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task  
force**

A European Public-Private Platform

# **Vision Paper towards European Research and Innovation for a sustainable and competitive livestock production sector in Europe**

A framework for suggested priorities for R&I within Horizon Europe

February 2019





# Core Team

President:	Jean-Louis Peyraud	INRA, France
Vice President:	Vivi Hunnicke Nielsen	Aarhus University, Denmark
Vice President:	Ana Granados	Fabre-TP
Secretariat:	Florence Macherez	Idele, France

***This paper is a consulted paper prepared by ATF members and engaged partners.***

Our members and engaged partners are research providers from 17 Member States of the EU (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Spain, Sweden, United Kingdom), plus Norway, Serbia and Switzerland, industry representative bodies that support the interests of Europe's livestock industries (AnimalhealthEurope, FABRE-TP, FEFAC, FEFANA) and livestock innovation groups (ECIP, EU-PiG).

## About the Animal Task Force (ATF)

ATF is a European Public-Private Partnership and a leading body of expertise linking European industry and research providers for developing innovation in the livestock sector.

We work together to identify actions that are needed to foster knowledge development and innovation for a sustainable and competitive livestock sector in Europe.

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# Introduction

In March 2018, the ATF published a position paper for research and innovation (R&I) within Horizon Europe supporting a sustainable and competitive terrestrial livestock production sector in Europe<sup>1</sup>.

**This Vision Paper has been jointly developed by ATF members and engaged partners during 2018, based on the outcomes of the platform's activities and events since its creation in 2011. It aims to provide a common framework and a scope for suggested priorities for R&I within Horizon Europe towards a resource efficient, sustainable, competitive and safe livestock production sector in Europe.**

The scope of the Vision Paper is European terrestrial livestock, including herbivores (ruminants, horses, rabbits) and monogastrics (pigs, poultry). Blue Growth and aquaculture (addressed by the European Aquaculture Technology and Innovation Platform, EATIP), fisheries, game, companion animals and bees for honey are not considered. However, we fully acknowledge that interrelations between green and blue economies should be carefully considered to achieve a sustainable European

food and non-food production. Insect production for feed is addressed in the context of the circular economy.

This Vision Paper provides an overview of the role of R&I in up-scaling the contribution of a diversity of European livestock farming systems towards sustainable agri-food systems and to the delivery of services to society. Part 1 stresses the importance of the European livestock sector in a global context. Part 2 describes the new paradigm shift and expected R&I support required to address the main challenges facing livestock farming. Part 3 proposes a framework for R&I around 4 main levers that may be combined: agro-ecological practices, circularity, innovative (bio)technologies and governance. Finally, part 4 outlines the main impacts expected from European R&I.

Suggested priorities for research and innovation for **Horizon Europe** will be developed during 2019 by ATF members and engaged partners, discussed with stakeholders and consolidated into a **Strategic Research and Innovation Agenda to be presented in November 2019**.

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<sup>1</sup> [http://animaltaskforce.eu/Portals/0/ATF/2018/ATF\\_Position%20Paper%20towards%20FP9\\_final.pdf](http://animaltaskforce.eu/Portals/0/ATF/2018/ATF_Position%20Paper%20towards%20FP9_final.pdf)

# Contents

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- PART 1. CURRENT IMPORTANCE OF THE EUROPEAN LIVESTOCK SECTOR FOR GLOBAL SUSTAINABLE DEVELOPMENT IN TERRITORIES AND AGRI-FOOD SYSTEMS 7**
- 1. Contribution of the livestock sector to the SDGs ..... 8
- 2. European livestock farming in a global perspective ..... 10
- 3. European R&I in livestock farming in a global perspective ..... 12
- PART 2: EUROPEAN R&I TO ACCOMMODATE A PARADIGM SHIFT IN LIVESTOCK FARMING WITHIN EUROPEAN SUSTAINABLE CIRCULAR AGRI-FOOD SYSTEMS 13**
- 1. Towards a new paradigm for livestock in European agri-food systems..... 14
- 2. Rethinking the place and role of livestock systems in achieving sustainable European agri-food systems..... 18
- 3. Expected contribution of R&I to achieve the potential of livestock in contributing to circular sustainable agri-food chains ..... 19
- PART 3. A FRAMEWORK FOR INNOVATION DEVELOPMENT IN THE LIVESTOCK SECTOR: MOBILIZING NEW CONCEPTS AND APPROACHES 23**
- 1. Agro-ecological practices to increase the sustainability of livestock farming systems ..... 25
- 2. Circularity towards more efficient and healthy agri-food systems..... 27
- 3. Innovative (bio)technologies to enhance the benefits of livestock systems..... 28
- 4. Governance of the sector and cooperation among stakeholders..... 30
- PART 4. EXPECTED IMPACTS OF FUTURE LIVESTOCK RESEARCH AND INNOVATION PRIORITIES 33**



# Part 1. