European Commission

Towards a long-term strategy for European agricultural research and innovation by 2020 and beyond

Background paper

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The purpose of the present background paper is to offer some first "food for thought" for the workshop

Agriculture and Rural Development

CONTENTS

1. INTRODUCTION: SUPPORTING PATHWAYS TOWARDS RESILIENT AND SUSTAINABLE FARMING SYSTEMS

1.1. WHY A LONG-TERM STRATEGY?

1.2. CHALLENGES AHEAD – CALLING FOR SMART SOLUTIONS

1.3. SCOPE OF THE RESEARCH STRATEGY

1.4. BUILDING A LONG-TERM STRATEGY FOR EUROPEAN AGRICULTURAL RESEARCH AND INNOVATION

2. CORE PRIORITY AREAS

2.1. RESOURCE EFFICIENT PRODUCTION SYSTEMS IN A CHANGING CLIMATE

2.2. ECOLOGICAL APPROACHES AT FARM AND LANDSCAPE LEVELS

2.3. HEALTHY PLANTS AND ANIMALS

2.4. NEW OPENINGS FOR RURAL GROWTH

2.5. DEVELOPING THE HUMAN AND SOCIAL CAPITAL IN RURAL AREAS

3. CROSS CUTTING ISSUES

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1. INTRODUCTION: SUPPORTING PATHWAYS TOWARDS RESILIENT AND SUSTAINABLE FARMING SYSTEMS

1.1 WHY A LONG-TERM STRATEGY?

The commodity price surge of 2007/2008 and long-term agricultural projections by the FAO have brought the issue of food and nutrition security back to the agenda of policy makers and societies at large. This has triggered adjustments in various policy areas, including in agricultural policies and research. At the EU level, budget devoted to research in the primary sector, food and bio-based industries has been significantly increased under the Framework Programme for Research and Innovation Horizon 2020[1]. With the increase of resources, calls have been made for a more long-term and strategic approach towards research and innovation, given the nature of the societal challenges to be tackled. Embedding research and innovation activities in a long-term strategy will improve their consistency, sequencing and impact.

The present document is meant to kick-off a process of reflections and exchanges on long-term agricultural research needs. The outcome of this process – an operational research agenda – is aimed at shaping major funding programmes for agricultural research at European level and possibly beyond. It will complement existing research orientations (for instance from European Technology Platforms) by looking at research and innovation needs from a longer time perspective and identifying guiding principles for research across wider areas (e.g. crops, animals production, rural development, private and public good delivery).

1.2 CHALLENGES AHEAD - CALLING FOR SMART SOLUTIONS

Demand for agricultural production worldwide will be increasing in the next few decades owing to global population growth, changes in consumption patterns as well as growing demands for new non-food uses (bio-energy, bio-products). Agricultural land resources are finite and productivity gains for major agricultural commodities, which were achieved in the past decades, are slowing down partly due to lower investments in research or the adverse impact of climate change. Natural resources, such as soils and water, that underpin agricultural production, face strong pressures due to inappropriate practices and overuse[2] . We briefly discuss below the main challenges that EU agriculture will face in the coming decades, several of which extend beyond Europe's case.

1 The Societal Challenge "Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy" has been granted a budget of €3.85 bio (Regulation (EU) 1291/2013 establishing the Framework Programme for Research and Innovation) whereas activities in the area of Food, Agriculture and Fisheries and Biotechnologies benefited from €1.94 bio under FP 7 (Decision 1982/2006/EC concerning the 7th Framework Programme).

2 Several publications of the European Environment Agency have shown the extent of biodiversity losses in EU agro-ecosystems or of soil degradation (State and Outlook of the European Environment). Water resources are also under increasing pressure. For instance projects show that the number of river basins under water scarcity is expected to increase by up to 50% by 2030 (Communication from the Commission to the European Parliament and the Council "Report on the Review of the European Water Scarcity and Droughts Policy" (COM(2012) 672 final)

The capacity of agricultural (and food) systems in Europe and globally to respond to the challenge of sustainability will at least partly depend on the generation of the necessary knowledge and its mobilisation into improved approaches and practices. By deploying appropriate technologies and management tools and properly using ecosystem services, agriculture has the capacity to meet societal demands for **private and public goods.**

Increased scarcity of resources, such as water, will trigger a fundamental rethinking of strategies for resource uses. Our agricultural systems have developed in the past decades on the basis of a simplification of natural processes. We will need to shift our approach towards taking advantage of the complexity of nature. A deeper understanding of agro-ecological principles is indeed changing our views into the functioning of agricultural systems and will potentially allow us to take advantage of ecosystem services for the benefit of sustainable production. While advances in agriculture have often resulted from innovations on single components (such as breeding, chemical inputs, irrigation technologies), future solutions are expected to arise from the **optimisation of systems**, i.e. the optimisation of the interplay between their components. Moreover, innovations are expected to capitalise on the specificities of local conditions and provide tailor-made solutions rather than solutions with broad applications.

