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HORIZON 2020 SOCIETAL CHALLENGE 2

FOOD SECURITY, SUSTAINABLE AGRICULTURE, MARINE AND MARITIME RESEARCH AND THE BIO-ECONOMY

STRATEGIC ACTION PLAN

for

2.1 SUSTAINABLE AGRICULTURE AND FORESTRY

CHALLENGES, PRIORITIES & ACTIVITIES
FOR RESEARCH AND INNOVATION IN THE PERIOD 2014-2020

WORKING PAPER

FOR DISCUSSION

DG AGRICULTURE AND RURAL DEVELOPMENT

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Outline

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INTRODUCTION

The second Societal Challenge of the Specific Programme of Horizon 2020 "Food security, sustainable agriculture, marine and maritime research and the bio-economy" comprises four main components: "sustainable agriculture and forestry", "sustainable and competitive agri-food sector for a safe and healthy diet", "unlocking the potential of aquatic resources" and "sustainable and competitive bio-based industries".

The present document provides a Strategic Action Plan for the component "sustainable agriculture and forestry". It covers the whole range of research and innovation activities to take place within the component "sustainable agriculture and forestry" of the Societal Challenge in the period 2014-2020. It will form the basis to develop a more detailed programmatic document covering the whole 2014-2020 period as well as the annual work programmes for the period 2014-2020. The document should not be confused with the Strategic Programme which is being prepared for the whole Horizon 2020. The Strategic Programme of Horizon 2020 indeed will concentrate on a limited number of focus areas to be implemented in a three-year basis.

The document endeavours to provide a comprehensive description of the responses that agricultural research can bring to the challenges facing agriculture today and in the coming years. It is built around the main challenges identified during a large consultation which took place in 2010 in the framework of the CAP towards 2020, i.e. contributing to food security with sustainable management of natural resources in a changing climatic environment and ensuring a balanced territorial development of rural areas. Ensuring food security implies research work in a broad range of areas, including the management of natural resources and climate change. This work will be carried out in synergies with the relevant parts of Horizon 2020 (most notably the Societal Challenge "Climate action, resource efficiency and raw materials"). Compatibility between policy objectives and research priorities, both built on the same challenges identified by society, is therefore ensured.

The document draws also from recent foresight work on agriculture and food[1] and reflects the high priority assigned to food security in the agenda of the international community. The document sets agricultural research in a long-term perspective. Continuity with the activities carried out in previous framework programmes, in particular the Seventh Framework Programme, will be ensured. The document exposes challenges, objectives and expected outcomes. It does not elaborate on the solutions to be developed to reach these outcomes, as this will be the role of the various actors directly involved in the research and innovation process as implemented by Horizon 2020. Working on solutions will involve the whole spectrum of research and innovation, from basic research ("basic research with a purpose") and applied research to support to innovation.

In order to tackle complex issues, research actions will often rely on the synergies between various scientific disciplines and involve several areas. Innovation, understood in a broad sense, extending well beyond the mere technological facet of it, will be implemented as a horizontal principle along all listed activities. The proposed approach will be flexible and pragmatic: as foreseen in the Horizon 2020 Regulation, research needs emerging, among

[1] Notably the third SCAR foresight exercise "Sustainable food consumption and production in a resource-constrained world" (2011)

others, from the activities of the European Innovation Partnerships will be incorporated into the priorities all along the Horizon 2020 period of implementation.

The mainstreaming of social sciences and humanities, which applies across Horizon 2020, will be reflected also in the field of research in agriculture and forestry. Socio-economic analysis will be integrated to provide insights into new business models, *ex ante* evaluation of the viability of potential innovations, facilitation of innovation, assessments of impact of climate change, environmental aspects and public goods, impacts of globalisation, coping with higher risks in agriculture, etc. Trade-offs between various approaches of farming systems and technologies will be examined in order to reveal their full consequences for the society. Finally such areas as balanced development of rural areas or analytical support to policies will mobilise significant inputs of social sciences.

The paper does not avoid overlaps in certain areas. These overlaps reflect the complexity of the problems and the interrelations between the various main objectives. As a matter of fact, research and innovation projects will often deal with several priorities / activities or areas in an integrated manner. The paper is structured around short texts summarising the main activities or areas and these areas are developed into bullet points. It should be clear for the reader that these bullet points do not represent necessarily single research/innovation actions. It is possible that some actions will involve several bullet points, from within the same area or beyond.

The paper does not cover international cooperation in research, although it is mentioned in several places where this dimension is obvious. A comprehensive approach to international cooperation will be developed separately.

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SUPPORTING PATHWAYS TOWARDS RESILIENT AND SUSTAINABLE FARMING SYSTEMS

Demand for agricultural production worldwide will be increasing in the next few decades owing to population growth and to the need to cater for new uses (bio-energy, bio-products), notably due to the depletion of fossil resources. Yet, agricultural land resources are finite and productivity gains for major agricultural commodities, which were achieved in the past decades, are slowing down for several reasons, including lower investments in research or the adverse impact of climate change.

On the other hand, natural resources, that underpin agricultural production, face strong pressure as a result of inappropriate agricultural practices in the world and in Europe. This is for instance the case of **biodiversity**: in the EU, over the last 20 years farmland birds have declined by 20-25% and grassland butterflies by 70%[2], alongside with serious threats to pollinators such as bees. **Soil degradation** is another threat: it is estimated that 45% of European soils face problems of quality, evidenced by low levels of organic matter, and almost one quarter suffer from moderate to high erosion[3]. Around 40% of agricultural land is vulnerable to nitrate pollution, threatening water resources.

At the same time, **energy prices** have increased significantly in the last years and will most likely continue to do so in the future. This will unavoidably lead to a fundamental rethinking of the strategies for direct or indirect (inputs) energy use for agricultural production.

Hence, it will be necessary to maintain or increase agricultural productivity with scarcer external resources (energy, fertilisers) and proper consideration to the natural resource base (soil, water, air, ecosystems). This will necessitate to step up the shift in the nature of the relations between agricultural activity and the ecosystems involved: from an approach where ecosystem resources are over-exploited in order to maximise agricultural production to an approach where ecosystems are viewed as the foundations of agricultural production and whose functionalities need to be preserved so as to ensure appropriate production without environmental harm. The development of agricultural systems which make a **sustainable use of the resources** involved will be a priority for European research under Horizon 2020.

Agriculture accounts for about 10% of the Union's **greenhouse gas (GHG) emissions** but it emits more than half of the non-CO_2 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 globalisation. Fostering the **resilience** of farming systems is therefore a necessity.

The above objectives need to be attained jointly with a **sustained competitiveness** of the sector. Agriculture has to be able to deliver quality products to the food supply chain and the consumers, together with other services and, at the same time, to generate **sufficient income** for the farmers and other concerned actors.

[2] European Environment Agency (2010), Assessing biodiversity in Europe, the 2010 report
[3] European Environment Agency (2010), Soil, SOER thematic assessment

In a nutshell, agricultural research in Horizon 2020 will support transition pathways towards resilient farming systems combining the goals of ensuring productivity while watching over all dimensions of sustainability (environmental, economic and social).

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STRATEGIC GOAL I. SUSTAINABLE AGRICULTURE: ENHANCING FOOD SECURITY AND THE PROVISION OF PUBLIC GOODS

The challenge

The farming activity delivers agricultural products and a variety of public goods, hence contributing to food security. Research is a key lever to ensure that the sector achieves this in a sustainable manner and in conditions that optimise the associated public goods.

Food security is understood as household's physical and economic access to sufficient, safe and nutritious food. This implies food availability in sufficient quantities and on a consistent basis. Food security is considered as one of the greatest global challenges for the coming years. Projections suggest that in 2050 agricultural production would have to increase by 60% to nourish a projected population of nine billion or more and cater for other needs. On the other hand, food losses and waste stand at an estimated level of one-third worldwide (FAO) and current malnourished and overweight populations reach both too high levels, with respectively 0.9 billion for the former (FAO) and 1.4 billion for the latter (WHO). All these figures show that ensuring food security goes well beyond addressing only agricultural production.

