EU-LEVEL AKIS DEVELOPMENT

In line with the previous suggestion, there is a need to strengthen the value added of organising innovation. The CAP is not the main policy instrument to organise the research and innovation system. Member States and private companies in the whole food chain supply most of the investment in research and innovation. Nevertheless, there are several reasons why the CAP should be involved in farm level innovation, connect farmers and advisory services, connect across borders and connect farmers to research and development institutions (see also Chapter 5). In climate change, there is a sharing of efforts and any progress in one MS is beneficial for others. Food chains are international, with multinational food processors and retailers, and intensive internal EU trade. Europe also has a large research and innovation programme (currently Horizon 2020, to be followed up by Food 2030 in FP9) that should have close links with agricultural and agri-environmental policies if it is to be effective. Especially on the aspect of territorial innovation, there is a need to link the more remote regions to the centres of innovation. Regions that have a large food industry are often a locus of innovation, with a well-developed AKIS, including the education system and interactions between company research labs and the universities. If we speed up innovation, this improves their competitive advantage and could marginalise more remote regions. Therefore, the CAP should link those regions to the centres. This includes good high tech, as digitalisation could play an import role in knowledge exchange and diffusion (broadband connections, as in the EU action for Smart Villages [24]), but also further professionalisation of the AKIS. This encompasses diverse issues such as training advisors with new technologies that monitor farm processes on a real-time basis, and better collaboration between different organisations in the AKIS - a well-known efficiency problem in some Central and East European Countries. An Erasmus program for farmers and collaboration with the professional journals on cross-border communication could be a creative solution. Strengthening the EIP-AGRI network is essential (Coffey et al., 2016). The fact that many of the centres of innovation are in the old MSs, and that regions in Eastern Europe have become producers of basic commodities as they have lost a large part of their food industry, adds a political dimension to this need. As some of the clusters in innovation centres also have negative externalities (pollution, traffic) and can move to higher value products and exports of innovative machinery and other inputs, it could also be in their interest to intensify this collaboration between centres and more remote regions.

Further development of national and regional AKISs is required to distribute knowledge in and between different regions outside current and future OGs. This is recognised by the EC and several networking initiatives and activities are currently on the agenda to promote the diffusion of knowledge outside OGs and from one region to another. In this respect, efficient national or regional AKISs are crucial. The CAP has a role to play to ensure that each MS is quickly equipped with a well-functioning AKIS.

> A FOOD SYSTEM APPROACH IS NEEDED

Given the challenges we face (see Chapter 2), the need for innovation in the food system (and even in the wider bioeconomy) is high, as we have argued throughout this report. There are opportunities in several innovation areas (see Chapter 3), but the transformative capacity of the food system for systemic change is too low. Studies and high-level policy recommendations (Agricultural Markets Taskforce, 2016) suggest that powerful actors in the food chain such as retailers, food processors and input providers compete strongly, but do not yet take enough responsibility to internalise the sustainability aspects with the smaller and more numerous actors such as farmers and consumers. Some of these powerful actors have taken responsibility by setting up sustainability schemes, sometimes built into food safety schemes, to make their sourcing more responsible. Others incentivise farmers by making sustainabiliy part of their buying contracts, or switching to organic farming. Nevertheless much more should be done.

This situation underpins the need for government action with an innovation system that performs all seven functions of innovation systems defined by Hekkert et al. (see Chapter 4). The CAP fulfils many of these functions (Chapter 5). Our analysis (Chapter 6) suggests strengthening some of them.

However, the CAP is still oriented towards farmers (with some minor exceptions like the Leader programme), and

23 Definition taken and shortened from: https://transitiepraktijk.nl/en/programma/monitoring/what-is-reflexive-monitoring

24 https://enrd.ec.europa.eu/news-events/news/eu-action-smart-villages_en

many farmers continue to see the CAP budget as "money for farmers". Transforming the food system into a desired future state requires that all actors (including consumers) take responsibility themselves for sustainable food production, and that includes responsible innovation to address new challenges. The risk is that food chain actors will continue to work as they do at present, leaving it to the government to subsidise farmers' low incomes and to try and solve the environmental issues by government-led innovation.

For the moment, the CAP is most likely to stay oriented towards agriculture, leaving the rest of the food chain to other policies. However, this should not block further innovation along the food chain within the framework of the CAP. Farmers can be incentivised by the (budget of the) CAP, others can probably be mobilised in another way, like sustainability programmes for food processors and retailers or food policies for cities.

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