Agriculture accounts for about 10% of the Union's **greenhouse gas (GHG) emissions** but it emits more than half of the non-CO2 gases. As an overriding objective of the EU, the agriculture sector will also have to contribute to the reduction of GHG emissions. In addition, agriculture is increasingly affected by threats and shocks which are mostly attributed to climate change (for instance a higher occurrence of extreme weather events) and by other drivers such as plant and animal diseases, as well as a broad range of economic and policy factors (e.g. globalisation, household purchasing power, functioning of the food supply chain, access to credit, etc.). Fostering the **resilience of farming systems** is therefore a necessity.

A particular challenge is to attain the aforementioned objectives while ensuring continued economic and social sustainability of the sector. Farmers have to meet the demands of consumers and deliver nutritious quality products in an economically sustainable manner within a food system which is characterised by concentration trends and ever increasing competition on the global markets.

As such, it is pertinent that EU agriculture answers to the needs of the consumers in terms of (chiefly) primary production and the provision of public goods, while ensuring that **sufficient income** is generated to allow for the viability of farmers and other actors along the food supply chain. Beyond incomes, on-farm working conditions are evolving constantly and **social conditions** of the farming activity deserve sufficient attention.

One cannot forget the **territorial dimension** of agricultural and related upstream and downstream activities. Rural areas are endowed with various types of assets and capacities which they need to mobilise properly so as to foster growth and reduce the gaps between rural regions and between rural areas and urban and intermediate areas. The

Europe 2020 strategy calls for smart, sustainable and inclusive growth. This may be more difficult to achieve in some rural areas for reasons of lack or declining economic activities, negative demographic trends, geographic isolation or unbalanced interactions with urban areas. Despite sustained growth in rural areas, there is indeed a persistent gap with urban and intermediate areas: in terms of GDP per capita predominantly rural regions stand at 70% of the EU average in 2010[3].

Research is necessary to deal with the challenges previously mentioned, yet it is only part of the story. It is of utmost importance that relevant knowledge - from tacit knowledge to new discovery - is mobilised, appropriated and implemented by the society. This is why **fostering innovation** is so important to be able to cope with the challenges that are ahead of us. This obviously goes far beyond merely paying attention to technological innovations. All dimensions of innovation indeed need to be mobilised. To achieve this, the whole knowledge and innovation system needs to be geared towards **fostering knowledge exchange between empowered actors**. This is the **interactive innovation model** which is implemented in the **European Innovation Partnership** (EIP) "Agricultural productivity and sustainability" (EIP-AGRI). Synergies are expected between Horizon 2020 and the Common Agricultural Policy (CAP) through the implementation of the EIP-AGRI.

In a nutshell, EU agricultural research and innovation will support **transition pathways** towards resilient **and sustainable farming systems** combining the goals of ensuring productivity while taking into account all dimensions of sustainability (environmental, economic and social).

1.3 SCOPE OF THE RESEARCH STRATEGY

The boundaries of the long-term strategy for EU agricultural research and innovation need to be clearly outlined. The present document does not cover the whole Societal Challenge "Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy" of Horizon 2020 (so-called Challenge 2). It focuses on the **primary sector**, yet establishes relevant links to the food chain, the bio-based economy and rural development. It should also be viewed as contributing to the development of a **sustainable bioeconomy in Europe**[4].

Research is by nature a long-term effort. Although implemented in the context of Horizon 2020, this strategy aims at extending beyond 2020 and providing a certain level of stability in terms of priorities to research efforts in a long-term perspective.

3 Eurostat data, elaboration DG AGRI. Available at: http://ec.europa.eu/agriculture/statistics/rural-development/2013/full-text_en.pdf

4 Communication from the Commission to the European Parliament and the Council "Innovating for Sustainable Growth: A Bioeconomy for Europe" (COM(2012) 60 final)

1.4 BUILDING A LONG-TERM STRATEGY FOR EUROPEAN AGRICULTURAL RESEARCH AND INNOVATION

The text box below provides a tentative list of questions as a basis for discussion. The workshop of 19 June 2015 will concentrate primarily on the first two blocks: the structure of the strategy and the technical content. Participants are also welcome to raise other questions for debate at the workshop.

Questions for discussion

How to structure the strategy?
Is the proposed organisation based on five main building blocks relevant and useful to structure our approach for a long-term strategy or would you suggest another approach?

What should research activities concentrate on?
- For each priority:

- Do you consider that the most important aspects are properly highlighted? What would you grant more attention or less attention?
- What is the underpinning knowledge that is needed to tackle the long-term challen ges facing agriculture and rural areas?
- What are the core research questions which should be addressed?
- Where do we need more basic research and where do we need more applied rese arch? How to balance our investments here?
- In which cases should we work at which scale: organisms, farms, farming systems, regions, Europe, global?

- Across priorities:

- Are there needs for system's driven innovations (i.e. going beyond advances on single components)? Which kind of research is needed to create added value from bringing together different disciplines, tools and approaches? Which areas lend themselves particularly well to demonstrate the benefits of system-wide approaches?

Approaches and instruments

- What role do you see for the different actors in delivering knowledge and exploiting it at best: scientists, businesses (farmers, SMEs, cooperatives, industry, retail, etc.), advisors, innovation support services, citizens, consumers? How to improve the multi-actor approach or public engagement?
- How can we foster complementarity and synergies with research and innovation activities implemented at Member State level?
- What role for research infrastructures and other research capacities? How to develop them?
- What do you consider should be the roles of public and private research and the appropriate balance between publicly funded initiatives, public-private partnerships and purely private research? How to leverage private money for agricultural research?
- How much should be invested in international cooperation, in which areas and why?

Five main building blocks have been identified, at this stage, to support pathways towards resilient and sustainable farming systems and rural economies. These five blocks are completed by a cross-cutting issues section:

A - Resource efficient production systems in a changing climate

B - Ecological approaches at farm and landscape level

C - Healthy plants and animals

D - New openings for rural growth

E - Developing the human and social capital in rural areas

The five core areas are not meant to be separate blocks but in fact reflect the interconnections between challenges and solutions. For example, some of the research orientations proposed under animal and plant health will contribute to resource efficiency. In the same vein, research activities on ecological approaches, which optimize ecosystem services in agricultural practices to save on external inputs, will also contribute to resource efficiency.

The last core priority on human and social capital in rural areas should be viewed both as a research object on its own and as a means to facilitate innovation. Hence, an important part of the activities in this priority area are meant to provide support to the implementation of the interactive-innovation approach of the EIP-AGRI implemented in both Horizon 2020 (with e.g. the multi-actor approach or thematic networks) and the CAP. In particular, networking activities implemented in this priority area will contribute to the other four core priorities.

2. CORE PRIORITIY AREAS

2.1 RESOURCE EFFICIENT PRODUCTION SYSTEMS IN A CHANGING CLIMATE

Activities in the primary sector depend heavily on the availability and quality of natural, mostly non-renewable resources such as land, water, nutrients and biodiversity. At the same time the primary sector impacts directly and indirectly on the integrity of these resources and contributes significantly to their depletion.

European agriculture has developed largely on the basis of high levels of natural and chemical resource inputs (e.g. water, fertilisers, pesticides, energy) thereby significantly raising yields and productivity of plants and animals. But productivity increases have often come at significant environmental costs. It is argued that systems of food production have reached or are exceeding environmental limits[5] and there are concerns about future availability, accessibility and distribution of natural resources. Water for example is becoming scarce in some regions of the EU partly as a result of high water abstraction by agriculture and by more extreme whether events. Agricultural soils are also threatened by inappropriate management leading to erosion, loss of organic matter and nutrients. Biodiversity in agro-ecosystems are under considerable pressure through both intensified farming and land abandonment.

It is increasingly recognised that a sound resource management holds the key to long-term productivity of the agricultural sector as well as to the reduction of negative externalities. In this vein, the Commission Communication on a Roadmap to a Resource Efficient Europe[6] highlights the opportunities arising from smarter ways in which to use and value resources.

Moves to support "resource smart" growth of the sector are supported by increasing knowledge on the functioning of agro-ecosystems as well as by a host of biological, technological and management options. Expectations are high for example that the use of ICT and precision faming (including irrigation systems) will result in a significant reduction of resource inputs while at the same time increasing the precision and effectiveness of farm operations. Similarly, a better use of ecosystem services in farm practices – e.g. to benefit pollination, soil fertility and pest control - is expected to strengthen the resilience of farming systems and stabilise production.

A research agenda to tackle resource use is complex as it needs to consider availability and quality of the physical and biological resources (the natural capital), the use of chemical inputs and the interactions between climate, agriculture and the natural capital.

Modern agriculture has developed on the basis of a decreasing pool of **genetic resources**, leading to increased genetic vulnerability or even to genetic erosion for some species. Diversity at various levels is seen as crucial to help buffer agricultural systems from environmental pressure. Significant efforts are required to improve preservation and use of genetic resources in breeding and farming as well as to embed diversity considerations into day-to-day farming practices. These efforts would have to cater for a large array of purposes and would require increasing investments in crops

5 See e.g. report of the EC Standing Committee on Agricultural Research (SCAR), "Sustainable food consumption and production in a resource-constrained world", 2011, available at: http://ec.europa.eu/research/agriculture/scar/pdf/scar_feg3_final_report_01_02_2011.pdf

6 COM(2011) 571

and animals that have been neglected in the last decades (so-called minor crops and breeds).