European agriculture and the food industry have demonstrated in the past their ability not only to provide sufficient food not only for their own population but also to compete on world markets with high quality products attracting a large number of consumers. However, this ability is challenged today by a decline in the yield growth rate of some key commodities, changing climatic conditions as well as the expected decrease of use of external inputs, in particular due to soaring energy prices. In addition, it is imperative to ensure productivity and production growth in environmentally friendly and sustainable ways, so as to maintain the natural resource base over the long term. Finally, agricultural production is also challenged by the mitigation efforts which are necessary to make the transition to a low carbon economy. Hence, food security, climate and environmental objectives need to be pursued together.

Agricultural activity is also associated with the provision of a range of ecosystem services and public goods, in particular environmental public goods which are of high societal interest (agricultural landscape, biodiversity, water quality, etc.). Fostering the linkages between agricultural activities and ecosystem services and public goods - together with improved knowledge on their monitoring and assessment (see Priority IV) - is expected to enhance the effectiveness and efficiency of the sector in its capacity to deliver them, which would in turn help ensuring its long-term viability.

Meeting the challenge: holistic solutions will have to be developed so that food security, climate and environmental objectives are pursued simultaneously. To ensure this, the successful mobilisation of a large array of research areas will be required, endeavouring to develop farming systems which are resource-efficient, diverse and competitive, which are equipped to deal with pest and diseases in a sustainable manner, which adapt to climate change and contribute to its mitigation and which optimise the delivery of public goods.

Striking the right balance between the various research disciplines which contribute to sustainable crop and livestock production will be important. It is widely acknowledged that no one single research avenue will be sufficient and that a pluralistic approach will be necessary,

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fostering synergies between genetics, agronomy, ecology, animal sciences including animal welfare, socio-economic sciences, etc. Working at different scales, in particular at plot, farm and landscape levels, will be necessary to deliver on the sustainability of production systems.

To foster synergies and facilitate the delivery of research and innovation activities at the European level, appropriate attention will be granted to information systems in relevant areas (genetic resources, pests and diseases, etc.) and to the facilitation of networks. Working on the environmental sustainability of the farming sector implies to develop adequate indicators and conduct experiments within long-term perspectives. This will be facilitated in synergy with the part of Horizon 2020 dealing with research infrastructures. Facilitating the networking of experimental farms and research stations at the European level will contribute to achieve this.

PRIORITY I.1. Green growth: resource efficient and competitive production systems along the value chain, and the provision of public goods

The overall sustainability of the agricultural sector will increasingly depend on an efficient management of the various resources it mobilises (genetic resources, plant varieties and animal breeds, soil, water, energy, labour). This implies the availability of genetic resources, the screening of their potential, their diversity and their mobilisation for crop and livestock improvement through various technologies and approaches, including through ecological intensification. To ensure an economically sustainable sector, research is necessary to foster the various quality and diversity attributes of agricultural production and the development of various marketing channels. Finally, a thorough attention to the various biomasses produced on-farm (including waste and by-products) needs to be paid so as to further both the competitiveness of the sector and its resource uses, hence contributing to its overall sustainability.

AREA I.1.1. Genetic resources and biodiversity

The Convention on Biodiversity (CBD) defines agricultural biodiversity as *"all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitutes the agro-systems. It includes the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystems levels, which are necessary to sustain key functions of the agro-system, its structure and processes".* While the CBD is directed at all biodiversity, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is the first international agreement focusing specifically on the conservation and sustainable use of plant genetic resources for food and agriculture. The Treaty recognises the contribution of farmers to the diversity of crops and establishes a global system to provide farmers, plant breeders and scientists with access to plant genetic resources.

Broadly speaking, agricultural biodiversity can be subdivided in two major categories. The first category consists of the genetic resources for food and agriculture that provides food and other agricultural products from domesticated crops and animal husbandry and their varieties including landraces, crop wild relatives, invertebrates (e.g. pollinators), fungal and microbial genetic resources. The second category comprises all those non-harvested components that contribute to, and sustain, agricultural productivity by provisioning supporting and regulating ecosystem services. The most significant organisms of this category include soil biota, pollinators and the antagonists of pest and diseases. Activities may also cover the interactions between micro-organisms and animal species (e.g. in ruminant digestion) or plant species (e.g. involvement in nutrient cycle). There is a close relationship between agriculture and

biodiversity in High Nature Farming areas, where biodiversity is dependent on the maintenance of particular forms of farm management. To support agricultural production in Europe, agricultural genetic resource diversity and variability need to be better documented, genetic resource conservation and evaluation need proper coordination and increased attention to minor crops and livestock is necessary.

Objective: preserving, enhancing and understanding the diversity of and availability for sustainable use of genetic resources is critical for the European agriculture as outlined in the EU Biodiversity Strategy to 2020[4]. This diversity has to be characterised, maintained and made available for crop and animal improvements, in particular through a comprehensive pre-breeding approach. Beyond crops and animals produced for agriculture, critical elements of biodiversity of ecosystems and its functional roles need to be better understood and characterised in terms of their biological parameters so as to promote the development of an agriculture which benefits better from the services provided by ecosystems.

Activities in the area of genetic resource conservation will contribute to the implementation of international undertakings regarding genetic resources[5].

a. Maintain, protect and expand our genetic resource base and foster the use of genetic resources for crop and breed improvements

Modern agriculture has developed in the last decades on the basis of a narrowed pool of genetic resources, leading to increased genetic vulnerability or even to genetic erosion for some species. However, challenges faced by agriculture – climatic variability, need for more sustainable / resilient production systems, increased pressure of pests and diseases, diversification of production to answer to emerging needs – call for an expansion of the genetic resource base utilised for crop and animal production. This necessitates an ambitious approach towards genetic resource identification, characterisation, evaluation and conservation relying on *ex-situ* conservation and coordinated *in-situ* conservation and involving a broad range of actors, from scientists to end-users. Appropriate policies related to the promotion of genetic diversity imply a better understanding of the economic value of this genetic diversity. The European approach on genetic diversity has to establish proper coordination and synergies with similar approaches at the international level.

Increased climatic variability and environmental sustainability necessitate renewed efforts in plant and animal breeding. Pre-breeding and genetic enhancement help to improve the link between the conservation of diverse crop genetic resources and modern breeding programmes by making available the desired traits to the potential users. Public research has an underpinning role to play in pre-breeding, in optimising the availability and exploitation of genetic resources by the concerned actors. This effort has to cater for a large array of purposes, extending well beyond mere productivity objectives and to reinvest significantly in crops and animals that have been neglected in the last decades.

[4] COM(2011) 244. The biodiversity strategy requires among others to conserve the EU's agricultural genetic variability.

[5] E.g. the second Global Plan of Action for Plant Genetic Resources for Food and Agriculture, the first Global Plan of Action for Animal Genetic Resources and the International Treaty on Plant Genetic Resources for Food and Agriculture, both under the aegis of the FAO and the Nagoya Protocol under the aegis of the Convention of Biodiversity.

Among possible activities:

- Foster the inventory characterisation, evaluation and **conservation** of genetic diversity and variability of agricultural ecosystems, wild food plants and crop-wild relatives with a view to maintain the long-term adaptability to future biotic and abiotic threats:
  - Contribute to a **long-term strategic approach for genetic resource diversity and variability conservation,** improve the coordination of related policies and foster synergies at European and global levels;
  - Ensure the **conservation** of genetic resources, including traditional crops / breeds, ancestral types and wild relatives, through *in-situ* and *ex-situ* in vivo and in vitro conservation. Improve conservation methods;
  - Assess the contribution of traditional products (based on local varieties and breeds) to the conservation of genetic resources and their diversity;
  - Foster **genotyping and phenotyping** (including epigenetic factors) of plant and animal resources, including landraces and wild relatives, and abandoned / orphan crops / animals, with the objective to improve crops and animals on a large array of traits responding to the many demands of a sustainable agri-food supply chain. This ranges from concerns at production level (abiotic and biotic stress, robustness, feed efficiency of animals, etc.) to concerns at the level of the consumer (nutritional and organoleptic qualities, etc.). The links between genetic diversity and diversified human diets will be explored. (together with the biotechnology component of Leadership in Enabling and Industrial Technologies of Horizon 2020 (LEIT and Research Infrastructures);
  - Foster the use of **information and communication technology** (ICT) in genetic resource management, especially in characterising germplasm and facilitating the introgression of desirable traits; work towards the establishment of a public database on crop pedigree data.
  - Design tools and harmonised and standardised methods for a **more effective and efficient characterisation / evaluation** for both crops and animals and decision support tools.
- **Genetic resources: a tool for breeding and improvement purposes**:
  - Contribute to a **long-term strategic approach of the EU on breeding** for crops and animals with a focus on sustainable intensification, low inputs systems, resilience, mixed cropping systems, plant and animal health, agricultural diversification and animal welfare, involving all concerned actors, including breeders and particularly farmers and other end-users;
  - Design tools and harmonised testing methods for a more efficient and appropriate characterisation of new plant varieties with regards to their resilience and suitability for agricultural systems that guarantee appropriate yields and quality with lowered input resources such as water, fertilisers and pesticides;
  - Ensure maintenance, harmonisation (interoperability) and improved access to existing **collections and databases** (curated databases); develop new databases as necessary and promote coordinated free access of data. The pertinent level of action will often go beyond Europe.
- **Improve husbandry management** and **crop techniques** for the economic sustainability of traditional crop varieties and animal breeds in agriculture. Provide the knowledge necessary to the development of approaches which evaluate and optimise the underutilised species, varieties and breeds in the supply chain, contribute to the diversification of local diets;