Climate change is already having an impact on European agriculture, for instance by increasing the occurrence of extreme weather events (such as the heat wave of 2003) and the increasing incidence of pests and diseases. The capacity of EU agriculture to deliver food and public goods is directly dependent on climatic conditions. European farmers will have to define their strategies for production, management and investment in a context of increasing uncertainty. Considerable efforts are necessary to better understand the medium- to long-term impacts of climate change and to strengthen the adaptive capacity and resilience of farming. Research is also necessary to unfold the capacity of the sector to mitigate GHG emissions without undermining its productive potential and overall competitiveness. Research on the impacts of climate change on agriculture is well under way, yet considerable work appears still necessary at various temporal and spatial scales. The latter would require to link European research and research outside Europe.

Understanding the effects of climate change on agriculture and forestry is far from trivial. Increases in temperature and carbon dioxide (CO2) can be beneficial for some crops in some places - provided that other conditions such as nutrient levels, soil moisture, water availability are met. But more extreme temperature and weather events are more likely to harm crops and livestock, reduce yields and increase the prevalence of parasites and diseases. Effective **adaptation** solutions need to be developed to anticipate and cope with these increased biotic and abiotic pressures. There is no silver bullet to cope with this and it appears necessary to strive for all kinds of solutions, 'grey' (technological and engineering), 'green' (ecosystem-based) and 'soft' (related to management) and to foster their implementation with a conducive policy framework.

Besides contributing to and being affected by climatic changes, agriculture and forestry can play a key role in providing solutions for **mitigation** in particular by sequestering carbon and reducing net GHG emissions. Overall, understanding the positive and negative feedback loops whereby climate change affects agriculture as well as natural resources and agricultural practices in turn affect climate change and the status of resource inputs is key to bringing about **mitigation and adaptation solutions** and ultimately ensure long-term productivity of the sector.

2.2 ECOLOGICAL APPROACHES AT FARM AND LANDSCAPE LEVELS

Ecological (or eco-functional) intensification consists in agricultural practices and systems which **optimise the use of ecosystem services** to produce while saving on fossil resources, reducing mineral fertilizer and pesticide use and water and minimising threats to habitats and biodiversity. This approach considers production systems holistically and in their diversity and implies the involvement of various research areas in a multidisciplinary manner. It thus goes beyond looking for technologies that allow saving on inputs (such as precision agriculture). Yet, for obvious reasons, this priority will overlap with priority A "Resource efficient production systems in a changing climate" and C "Healthy plants and livestock".

Biodiversity and various ecosystems provide many different services to agricultural production, not all of which are properly known. This includes pollination, biological pest control, maintenance of soil structure and fertility, nutrient cycling and hydrological services.

Using these services in a smart way enables agriculture to become more sustainable and allows for reduction of external inputs. To develop agricultural systems maximising services from ecosystems, a knowledge leap is necessary which can be supported by various scientific areas, from developing farming practices to modern technologies such as bioinformatics and high throughput genomics. It would be in particular important to explore the functional role of biodiversity in the delivery of ecosystem services. This would include the interactions between plants/animals and other organisms and natural enemies of pests and diseases, pollination, plant cleaning of contaminated soils, etc. (through e.g. ecological chemistry).

Research appears necessary in a large range of fields to enable agriculture to optimise the services provided by ecosystems, ranging from adapted plant varieties and animal breeds, the understanding of the complex web of interactions within ecosystems, work on integrated pest management and the development of agro-ecology systems, involving both crop and animal sectors (in particular ruminants), and tested and developed at various scales, from the plot, to the farm and to the territory.

Several low-input farming systems have developed in Europe which have their own research needs to be catered for. This concerns, in particular, the organic sector, which is not only the largest one, but which is subject to a specific regulatory framework and to an action plan which calls for strengthened research[7]. It is worth noting that research developed in these specific approaches has a potential of spinning out to other systems.

Ecological approaches are **knowledge intensive** and rest on the integration of formal and tacit (traditional, local) knowledge. Tacit knowledge, which is site-specific and evolving, constitutes an extensive realm of accumulated practical knowledge and knowledge-generating capacity that is considered necessary to achieve sustainability.

7 Council Regulation 834/2007 on organic production and labelling of organic products (OJ L 189, 20.7.2007, p. 1). Communication from the Commission to the Council and the European Parliament "Action Plan for the future of Organic Production in the European Union" (COM(2014) 179 final).

2.3 HEALTHY PLANTS AND ANIMALS

Crop and animal production are under mounting pressure due to the increasing number and frequency of new and re-emerging pests and pathogens as a consequence of globalisation, trade development and climate change which increase their potential for establishment and spread. This has significant impacts on agricultural sustainability as it entails production losses, reduced efficiency, trade disruption, impacts on public health (e.g. residues, zoonoses) and, as far as animals are concerned, on animal welfare. European agriculture needs to be granted sufficient means to cope with this threat to ensure food security and feed supply and a smooth functioning of the single EU market and ensure consumer confidence in food by mitigating potential risks to plant, animal and human health (including food-borne zoonoses). This extends largely beyond fighting against pests and diseases to developing appropriate practices that prevent their occurrence.

Reducing the uses of pesticides in the crop sector and **antimicrobials** in the animal sector is commanded by human health (problems of pesticide residues, antimicrobial resistance), animal health (antibiotic resistance), environmental considerations (e.g. biodiversity, wild pollinators) and long-term sustainability of the sector. In the crop sector, implementation of Regulation (EC) 1107/2009[8] results in the reduction of the available active substances which requires alternatives to be found. The slowdown of the development of new antimicrobials for human health constrains the availability and use of antimicrobials for animals, in particular critical molecules. Ambitious research would be necessary to provide producers with alternative approaches allowing a reduced use of pesticides and antimicrobials and to support the implementation of the Sustainable Use of Pesticides Directive (SUD), including integrated pest management (IPM)[9] and the Action Plan against rising threats from Antimicrobial Resistance[10].

This research would be all the more necessary in small sectors, which have been rather neglected by public and private research: this concerns in particular the so-called minor crops as well as marginal animal sectors (such as beekeeping, small ruminants).

In the **crop sector**, activities should provide fundamental insight into the biology of pathogenicity and resistance as well as develop breeding, agronomic tools and products and vaccines to increase the robustness of crops and minimize losses. Particular attention would need to be granted to integrated pest management approaches and the development of more sustainable alternatives to current pesticides. Activities could support the European Plant Health Regime and plant protection services through the development and improvement of tools and strategies, along with optimized information services on the dynamics and effects of pests and diseases both in Europe and worldwide.

Regarding **animals**, health can be interpreted rather broadly, addressing all aspects related in particular to prevention, surveillance, diagnosis and control mainly of infectious diseases, whether mono or multifactorial (multistressors), whether epidemics or production related, whether exotic or present in Europe, whether restricted to livestock or transmissible to human beings (zonoses, anti-microbial resistance).

8 Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the plac ing of plant protection products on the market (OJ L309 24/11/2009 p.1)

9 Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (OJ L 309 24/11/2009 p.71).

10 Communication from the Commission to the European Parliament and the Council “Action Plan against threats from Antimicrobial Resistance” (COM(2011) 748)

Activities could be developed in three main areas: animal diseases, zoonoses / one-health and welfare. The main objectives would be to understand the factors underpinning animal health and welfare; to improve the management of animal diseases to reduce losses, increase efficiency, reduce trade disturbances and improve competitiveness and sustainability; to improve the management of animal diseases to protect public health and avoid food scares; and to improve the management of animal diseases to support animal welfare. A continuous effort could be devoted to major diseases threatening Europe or causing important losses and on epidemiology for more cost-effective surveillance and control. Deciphering interactions between hosts, environment / vectors and pathogens can be a key to improved / innovative control, including the development of new treatments (e.g. vaccines, immune modulation). Further refinement of diagnostic tools, with reliable, fast and convenient tests is a continuous challenge. Enabling research to improve the understanding of biological mechanisms (immunity, microbiome, connection between genotype and phenotype, system biology) would provide the basis of potential further progress and innovation. Integrated management of animal health and welfare would also be addressed. One-health[11] approach could be developed, in particular regarding neglected or emerging zoonoses or anti-microbial resistance. Integrated management of animal health and welfare would also be addressed.

Coordinated research at the global level is slowly improving on animal health, yet it is highly necessary in the context of permanent health risks, transnational aspects and scarce resources. Hence, fostering increased coordinated efforts for optimal leveraging should be pursued.

2.4 NEW OPENINGS FOR RURAL GROWTH

Rural areas across the EU have undergone profound changes in the last few decades. The most pervasive are probably the sectoral shift and the decline of the relative importance of agriculture in the rural economies of Europe, driven largely by productivity increases across the sector. The tertiary sector appears to be one of the main drivers of economic growth in rural areas even though the food industry still plays an important role. New activities have developed, including tourism, small scale and niche manufacturing and food production and business services. ICT development brings solutions to remoteness and opens new business opportunities. Yet, rural areas face a series of challenges, among them demographic changes, exemplified by ageing and a declining share of the active population. Other challenges are a lower access to services of general interest, communication infrastructures and accessibility, lower skills and business capacity and increased pressure for environmental protection. These challenges will constrain future economic growth. Research and innovation are necessary to enable rural areas to better capitalise on their assets to generate sustainable activities and elaborate innovative solutions to the above-mentioned challenges.

Rural areas supply food, timber, water and a range of other ecosystem services. Yet society's demand for products and services based on natural resources is widening and the capacity of rural areas to match it will contribute to shape their future economic growth. This concerns in particular: 1) the evolving food demand by consumers regarding various quality attributes (authenticity, healthy, local/regional supply, etc.) which can generate higher income to producers and supply consumers at affordable prices on the basis of renovated

11 One health can be defined as the collaborative effort of multiple disciplines - working locally, nationally, and globally - to attain optimal health for people, animals and the environment.

business models; 2) new sustainable biomass uses which would allow moving away from current fossil-fuel based economy and promote resource efficiency and green growth; 3) the increasing value placed by society on public goods.