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- Explore the concept of **ecosystem genetics** within an agricultural / forestry system framework, develop indicators of genetic diversity / erosion / vulnerability;
- Raise the **awareness of all concerned stakeholders** on the importance of genetic resources and of their variability for a sustainable agriculture. Promote a continuous flow of knowledge and information between the various actors, notably scientists, policy makers, the breeding industry and end-users.

b. Improve the knowledge on biodiversity, its functional roles and ecosystem services for sustainable agriculture

Biodiversity and various ecosystems provide many different services to agricultural production, not all of which are properly known. 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.

Among possible activities:

- Improve **knowledge of biodiversity**: meta-genomics of above- and below-ground biodiversity; soil functions and microbiology (including through soil meta-genomics), biotic and abiotic interactions. Foster the development of curated genetic databases of relevant elements of biodiversity and facilitate access to these databases;
- Explore the **functional role of biodiversity in the delivery of ecosystem services**. In particular 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);
- Increase the understanding of factors which govern the performance of organisms to deliver ecosystem services, including agricultural management and landscape characteristics;
- Develop approaches to increase the performance of ecosystem services by targeted promotion of e.g. pollinators and predators through habitat provision and management;
- Develop integrated risk assessment methodologies to ensure the delivery of ecosystem services by wildlife in the aerial, terrestrial and aquatic environments and contribute to protection goals for species providing ecosystem services at landscape level;
- Explore the role and the value of ecosystem services for agricultural production, and how agricultural management can preserve and enhance biodiversity underpinning such services, especially in the context of climatic variability.

AREA I.1.2. Optimisation of sustainable production systems in the value chain

a. Resource efficient and productive farming

Objective: support the agricultural sector to be resource efficient so as to foster its environmental and economic sustainability.

A large part of European agriculture has developed on the basis of high levels of use of resources (fertilisers, animal feed, energy, water, soil, etc.). However, these resources are

becoming increasingly scarce and expensive, in part due to increasing energy costs, unsustainable use or insufficient recycling. Improving natural resource management is crucial for the environmental sustainability of the sector: water will become scarcer in some regions of the EU partly as a result of climate change and competition with non-agricultural uses; agricultural soils are also threatened by inappropriate management leading to erosion, loss of organic matter and nutrients. Efficient use of resources is an EU priority as outlined in the Commission Communication on a Roadmap to a Resource Efficient Europe[6].

A more efficient use of resources is not only a necessity for environmental reasons and the promotion of green growth; it is also a pre-condition for the long-term competitiveness and sustainability of the agricultural sector. A host of scientific domains and technologies have to be mobilised in a multi-disciplinary and systemic manner to this aim. Breeding, plant and animal sciences and ICT will play an important role as part of integrated approaches to improve agricultural practices and farming systems. Particular attention will be devoted to restoring soil functions and to minimise GHG emissions; the sustainable supply of vegetal and animal proteins. Regarding the livestock sector, Horizon 2020 will contribute to the implementation of the Global Agenda of Action steered by the FAO.

Among possible activities:

- Use appropriate **conventional and modern breeding approaches** (including approaches such as varietal associations, genomic selection, new plant breeding techniques, etc.) to develop low input and higher efficiency plant varieties and animal breeds. Research should pay attention to both major crops and animal breeds and to "orphan" / minor crops and breeds which have been neglected in recent years (e.g. horticultural crops, ancestral varieties of commodity crops, abandoned crop types). Research should also take account of adaptation to climate change (Priority I.3), the need for plant varieties and animal breeds that show greater tolerance of diseases and pest (Priority I.2) or factors, where relevant, such as resistance to toxicogenic fungi (mycotoxins), lower uptake of heavy metals and lower content of asparagine;
- Support the development of **integrated crop / livestock farming systems**: these systems have reduced significantly in Europe as a result of production specialisation and strong economic drivers, yet innovative mixed farming systems have potentially an important role to play in maintaining soil fertility and optimising the use of energy and nutrients and coping with climate change;
- Provide **evidence** and develop **indicators on the overall sustainability** of the different agricultural production systems / farming patterns. Assess the performance of farming practices and farming systems with reference to resource efficiency and life cycle analysis;
- Provide socio-economic evidence on business models that underpin the implementation of innovations and *ex ante* socio-economic evaluation of potential innovations;
- **Optimise production systems** and save on resource use (including labour), through the use of ICT and other technologies (precision farming, sensors, robotics, automation, etc.). Use of agro-technology for improved farm constructions and on-farm infrastructure (including machinery and stable construction in view of a better management of water, air, energy, temperature, etc.);

[6] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Region « Roadmap to a Resource Efficient Europe », COM(2011) 571 final.

- **Water management**: improve water quality and water management through irrigation technologies (including precision / drip irrigation), strategies for capture, storage and re-use of water;
- **Soil preservation and plant nutrition**: improve soil management to restore and improve fertility and enhance carbon sequestration (including through the incorporation of plant residues, the use of cover crops and protein crops and an enhanced role to grasslands); enhance humus content and soil microbiology and interactions between plants and soil (including through enhanced nitrogen fixation). Reduce the use of fertilisers including through precision agriculture or the use of biological methods to increase the efficiency of nutrient uptake; improve plant rhizosphere development and activity; foster the harmonisation of measurement of soil features (macro- and micro-nutrients, etc.) so as to improve monitoring and management at local to global scales. Investigate the potential wider agronomic benefits of crop rotations. Explore strategies to cope with increasing costs for phosphorus fertilizer: evaluate the phosphorus status of European soils, assess options for recycling;
- Improve **animal nutrition** and feed efficiency so as to improve resource use and reduce GHG emissions: foster breeding of grass and clover and improve grazing management to improve forage digestibility and to better integrate feed from pastures in diet formulation, research on potential new diets for livestock using more sustainable feed and by-products, use of precision nutrition to minimise excess nutrients, etc. With the objective to mitigate the footprint of livestock, improve **animal longevity and fertility.** Research in various areas regarding the animal sector (farming practices, breeding, feeding) will take appropriate attention to animal welfare and disease prevention;
- Foster the **sustainable supply of vegetal and animal proteins** through a comprehensive approach combining genetic improvement (in particular protein crops, including soya and other alternatives), farming systems, new sources of proteins, improved animal feed, etc. (together with other parts of the Societal Challenge).

b. Ecological approaches and low external input agricultural systems

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 minimising the impacts on the environment. This approach considers production systems holistically and in their diversity and implies the involvement of various research areas in a multidisciplinary manner.

Objective: foster the transition of European agriculture towards a resource-saving model with testing and demonstrating integrated approaches optimising ecosystem services and preserving biodiversity.

This approach is meant to foster sustainable agriculture and forestry production systems. Research in this area will extend to such systems as organic production, integrated production, conservation agriculture, agro-forestry systems, high nature value farming and urban agriculture / horticulture. Building knowledge of the underpinning mechanisms of the ecosystem services provided by the biodiversity (e.g. trophic networks) will be a key area of research within this activity.

The knowledge necessary to develop farming systems based on ecological intensification will rely partly on the research done on functional biodiversity indicated in the above-mentioned Area I.1.1.