A **sustainable and resilient food system,** resting on highly diverse food chains, is a prerequisite for sustainable growth in rural territories and, more generally, for food and nutrition security.

Research has a role to play in unravelling the links between the complexity of the food system and its efficiency, resilience and sustainability. Food chains operate in an increasingly complex and dynamic environment. Fostering their sustainability and resilience implies to understand their own dynamics (and of their components) and the interactions between them and with non-food chains. All dimensions of sustainability would be investigated: environmental (resource efficiency, waste reduction, climate change), economic (business approaches, incentives and behaviours, transparency and market power, competitiveness) and social (contribution to the quality of life, i.e. in terms of food availability and various dimensions of quality, working conditions). Attention should be granted to emerging approaches (such as short-supply chains, new business models) inasmuch as they may provide solutions towards increased sustainability. The role of consumers would be given due attention as it has a strong bearing on the whole food system and the manner it works. Similarly, policies shaping food chains would also be scrutinised. Crucial will be the capacity of small and medium-sized enterprises (SMEs) to benefit from and accede to research and innovation activities. They indeed represent the vast majority of the enterprises in the food sector, have a strong potential for innovation but lack own resources to implement research and innovation activities.

Agriculture and forestry have since immemorial times produced for other purposes than food, whether for energy (e.g. fire fuel) or industrial purposes (e.g. raw material for paper or textiles). However, looming prospects of fossil fuel depletion compounded with considerations of resource efficiency call for renewed attention to diverse uses of the biomass permitted by scientific and technological progress. Markets for new biobased products are projected to be very promising, thereby potentially contributing to the rural economy. However, ensuring that these new markets do not endanger environmental sustainability and food and nutrition security will be a challenge that should not be overlooked and which research and innovation will contribute to solve. Research activities would address **low-carbon short-chain delivery systems for innovative and sustainable non-food applications of the bioeconomy** (e.g. bioenergy, biochemical, biomaterials) while using a system-based approach for the provision of biomass for all uses (food/feed and industrial applications, traditional and new uses) preserving the delivery of other ecosystem services. Emphasis would be placed on integrated and diverse production systems and agronomic practices, including the

use of ecological intensification approaches, to increase the overall productivity of land for food and non-food applications. Other opportunities would be generated by uses of residues, co-products and waste on farm and along the value chains. Minimising adverse environmental impacts will be crucial and require appropriate solutions (such as the establishment of closed circuits of nutrients, including between rural and urban areas). Activities would focus on biomass production and logistical improvement to foster the emergence of new biomass supply chains for non-food applications while considering the sustainability of related land-use systems and integration / synergies with food systems. Innovation strategies developed at local/regional level would be complemented by cross-sectoral activities at a larger geographic scale. Investigations could extend to the tools, indicators and forward-looking activities which are necessary for all concerned players to implement and monitor relevant strategies, policies and legislation targeting rural areas.

The increasing value assigned by the society to environment, culture and heritage of rural territories can be a driver of their sustainable growth. This materializes already to a certain extent for public goods related to culture and heritage for instance through tourism resting on traditional landscapes. However, the situation is less favorable regarding **environmental public goods**. Delivery of the latter is widely reckoned to be insufficient or even degraded.
Agriculture and forestry are responsible for the management of most natural land in the EU and, depending on practices used, can indeed be sources of a wealth of environmental public goods or can contribute to undermine them, thereby impeding long-term sustainable growth of rural territories. Investigations would therefore address the main environmental public goods without neglecting holistic approaches. Attention would be directed to policy and socio-economic dimensions, including the development of new policy instruments and delivery mechanisms as well as necessary decision-making and monitoring tools.

Investigating the conditions for **sustainable growth in rural areas** will be one cross-cutting activity in the priority.

Economic policies supporting growth in rural areas reflect to some extent the underpinning theoretical models prevailing at the time they are implemented. Thus, along the decades, explanatory frameworks have switched from exogenous – i.e. development underpinned primarily by external factors – to endogenous growth – i.e. fostered by own endowment of resources. Current thinking acknowledges the contribution of mixed approaches which aim at mobilising own rural capital (natural, human and social) without neglecting potential support and synergies originating from outside the rural areas. In addition, policies focusing on specific sectors (e.g. support to the food industry) have given place to integrated approaches at territorial level which take account of local circumstances (so-called place-based approaches).
Attention has been placed recently on **territorial linkages** (urban-rural, rural-rural, land-sea) and their contribution to sustainable growth in concerned territories.
Various dimensions of these linkages could be investigated: the analytical framework would be clarified, governance approaches which enhance synergies between rural and urban development and between economic sectors in concerned territories would be analysed and avenues for new business developments building on these linkages would be identified.
Beyond those linkages, holistic analytical frameworks could be developed, together with the necessary analytical tools and indicators, which allow a thorough assessment of synergies and trade-offs between sectors, taking into consideration the delivery of ecosystem services, creation of jobs and added value as well as land use management. In order to properly comprehend the dynamics of development in rural territories, research activities should capture their **social underpinning** (e.g. role of networks, citizen's engagement in local decisions and policies, etc.).

Smart and mobile technologies are hailed as one of the most important recent innovations for farmers all over the world allowing access to a host of services from real time market information to crop disease identification. Beyond assisting in primary production through e.g. precision farming, **information and communication technologies** (ICT) have an immense potential to support all elements of the rural economy, from food supply chain management to new business development. Private and public goods and services would be sought from opportunities opened by the internet of things and big data approaches, fostering interoperability between systems and taking into account unresolved issues such as data ownership and user rights.

2.5 DEVELOPING THE HUMAN AND SOCIAL CAPITAL IN RURAL AREAS

The necessity to foster innovation in agriculture is a message almost universally conveyed in recent years. Agricultural activity has never taken place in a static environment. Yet, in the last decades, this environment has become more complex owing to more open economic conditions and associated opportunities and risks. While taking advantage of new market developments, agricultural production needs to be achieved in a manner which produces sufficient income, does not jeopardize natural resources and is resilient to increased risks emerging as a result of globalisation or climate change. Beyond agriculture, innovation in rural areas can play an important role in stimulating a green and socially inclusive economic growth, mitigating geographic isolation and avoiding economic and social marginalisation.

Human and social capital, i.e. skills, values and norms which underpin the capacity of actors to cooperate, are essential to successful rural innovation.

Innovation has been assigned a key role by the Commission to meet the objectives of the strategy 'Europe 2020'[12]. Horizon 2020 has been consequently aligned towards the objective of fostering innovation. European Innovation Partnerships (EIP) have been established in various areas to accelerate research, development and market deployment of innovations to tackle major societal challenges, pool expertise and resources and boost the competitiveness of EU industry. Among these, the EIP-AGRI tackles innovation in agriculture and rural areas and is implemented through both Horizon 2020 and the rural development arm of the CAP.

This call for innovation would be worthless if it would not take into account that the conditions for delivery of the (agricultural) knowledge and innovation system have fundamentally changed. The complex environment outlined above does not call for simple solutions developed across the board but for a variety of solutions adapted to a variety of contexts. Hence, the so-called linear approach, whereby solutions developed by knowledge centres were transferred and implemented uniformly by farmers via the support of advisory services and relevant policies, no longer works. Dealing with complexity indeed implies to mobilise all available knowledge sources,

12 Europe 2020 flagship initiative Innovation Union, COM(2010) 546 final

including tacit knowledge at farm and business level. The implementation of a variety of solutions to complex problems requires the involvement of all relevant actors in a process of knowledge co-creation and appropriation. Developing knowledge exchange between all concerned actors outpaces the so-called knowledge transfer of the linear model. This is what we refer to as the **interactive innovation model**.

Activities under this priority would aim at supporting sustainable growth in rural areas by fostering innovation. They would have two main dimensions. The first one would investigate the skills, human and social capital of farmers and rural dwellers which are essential to enable them to develop their activity in the above-mentioned complex environment. The second one would pay attention at the knowledge and innovation systems and aim at improving their delivery.

With the EIP-AGRI, the interactive innovation model is set in motion by a variety of measures or instruments both in the CAP (at local and regional level) and Horizon 2020 (at transnational level). Operational Groups are the cornerstone of the EIP-AGRI in the CAP and support the development of innovations by groups of relevant actors[13]. With Horizon 2020 the focus is set on the one hand on the implementation of the so-called multi-actor approach in collaborative projects, aiming at establishing a genuine process of co-creation and implementation of knowledge in agricultural practice. Participatory research is particularly important in this regard and needs to be properly rewarded. On the other hand, knowledge exchange should be facilitated by supporting transnational networks: thematic networks which investigate particular sectors or issues and networks of experimental and demonstration farms. These networks strengthen connections between concerned actors and facilitate the inventory and use of knowledge as well as the collection of tacit knowledge. They provide inspiration to the actors, stimulate peer-to-peer exchanges and strengthen long-term connections and mutual trust between rural actors.

In addition to providing the above-mentioned 'facilitating instruments', Horizon 2020 and its succeeding Framework Programme could be mobilized to provide knowledge on the functioning of the innovation and knowledge systems with the objective to improve their delivery to rural areas. This would cover all segments of the systems (science, education and training, advisory services), categories of actors (knowledge users, intermediaries and researchers), types of innovation (technological, social, organizational, etc.) and policies (CAP, science policies). Investigations would cover such aspects as: rewarding of participatory research; balance between basic and applied research and between short-term and long-term needs; capacity of the knowledge and innovation systems to deliver both necessary private and public goods; skills of farmers and rural dwellers; new roles and functions of advisors; functioning of rural networks; factors enabling cooperation and constraints to access to the innovation systems, etc.