- Support the development of crop and animal farming systems based on ecological intensification

Research is 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.

Among possible activities:

- Develop production systems based on ecological intensification through:
  - Development of **improved plant varieties and animal breeds** adapted to various agro-climatic conditions (including through participatory breeding) (in coordination with Priority I-1);
  - Exploration and documentation of the potential of **more diverse crop systems** (intercropping, etc.) for improved resource use, stabilisation of yields, product quality and ecosystem service delivery;
  - Development of **strategies for pest and disease management** at various scales (plot, farm, territory) optimising ecosystem services, including, where applicable, the biological characterisation of pathogens, pests and weeds and the development of economic thresholds and decision support tools;
  - Development of prototypes of sustainable **agro-ecology systems** at various scales from farm level to landscape / territorial level (including in peri-urban agriculture);
  - Development of **farm-level or inter-farm strategies to enhance soil conservation**, including strategies to maintain soil organic matter in the context of enhanced uses of biomass for various non-agricultural purposes;
  - Support networking and data collection on adjustment of agro-ecological systems to local conditions.
- Investigate the **implications of ecological intensification on socio-economic business models** of the various actors of the supply chain and on the role of consumers: input suppliers and cooperatives; role of advisory services; variety of agricultural production versus product normalisation to facilitate processing; perception of the consumers and market signals, etc.
- Facilitate the reconciliation of resource efficient farming with the conservation biodiversity across all relevant scales (plot, farm, landscape).

- Support research in specific farming systems

Various 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. Research in other or

[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 "European action plan for organic food and farming" (COM(2004)415 final).

more recent forms of agricultural systems, such as peri-urban and urban agriculture, will be supported.

- Sustain the development of the organic sector:
  - Contribute to the development of standards (including evaluation of the need to adapt organic standards to long-term organic management regarding phosphorus and potassium provision of soils; exploration of standards for the support and promotion of farmland biodiversity on organic farms);
  - Develop methods of authentication of organic products;
  - Seek the improvement of production methods, notably in the field of crop protection against pests and diseases;
  - …

- Conservation agriculture
- Agro-forestry: among priorities initiate a cross-European long-term network of experimental agro-forestry sites to evaluate the productivity and environmental performance of locally adapted agro-forestry systems;
- Integrated production
- High Nature Value farming
- Peri-urban agriculture, urban green areas and horticulture
- Other low input farming systems

c. Farming and marketing quality products for a competitive sector

Objective: for the agricultural sector to achieve all dimensions of sustainability, knowledge is necessary to help it develop products of high quality and added value and efficient supply systems.

The competitiveness of the agri-food sector extends to its capacity to deliver products which meet consumer and industrial demand for quality at remunerative prices for the sector. All dimensions of quality and safety need to be constantly adjusted and improved. Therefore the organisation of the food system needs to adapt to changing social, political, economic and environmental contexts (short-circuits, niche markets, direct sales on internet, public food procurement, etc.). Welfare has an important role to play to help the sector meet society and consumer demands. Research into quality and safety attributes, norms and standards is also necessary to ensure the proper functioning of markets. Activities will focus on primary-production related research and innovation so as to avoid overlaps with the second component of the Societal Challenge ("sustainable and competitive agri-food sector for a safe and healthy diet").

Among possible activities:

- Develop **appropriate plant varieties and animal breeds** and production methods (e.g. animal nutrition and quality of products) for product quality improvement (sanitary and phytosanitary, organoleptic, nutritional and technological). Develop simple testing methods to evaluate their characteristics as regards product quality and safety improvements;
- Ensure that improved animal welfare production systems, going beyond the legal baselines, are based on accountable and transparent elements. Investigate and enhance **animal welfare** on farms and down the supply chain, in particular:

  - Relations between housing conditions and occurrence of health and behavioural problems requiring veterinary treatments or reducing production performance. Development of welfare solutions and practices (e.g. using ICT, etc.);
  - Effects on the quality of animal products;
  - Socio-economic analysis on implications regarding consumer preferences, international trade, policy regulation.
- Develop and foster cost-effective and objective **quality indicators and classification systems** in different sectors to improve marketing efficiency and consumer information;
- **Supply and marketing**: provide the necessary knowledge (including on food safety standards and implementation methods) to the development of new spatially bound relationships between producers and consumers on the one hand (short-circuit marketing and niche markets of agricultural and first-stage processed products) and producers and the public sector (e.g. public procurement) on the other; explore the use of ICT to improve the marketing of agricultural products (logistics, traceability, etc.) and access to food and food information by consumers.

d. Production for alternative uses, recovery and reduction of waste

The development of new uses of the biomass contributes to the competitiveness of the agricultural sector by developing new outlets and increasing value for agricultural and biomass production. It also has the potential to contribute solutions to the depletion of fossil resources and to environmental sustainability by offering better uses to wastes and by-products[8]. Minimising and using farm waste will be a priority. Appropriate balance has to be found so as not to impact negatively food security and natural resources.

Among possible activities:

- Study plant species and varieties adapted to the **sustainable and efficient production of biomass for various types of land** (including derelict land) and provide new biological material and improve plants suited to new uses of the biomass. This will include the evaluation of traditional, orphan and novel types;
- Develop new uses of **agricultural by-products** (e.g. wine by-products, etc.), non-marketable products or waste (e.g. spoiled or contaminated feed/food, e.g. by mycotoxins) and investigate related logistics. The emphasis will be placed on the creation of value and the development of new uses for by-products with negative environmental impact;
- **Farm waste**: minimise farm waste, foster efficient recycling processes and support the development of value-added and resource-efficient outlets for plant and animal waste, manure and slurry, carcasses, etc. in order to reduce their environmental impact, to reduce GHG emissions and increase productivity. Emphasis will be put on the recovery of nutrients and the development of novel products derived from plant and animal waste streams;
- Develop **sustainable agricultural production systems delivering agricultural produce and bio-mass** for bio-products and bio-energy and assess their environmental impact and ecological services including at a landscape / territory / rural society levels;
- Provide analysis on the **environmental impact and sustainability of the development of production and alternative uses of the biomass**, in particular as regards potential

[8] Communication from the Commission "Innovating for sustainable growth: a bioeconomy for Europe" (COM(2012) 60 final

negative impacts on soil organic matter decline and fertility (including life cycle analysis, analysis of indirect land use change, etc.) and develop appropriate methodologies.

[It is expected that most research necessary for the development of bio-based products in the farming sector will originate from the fourth component of the Societal Challenge "Sustainable and competitive bio-based industries", e.g. work on second generation biofuels]

PRIORITY I.2. Preventing and controlling pests and diseases

Objective: 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 of climate change which increase their potential for establishment. 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.

AREA I.2.1. Better understand, prevent and control pests and diseases

The increasing pressure of pests and diseases necessitates to improve the knowledge base on pests, weeds and pathogens and to make it available for appropriate and timely responses. Appropriate knowledge of the biological characteristics of pests, weeds and pathogens and their interactions with hosts and vectors needs to be enhanced. Proper detection and diagnostic tools for monitoring need to be improved or developed.

Among possible activities:

- **Explore the genome / biology of pests, weeds and pathogens** and their interactions with hosts, vectors and crop species. Promote the development of curated molecular/taxonomic databases on pests and pathogens and access to these databases. Improve the understanding of the importance of European wildlife and wild plants as reservoirs of agricultural pathogens;
- Develop **detection and diagnostic tools** for monitoring plant and animal pests and diseases (including threshold values and warning systems). Improve **pest and disease surveillance**, risk assessment and control strategies (suppression, containment and eradication) for crops and animals). This will include the development of new strategies and tools to identify and prioritise emerging risks such as new pests and pathogens of crops and animals. Develop methods and tools to evaluate the efficiency and effectiveness of pest and disease control (including controls at border inspection posts);
- Improve the understanding of **basic functionalities of multi-trophic interactions** between crop pests and their natural enemies or other ecosystem parts for developing new green technologies and production methods in agriculture. Such ecological chemistry is meant to lead to the development of alternatives to pesticides for the control of pests and diseases.

A variety of research activities are necessary to fight against agricultural pest and diseases, starting from the breeding of sustainably resistant crops and breeds, to developing more

effective, sustainable and cost effective agricultural and rearing practices and treatments. Equally important is supporting concerted approaches at EU and international levels. Activities will support the European Plant Health Regime and plant protection services and the Community Animal Health Policy.

Among possible activities:

- **Fighting against pests and diseases** will aim at the development of effective, sustainable and cost-effective, improved or novel methods for the suppression, containment and eradication of pest and diseases and will request the mobilisation of research in several areas: develop pest / disease sustainably resistant or tolerant animal breeds and crop varieties (including resistance to fungi and bacteria that produce toxic substances); substitution and enhanced synergies between chemical and non-chemical veterinary medicines and plant protection products and methods; enhanced ecological mechanisms (intercropping, variety mixtures, functional biodiversity, mycorrhizal activity); management strategies to reduce the incidence and impact of production diseases in farm animals; develop more effective vaccines for major animal diseases and zoonoses to overcome either absence or deficiency of current vaccines;
- Develop methods and tools to forecast and evaluate the **economic and environmental impacts of novel pests and diseases**. Develop models to assess the overall economic costs and benefits of the EU phytosanitary legislation;
- Develop methods and risk mitigation options for the treatment of commodities infected or contaminated with pests and diseases for safe trade (intra EU and international);
- Investigate the potential threats to human health of **zoonoses** and provide solutions to mitigate them, in particular with the establishment of active surveillance systems;
- Investigate the various causes of honey **bee health** problems, extend attention to wild bees and assess potential interactions between multiple stressors and exposure to various chemicals used in agriculture or bee keeping and determine underlying mechanisms, in order to develop an overall approach with these important pollinators (including capacity of wild bees to compensate reduced performance of domestic bees). Explore at both individual and colony levels;
- Develop a systematic approach to reduce **contamination** risk by toxins in feed and food;
- Support coordinated approaches at EU level, establish a mechanism for **small-scale fast-track projects** for rapid responses to new diseases and pests;
- Develop **international cooperation** for both plant and animal sectors: studying alien invasive pathogens, pests, weeds and diseases in their place of origin; risk assessment on potential invasive species including projection of their behaviour in other / new geographic areas; diagnostic tools; monitoring and surveillance systems, new vaccines, economic assessment tools; classical biological control[9] and other management options.

AREA I.2.2. Elaborate strategies and programmes at farm level for reduced use of pesticides in the crop sector and of antimicrobials in the animal sector

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

[9] Classical biological control refers to the use of appropriate natural enemies to fight invasive pests.

Regulation (EC) 1107/2009[10] results in the reduction of the available active substances which requires alternatives to be found. Ambitious research is 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)[11] and the Action Plan against rising threats from Antimicrobial Resistance[12]. This research is 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).

Among possible activities:

- Provide **socio-economic evidence on alternative approaches** to pest and diseases prevention / treatment, impacts on farm profitability; multidisciplinary work along the whole supply chain to understand the role of all actors (from input suppliers to retail sector and consumers); economic analysis of the application of general principles of integrated pest management on the food chain;
- Design suitable **plant pest management strategies**, in particular for the so-called **minor use crops** and non-traditional (e.g. biomass) crops;
- Explore the **combined effects of chemicals (including pesticides and contaminants) on biodiversity** in the laboratory and in the field to investigate recovery in relation to protection goals for ecosystem services. This will involve the development and standardisation of analytical methods to measure exposure, the development of toxicity tests and integrated risk assessment methodologies. Particular attention will be paid to bees (including wild bees) and test species and wildlife in the aerial, terrestrial and aquatic environment);
- Elaborate strategies in crop and livestock sectors to **reduce risk** and impact of the use of pesticides / antimicrobials and develop alternative approaches or techniques reducing the occurrence of pests and diseases. Develop monitoring indicators (level of usage, development of resistances). The following will be explored:
  - Research into **long-term cropping systems / rotations** for pesticide reduction / pest control (crop rotations, varietal mixtures, weeding and soil management regimes, interactions with biodiversity);
  - **Precision farming** technologies to increase the efficiency of plant protection techniques;
  - Maximise the **role that biodiversity can play** on crop and animal health and develop new bio-control methods for pests, weeds and diseases using natural enemies (micro- and macro-organisms) or adapt existing methods to new ecological situations;
  - Increase the knowledge on **plant secondary metabolites** and plant defence mechanisms to elaborate new crop protection methods;
  - Elaborate approaches to ensure that structural investments made in **animal husbandry** improve bio-security and animal welfare conditions in order to reduce the needs for systematic (prophylactic, curative) treatments and animal welfare problems.

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

[11] 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).

[12] Communication from the Commission to the European Parliament and the Council "Action Plan against threats from Antimicrobial Resistance" (COM(2011) 748)

PRIORITY I.3. Climate smart agriculture: mitigating and adapting to climate change[13]

Climate change is already impacting European agriculture by constraining the yield increase of several crops or by the increasing the occurrence of extreme weather events (such as the heat wave of 2003, recent droughts or high rainfalls). The capacity of EU agriculture to deliver food and to contribute to ecosystem services is directly dependent on climatic conditions. Higher average global temperatures are likely without dramatic changes in the path of global GHG emissions. 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 strengthening 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.

Objective: provide the knowledge necessary for the agricultural sector to mitigate and adapt to climate change and develop relevant strategies.

AREA I.3.1. Understand the impact of climate change on agriculture

Investigation of the impact of climate change on agriculture is well under way, yet considerable work is still necessary at various temporal and spatial scales. This concerns the medium- and long-term impact of climate change on agricultural production and food security in the different pedo-climatic areas of Europe as well as the impact on biodiversity and ecosystems related to agriculture. Critical for this understanding will be our capacity to properly comprehend all interactions between the climate and agriculture and model them at various scales, from micro, meso, to macro levels. The latter will require to link European research and research outside Europe.

Among possible activities:

- Improve the current **modelling capacity**, in particular concerning the linkages between climate / agronomy / micro- and macro-economic impacts;
- Analyse the medium- to long-term impacts of climate change and increased climatic variability on a range of important dimensions: natural resources (soil organic matter, water availability), crop and animal production, occurrence of pests and diseases, bio-diversity and (agro)ecosystems, agricultural markets and food security, taking account of socio-economic and technological developments.

AREA I.3.2. Sources and sinks of greenhouse gases (GHG) of agriculture and options for on-farm GHG mitigation and carbon sequestration

Agricultural emissions of methane (CH_4) and nitrous oxide (NO_2) account for about 9% of EU's total GHG emissions. Carbon dioxide (CO_2) emissions from land use and land use change represent an additional 1%. Human-induced land use, land-use change and forestry activities can be sources or sinks of CO_2. Research is necessary to improve the contribution of agriculture to the mitigation of climate change. This concerns the reduction of emissions of

[13] Activities in this field will take place in close coordination with the Societal Challenge "Climate action, resource efficiency and raw materials" and with the Joint Programming Initiative "Agriculture, Food Security and Climate Change" (FACCE).

GHG and the increase of carbon sequestration. Specific solutions need to be found for specific "hotspots" such as the agricultural management of rich organic soils.

Research work implies to understand better the sources and sinks of GHG and the manners to best deal with them. Methodologies and data sources for the accounting of GHG at various levels are necessary to understand, monitor and project impacts at various scales. Finally, research has a role to play in investigating the policy measures that might be established to foster the contribution of agriculture to mitigation of climate change.

Among possible activities:

- Foster our knowledge on **sources and sinks of GHG**:
  - Various methodologies and tools for the assessment of the "**carbon footprint**" have been developed and applied to agricultural production systems (at various levels: soil, field, livestock, farm and forest levels). Further research aiming at improving **harmonisation,** emission **standards** and accounting all factors (e.g. imported feed) is necessary;
  - Improve knowledge of the **net GHG emission balance** (emissions and removals) from agriculture resulting from land use changes;
  - Enhance the **monitoring and reporting of soil carbon** for climate change mitigation purposes;
  - Improve the understanding of **indirect land-use change** (ILUC) (modelling, development of methodologies, assessment of specific supply chains, etc.).
- Support **innovation** and improve **agricultural practices** to minimise CH_4 and NO_2 emissions:
  - Foster appropriate use of **fertilisers** (see Sub-area I.1.2.a);
  - Improve use and management of **livestock manure** (see Sub-area I.1.2.d); improve **nutrition** (optimise diets, increasing, forage digestibility and minimise excess nutrients, see Sub-area I.1.2.a);
  - Foster carbon sequestration in agricultural soils.
- Support the **substitution of fossil-based energy and products** through increased production and use of the biomass and other renewable energies in the agricultural sector taking account of sustainability requirements (GHGs, direct and indirect land use change (ILUC), biodiversity, water, soil, etc.). Design strategies of sustainable biomass sourcing addressing trade-offs in local economies;
- Develop the knowledge base on the potential **mitigation policy instruments** targeting agriculture (e.g. regulatory instruments, carbon markets, offsetting schemes) and the conditions for their successful implementation.