13 See www.ec.europa.eu/eip/agriculture

3. CROSS CUTTING ISSUES

Research, in particular social sciences and humanities, plays a crucial role to underpin the design and implementation of efficient and effective **policies** which impact rural territories and food systems and which are not necessarily addressed in the five building blocks.

This concerns a range of policies, not just the CAP, and requires attention at various scales: from the individual to the society and from local to global dimensions. On the other hand, it is necessary that research investigates the conditions (policies, markets, etc.) which constrain or facilitate the implementation of research results and innovations. In particular the **socio-economic impacts** (at micro – e.g. cost-effectiveness, income, – and macro levels) of proposed solutions need to be thoroughly assessed.

Research and innovation activities funded under Societal Challenge 2 of Horizon 2020 are for an important part of applied nature, as in previous framework programmes, although basic research can also be implemented. With Horizon 2020 and the implementation of the EIP-AGRI, the weight of applied science might further increase. The European arm for basic research is the European Research Council (ERC), which is not taken into consideration in the present document. Finding the **right balance between basic and applied science**, or innovation-led science versus research-led science is not an easy task. Given current changes in the European research landscape, with often more importance being assigned to applied research in Member States as well, this is a question of high significance. Another important matter concerns possible areas of research (whether basic or applied) which may be given insufficient attention with regards to the challenges ahead. Finally, one should not overlook potential complementarities and synergies between various compartments of Horizon 2020. For instance, infrastructures have a role to play in agricultural research.

EU agriculture and food systems contribute to **food and nutrition security** (FNS) not only in the EU but also at world level. Demographic, dietary and income trends, climate change and environmental sustainability as well as domestic policies on trade and food distribution are perceived as the major drivers that shape current and future FNS. Most of these concerns have an obvious **global dimension**. Therefore, in line with the strategy for **international cooperation** in research and innovation[14], international activities are an integral part of a long-term strategy for research and innovation in agriculture. This would entail that the EU strengthens its dialogue and cooperation with key international player countries and regions (e.g. Africa, China, the Mediterranean region or Brazil) as well as with international organisations[15] and global initiatives to build critical mass and develop synergies to tackle global challenges.

International cooperation has a role to play in fostering the competitiveness of European economy and the capacity of European research and innovation system itself.

14 COM(2012)497 final

15 For instance the CGIAR, FAO, the Global Forum for Agricultural Research (GFAR), the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)

On the other hand, international cooperation can make a strong contribution to support the EU's external dimension. In particular, the role of the EU in reaching global FNS and other development goals is of paramount importance. In this context, activities related to agricultural research for development (ARD) will aim at achieving EU wider objectives regarding development and will aim at complementing and establishing synergies with other investments made by the EU in this area, taking into account lessons learned from past and ongoing cooperation. Key initiatives will focus on sustainable agricultural production and on FNS in particular in Sub-Saharan Africa and in the Mediterranean region.

Involvement of the **private sector** will be sought so as to raise the leverage of Horizon 2020 investments. However, this involvement will take due consideration to the nature of research carried out under Horizon 2020. Public and private research do not indeed necessarily aim at the same objectives. Private research aims primarily at profits whereas public research can invest in areas of a public good nature and long-term challenges, which is in particular the case of a large part of research aiming at sustainability or research with a high level of risk. Creativity from small players would need to be incentivised actively. Small and medium-sized enterprises (SMEs) should be given due attention owing to their strong needs for research and innovation and low own capacity to finance it. Finally, aspects related to the feasibility of proposed solutions need to be better mainstreamed into research and innovation activities.

Although resources allocated to agricultural research (and more generally to the bioeconomy) have increased significantly in Horizon 2020 in comparison with the previous programme for 2007-2013 (Framework Programme 7), they still amount to a fraction of Member State investments[16]. Building the **European Research Area** (ERA) is a key objective of Horizon 2020. Within this, fostering synergies between Member States and between Member States and the EU framework programme is a necessity, not just in times of public budget austerity. Relevant Joint Programming Initiatives (JPIs) such as FACCE (agriculture, food security and climate change) will be supported with a view to enhance the European integration of their programmes. The Standing Committee on Agricultural Research (SCAR) will be the natural place for discussions of aspects relevant to research and innovation policies.

16 A rough comparison can be made through GBAORD data from Eurostat. They suggest that EU investments correspond to around 8% of Member State spending. Yet one should not forget that the nature of what is compared is not exactly the same: EU investments are project investments whereas Member States data cover also running costs of their research and innovation activities. In addition, the multinational nature of Horizon 2020 activities represents often an added value to activities implemented at the national level. Finally, if one would take account of research and innovation activities financed through the Structural Funds, the share of EU-financed agricultural research may well increase to about 15% of Member State investments.

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