AREA I.3.3. Adaptation of agriculture to climate change

Climate change brings a series of changes which increasingly affect agricultural production (levels and stability) both globally and within the EU. It is necessary to adapt production systems to these changing conditions. However, future socio-economic conditions, international competition, technological development, as well as policy choices will determine the impact that agro-climatic changes will eventually have on the EU agricultural sector.

Adaptation solutions are necessary to address both current and future climatic variability and longer term climate change. To do so, research needs to invest in a variety of areas, ranging

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from crop and animal breed improvements and improved farming practices that increase resilience, to adaptive soil and water management. There is a need to strive for all kinds of adaptation solutions such as "grey" solutions (technological and engineering), "green" (ecosystem based) and "soft" (related to management). Research needs to explore policy measures that can help fostering adaptation and resilience of production systems. The international cooperation dimension should not be neglected so as to explore conditions which are not currently present in Europe but may develop in the future.

Among possible activities:

- Support the **capacity of the agricultural sector to adapt**:
  - Develop **crops and plant varieties tolerant to abiotic stresses** (drought, flooding, salinity) and to changing climatic and environmental conditions (e.g. increased CO2, changes in growing season), taking into account that this task ought to be tailored to address regional and local conditions and needs;
  - Investigate the effect of climate change and the associated risks **for animal production** (e.g. animal growth and health, productivity of pastures), and the needs for adaptation of livestock systems and animal breeding;
  - Monitor the impact of climate change on **mycotoxins** and develop measures to mitigate any adverse effects;
  - Monitor the impact of climate change on **spreading of pests and diseases**, improve risk assessment, increase protection and develop climate-informed crop and animal protection (see Areas I.2.1 and I.2.2);
  - Foster agricultural practices and production systems that cope with increased **abiotic stress** and increase all dimensions of resilience (e.g. intercropping, agro-forestry);
  - Develop strategies for sustainable **soil management** in the context of a changing climate (see Sub-area I.1.2.a);
  - Foster appropriate **water management** (see Sub-area I.1.2.a);
  - Encourage cooperation at regional and international levels in the field of adaptation of agriculture to climate change.
- Facilitate **adaptation through relevant policies**:
  - Develop **tools to support decision making** under uncertainty and risk conditions. Assess costs and benefits of possible policy measures to facilitate adaptation and definition of collective modes of organisation in the face of climate change;
  - Develop guidance on designing and fostering adaptation by using integrated approaches, both for the assessment of threats and opportunities and for policy making, that can adequately complement sectoral approaches;
  - Assess the potential role of **agricultural ecosystems** to mitigate the consequences of climate change (e.g. flood control, etc.).

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STRATEGIC GOAL II. FOSTERING THE SUSTAINABILITY OF FORESTRY

The challenge: forests cover more than 40% of the total territory of the EU and play a specific role in the sustainability of rural areas. The forest sector plays an important economic role and delivers economic, social and environmental benefits to the society. As the agricultural sector, it faces threats, among which climate change and its consequences. Yet it can make an important contribution to mitigation by increased carbon sequestration in forests, soils and wood products and replacing carbon intensive materials and fuels.

Meeting the challenge: to ensure the long-term sustainability of the sector research in a series of areas is necessary including dealing with pests and diseases and climate change, the development of wood products and biomass, the implementation of adequate production practices and systems. Adequate socio-economic analysis and foresight exercises are also necessary to ensure that contributions of the sector to the rural economy and society at large are well understood and catered for.

Objective: enhancing the sustainability of the forestry sector and its contribution to the rural economy in particular through sustainable forest management and the improved capacity to face biotic and abiotic stresses and the development of improved forestry production systems and products.

Among possible activities:

- Foster the **characterisation and conservation of genetic diversity** of forests with a view to maintain the long-term adaptability to future biotic and abiotic threats and the sustainable use of genetic resources;
- Contribute to **long-term strategies for tree breeding** incorporating objectives of production value and sustainability under the conditions of climate change;
- **Breed and develop pest/disease resistant or tolerant trees**, improve disease surveillance, risk assessment, understanding, prevention and control strategies (including international cooperation: sentinel nurseries, activities mentioned under Area I.2.1 for agricultural crops, etc.) including simple techniques for testing new improved varieties;
- Foster the quality and traceability of **forest reproductive material** by developing control and traceability systems including ICT;
- Develop strategies for the protection of forests against **abiotic factors** (e.g. fire, extreme weather events, etc.) and enhance the existing information on these effects at the European level within a comprehensive European forest information system;
- Analyse the long-term impacts of climate change on forest ecosystems and soils;
- Optimise the **mitigation role of European forests** including the substitution effect of energy-intensive products by forest products;
- Develop **sustainable forestry production systems** delivering both wood products and other biomass (in particular for energy purposes) and useful services to the society and assess their environmental impact and ecological services at a landscape / territory level;
- Analyse the **provision of ecosystem services and public goods** by forestry systems. The activity will extend to such field as the protective function of forests (floods, avalanches, erosion), social and cultural benefits (including recreation) and other services (e.g. provision of water or soil stability);

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- Explore the use of **ICT, mechanisation and other technologies** to optimise sustainable and climate-friendly forestry production systems;
- Improve the **quality of existing forestry products** (wood, cork, resins) and support the development of new added-value products (i.e. bioactive molecules) and efficient marketing systems, including quality assurance of wood material;
- Explore the potential for **regionally appropriate strategies** for low conflict use of forests by different user groups (foresters, farmers, citizens, tourists, etc.);
- Carry out **socio-economic analysis** of the forestry sector, including international aspects (e.g. international trade in wood products) and foresights;
- In view of forest resource monitoring and forecasting (in particular for reporting obligations at Member State and EU levels), develop improved **forest survey, planning and management tools** (models of forest growth, productive potential, projecting impacts of management interventions).

Appropriate coordination with Societal Challenge 5 "Climate action, resource efficiency and raw materials" will be established.

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STRATEGIC GOAL III. BALANCED DEVELOPMENT OF RURAL AREAS

The challenge: inclusive growth, which is a priority of Europe 2020, may be more difficult to achieve in some rural areas for reasons of lack or declining economic activities, negative demographic trends, geographic isolation or imbalanced interactions with urban areas. Hence there is an increasing heterogeneity and inequality between rural areas. Furthermore, despite sustained growth in rural areas, there is a persistent gap with urban and intermediate areas: in terms of GDP per capita predominantly rural regions stand at 73% of the EU average[14]. It is therefore necessary to stimulate economic activities in rural areas to reduce the gaps between rural regions and between rural areas and urban and intermediate areas.

Meeting the challenge implies to explore the demographic, economic and social dynamics and the capacity of rural areas to develop new and diversified economic activities and find the leverages for increased innovation. To contribute to achieve a balanced development of rural areas research needs to investigate the capacity of rural areas to generate new and diversified economic activities, in particular as a result of their innovative capacity. It is in particular important to gain a deeper insight into the social dimension of agricultural and rural innovation, which consequently may lead to more sustainable agro-food systems and dynamic rural societies. It is also necessary to shed light on demographic and social dynamics and drivers and the interactions with urban areas. The synergies and interactions between the various policies applied on rural territories play a crucial role. Finally, the different uses that land has to cater for imply proper arbitrage and innovative approaches to land management.

PRIORITY III.1. Enhancing the sustainability of rural areas

Objective: enhancing the sustainability of the rural areas through fostering economic activities, fostering their capacity to innovate, their interactions with urban areas and through appropriate synergies between various policies.

AREA III.1.1. Exploring economic activities, public and private services, provision of infrastructure and technology *to enhance sustainability and identify appropriate practices for dynamic rural areas*

Research has a great role to play in investigating how diverse economic activities, public and private partnerships, rural infrastructures and technologies (in particular ICT) can contribute to buoyant and sustainable rural economies. In particular, investigation in the bases of case-analyses can bring useful information to other EU rural areas.

Among possible activities:

- Identify mechanisms and develop methods to measure potential social and economic benefits – spill-over effects (diversification of activities, etc.) arising from the **provision of public goods and services** by agriculture and forestry in rural areas;

[14] Eurostat data, elaboration DG AGRI. Available at: http://ec.europa.eu/agriculture/statistics/rural-development/2011/index_en.htm

- **Infrastructures, partnerships and services** to facilitate economic activities: assess the access to high-speed broadband networks in rural areas and the delivery of fast and effective e-services for rural population. Explore the potential offered by ICT to provide services and economic activity in rural areas. Investigate public-private partnerships and their role in sustaining a green rural economic dynamism (including facilitating and hindering factors). Evaluate the role of financial instruments in providing access to rural businesses – elaborate appropriate models and practices / projects;
- From **integrated farming to energy sufficiency**: develop appropriate models and approaches and identify climate-related investments for renewable energy development and reduction of GHG emissions in rural areas;
- Investigate the contribution of various farming systems and related supply chains to the socio-economic sustainability of rural areas and potential levers to improve it. Analyse the role of **additional on-farm activities**, such as rural tourism, on-farm education or care farming, in enhancing integrated local territorial development.

AREA III.1.2. Exploring incentives and identifying barriers that hinder innovation *and evaluate novel mechanisms and socio-economic structures which encourage interaction and innovation in rural areas*

Innovation[15] has been identified as a priority for EU policies. Innovation in rural areas can play an important role in stimulating a green and socially inclusive economic growth, mitigating geographic isolation and avoiding economic marginalisation. Socio-economic research has an important role to play in identifying needs for and bottlenecks to knowledge exchange and innovation and addressing them, whether they concern appropriate generation or provision of knowledge, gender issues, geographic isolation, absence of adequate services and facilitating mechanisms. Investigations in the agricultural and rural knowledge and innovation systems are expected to deliver practical approaches in removing constraints to innovation.

Among possible activities:

- Examine the **mechanisms of innovation and knowledge exchange** and the necessary pre-conditions for their stimulation and development. Explore the role of interactions and networking between rural actors in encouraging innovation. Evaluate the needs for and the access to (applied) research and knowledge, especially for rural micro and small farms and enterprises. Explore the potential and policy framing of innovative social farming initiatives;
- Socio-economic analysis to support **research and innovation** in the agro-food sector: 1) explore the contribution of the CAP and other EU policies to innovation in agriculture and forestry sectors and rural areas; 2) Investigate the delivery of agricultural knowledge and innovation systems (AKIS) and explore ways to improve it (benchmarking, participation of actors, role of advisory services and other facilitators, intellectual property rights, etc.);
- Identify **economic and cultural barriers** (including gender) hindering rural entrepreneurs and assess their access to finance;
- Investigate the role of **short-supply chains** in integrating local agricultural innovations into territorial / touristic development innovations.

[15] In the present document innovation is envisaged in a broad sense which includes the technical, organisational or social dimensions of innovation.

***AREA III.1.3. Assessing demographic and social dynamics and rural / urban interactions and impacts on** the potentials for sustainable rural development*

The economic sustainability of rural areas is conditional upon their social and demographic dynamics and the interactions they develop with urban centres. Labour and human capital is one of the keys which can prevent economic marginalisation. Within this, migrations, whether they are rural-urban, foreign, permanent or temporary, can play an important role which still needs to be better understood, on the prosperity of rural areas. Most rural areas have urban centres of various sizes in their neighbourhoods, with which they interact: commuting, direct marketing, etc. The quality and the modalities of interactions with urban centres have a strong bearing on the prosperity of rural areas. Increasing energy costs will have strong implications on interactions between rural and urban centres which need to be investigated so as to design relevant territorial policies and planning. Research will contribute to assess the impacts of specific urban-rural interactions on sustainability and identify opportunities and solutions.

Among possible activities:

- Analyse the balance of **agricultural and rural labour** and develop models to reduce the **labour supply gap**. Evaluate the role of local and foreign seasonal labour in developing rural areas' demographic and economic fabric. Assess the dynamics of the provision of social services in rural areas and access to skill upgrade for farms and other businesses;
- Analyse the impact of **increasing energy costs** on housing, commuting and organisation of transports, economic activities in rural areas and delineate implications in terms of public policies and territorial planning;
- Define **territorial and social isolation** and evaluate novel mechanisms to reduce it. Define typologies of rural-urban strategies and corresponding partnerships (e.g. civic food networks, different forms of cooperation between producers and consumers, etc.).

***AREA III.1.4. Identifying mechanisms of interaction between sectoral policies** and intended / unintended territorial impacts. Improve the coordination of sectoral policies fostering synergies*

Several policies, whether at national or EU levels, play a role in the rural economy. Yet, appropriate coordination and synergies do not always materialise and this may lead to sub-optimal results. Research work on interactions between these policies is meant to facilitate harmonisation between these different polices for better delivery to the society.

Among possible activities:

- Assess mutual impacts of **urban and rural development strategies** and provide recommendations for support by public policies (e.g. rural development and regional policies);
- Analyse the **interactions**, including possible frictions and scope for synergies, between the Common Agricultural Policy (CAP), the climate and environmental policy and other EU policies;
- Analyse the complementarities and synergies between the CAP and policies implemented at territorial level by the Member States.

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PRIORITY III.2. Exploring innovative land use and management practices

Objective: land use faces mounting pressure owing to an increasing number of potential uses or objectives which can be sometimes conflicting (food, non-food, forestry, bio-energy and other renewal energy, recreational, maintenance of biodiversity, etc.). On the other hand, sizeable land areas are lost as a result of soil sealing due to urban sprawl or as a result of land abandonment. Potential conflicts between these various uses and the necessity to ensure sustainable management will call for new approaches to land use and land management. At the same time, new forms of farming are developing in peri-urban areas and, to a yet minor level, in urban green areas as well. Although of limited importance, such new uses of land or available areas may deliver new approaches of land use and management that could prove beneficial beyond their boundaries, e.g. for consumer understanding of food production or for urban-rural connectivity.

Among possible activities:

- Improve the **knowledge of land use and land cover**, including changes over time, in rural, peri-urban and urban areas. This will include developing methodologies to build accurate statistics covering all types of land-use, representative at detailed regional level which are necessary to analyse the impact of policies on land use change will be done;
- Explore **innovative approach to land use and management** and the potential of various systems (agro-forestry, forestry, extensive livestock systems, etc.) to cope with conflicting demands and to deliver ecosystem services and public goods. Explore peri-urban and urban crop and livestock production: constraints and specific requirements for their development;
- Assess **the impact on land use of new paradigms** (e.g. development of the bio-economy or green growth).

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STRATEGIC GOAL IV. ANALYTICAL SUPPORT TO POLICIES

The challenge: evidence-based policy making implies a wealth of knowledge which is all the more important that public policies now have to respond to multiple objectives and also interact with each other. In particular, policies which are involved in solving the challenge of food security need proper knowledge of current and future implications.

Meeting the challenge implies socio-economic analysis on a variety of areas, adequate tools for modelling and projecting, decision making and monitoring. Given the specific importance of the challenge of food security, a major effort will be granted to the better knowledge of its various dimensions.

Proper design and implementation of public policies necessitate inputs from the research side. Given the challenges faced by the agricultural and forestry sectors, of particular importance is our capacity to understand the different dimensions of food security, at EU and at world level, and their short-term and long-term implications. In order to maximise the delivery of ecosystem services and public goods by farming and forestry systems, it is crucial to improve our capacity to measure them. Moreover, significant efforts of research are necessary to provide the economic analysis which is necessary for an evidence-based policy management, in particular for the CAP and the EU plant and animal health regime, and to ensure that results, tools and data developed by research are available for use for policy formulation. Finally, research is expected to contribute to the implementation of various policies aspects, in particular by providing the necessary knowledge to improve monitoring and evaluation systems.

PRIORITY IV.1. Better understanding of food security issues at EU and world levels

EU agriculture and food systems contribute to the developments of food security not only in the EU but also at world level. Demographic trends, climate change and environmental sustainability are major drivers that shape current and future food security. Hence, proper capacity to deliver on food security, whether in the short or in the long term, imply the capacity to integrate many different factors so as to construct a comprehensive understanding of it. A variety of scientific domains, approaches and technologies need to be mobilised for this important objective. That runs from ICT and remote sensing to improve short-term harvest forecasts, to carrying out regular foresight exercises and to improving our modelling capacity. This activity will obviously include a dimension of international cooperation reflecting the significance of food security at world level and inter-linkages between EU and world levels.

Among possible activities:

- Understand the **drivers of food security** on both supply and demand sides:
  - Provide quantitative analysis of food security with **long-term modelling** integrating socio-economic and bio-physical models and allowing the elaboration of scenarios linking supply and demand, the investigation of trade-offs between the various uses of the biomass and the implications on land use and sustainability;
  - Support **foresight** exercises on sustainable farming, food supply and food security at EU and at world level.

- Monitor the **security of agricultural input resources** (availability, traceability, identity and quality of plant reproductive material, fertilisers, pesticides, etc.) for food and feed production;
- Improve the understanding on the linkages between local, regional and global markets;
- Support **short-term harvest forecasts and early warning systems** (EU and world) making use of ICT (including ground sensor measurement), meteorology and remote sensing;
- Analyse **farm risk management** in the context of climate change;
- Outside the EU, this activity will include such questions as: the food security of vulnerable households; the contribution of different types of farming (family farming, estate farming) to food security and the resilience of food systems to shocks in the globalised world; mitigation of price volatility (market information systems, etc.); the role of nutrition; the role of infrastructures, trade, policies and governance in achieving food security; the links between food security and poverty alleviation.

PRIORITY IV.2. Fostering the provision of ecosystem services and public goods through better monitoring and policy performance

Agricultural and forestry ecosystems provide a range of services[16] and public goods which are not properly taken into consideration by the society. The lack of proper knowledge on these services and public goods entails a higher risk of damaging the underpinning resource-base and of sub-optimal level of their delivery to the society. Stimulating the provision of ecosystem services and public goods implies the design of methodologies to characterise the ecosystem services and public goods and monitor them and to understand their interactions with farming and forestry systems with the objective to design decision support tools and policy instruments. The research will cover a wide range of ecosystem services and public goods. It will pay sufficient attention to the ecological integrity and scenic / cultural value of landscapes as assets for the rural economy.

AREA IV.2.1. Identify the various types and qualities of ecosystem services and public goods and improve monitoring systems to ensure their sustainability

Better understanding of the various services that can be provided by ecosystems linked to agriculture and forestry systems, their evolution in space and time and their economic value is necessary to ensure that they may be taken into consideration in agricultural and other activities in rural areas and deliver to the society at optimal levels.

Among possible activities:

- Provide an **overview and classification of ecosystem services and public goods** linked to agriculture on different spatial and temporal scales;

[16] These services are classified into three categories: provisioning (food, freshwater, etc.); regulation and maintenance (climate, flood, water purification, pest and disease regulation, etc.); cultural (aesthetic, educational, recreational, etc.). Important services include: cultural landscapes, pollination, water storage for flood regulation, erosion reduction and carbon sequestration / GHG mitigation; but also less known services like phyto-accumulation, soil bioremediation, etc.

- Define **indicators** for the measurement and monitoring of these ecosystem services and public goods (including biodiversity);
- Develop methods for the **measurement of the economic value** of ecosystem services and public goods linked to agriculture;
- Develop sound scientific approaches on harmonised monitoring and reporting on management of protected areas for nature (e.g. Habitat's Directive 92/43/EEC).

AREA IV.2.2. Assess the effect of agricultural practices and systems with respect to the delivery of ecosystem services and public goods

Investigation of the interactions between various farming and forestry systems and the provision of ecosystem services and public goods is necessary to understand which systems maximise their delivery. In a further step, research needs to design decision support tools and explore policy instruments that would allow orienting agriculture towards them.

Among possible activities:

- Develop methods for the analysis of the interrelations between different farming and forestry systems and practices, on the one hand, and the provision of ecosystem services on the other;
- Develop methods to assess in a holistic manner the environmental impact of farming practices, crop threats and threat mitigation measures to biodiversity and ecosystem services in order to develop risk assessment tools to analyse the environmental costs and benefits of interventions, thus providing better support to EU decision making;
- Design **decision support tools** and explore **policy instruments** to ensure optimal delivery through agriculture and forestry of ecosystem services and public goods to the society. Attention will be paid, among other, to landscape features and to the public perception on their provision by the agricultural and forestry sectors (e.g. landscape scenery). This would include the development of approaches for the remuneration of their provision (innovative financing mechanisms, crowd funding, etc.). Explore the role of various actors (in particular advisory services).

PRIORITY IV.3. Support to the CAP and other public policies

There is a large variety of **economic research** that needs to be done to help manage and monitor the CAP and other public policies. Areas range from international trade, competitiveness and working of supply chains, micro-economic analysis (income, etc.), improvement of the capacity of analysis and models to explain recent evolutions (links with other sectors, energy, impact of financial markets, etc.). The impact of the CAP on the status of **natural resources** needs to be better evaluated and appropriate and efficient monitoring systems need to be developed and implemented.

Among possible activities:

- **Economic analysis and modelling** (including alternative economic theories and approaches) at macro level (long term projections, international trade, international competitiveness of supply chains, etc.), meso level (functioning of markets, supply chain analysis, agricultural labour) and micro-level (income, FADN, etc.) of the different sub-

sectors of EU agriculture and on the CAP design. This will include modelling of regional and spatial impact of the CAP;

- **Integrated modelling framework** linking the economy and the environment in policy scenarios / impact assessments. This will include **bio-physical modelling** of aspects such as soil, water, land use and landscape development;
- Monitoring of **third country policies** and impacts for EU agriculture;
- Impacts of economic and social policies as well as the institutional framework on the agricultural sector.

Research has an important role to play in helping in the management and monitoring of agricultural and other policies. An important contribution concerns the development of **geo-spatial tools and indicators** for the monitoring and evaluation of policies and subsequent adaptations. Equally important is the support to controls of implementation of policies to ensure fair competition in food supply chain, including the design and implementation of certified schemes. Contributions are also expected for specific elements of the CAP and for other policies, which have an impact on agriculture and rural development, in particular the environmental policy, the climate policy or the EU plant and animal health regime. Finally, the contribution of the CAP and other policies to foster the delivery of knowledge and innovation in agricultural / forestry systems and rural areas requires sufficient investment in socio-economic research.

Among possible activities:

- Research to support the CAP, the Forestry Strategy, CAP quality policy, organic sector policy, Biodiversity Strategy, European Innovation Partnership, support to the implementation of the Roadmap to a Resource Efficient Europe, modelling the global costs and benefits for the society of the phytosanitary legislation, support to future new EU legislation on plant reproductive material, intellectual protection of agricultural innovation, Innovation Union, etc.;
- Methodological support on **policy monitoring and evaluation** (indicators, etc.);
- Conceptualise indicators and implement targeted programmes to evaluate the effects of specific CAP measures (e.g. rural development programmes) on natural resources and to monitor the status of critical natural resources (e.g. biodiversity, water quality);
- Exploration of the potential contribution of **ICT** to data collection and monitoring of policies;
- **EU quality policy**: EU certified schemes (PDO, PGI, TSG, organic agriculture, varietal wine), marketing standards, oenological practices, etc.: support standard establishment and implementation; improve the efficiency of control and supervision systems and their capacity to detect frauds; encourage synergies between national control bodies and ICT for better exchange of data; develop methodologies for the assessment of the authenticity of agricultural products; investigate the contribution of certified schemes to public goods and the rural economy. Support to the development of more outcome-oriented certification schemes;
- Incentivising **climate smart agriculture and rural development** (in addition to Priority I.3.): comparative analysis of rural development measures from a climate point of view; developing scenarios and appropriate practices examples of cost-effective policies for climate-friendly and resilient agricultural production at NUTS 2 or 3 level;
- Establishment of mechanisms for **horizon scanning**, foresight in the areas of research in "sustainable agriculture and forestry" so as to better anticipate new research and innovation needs.

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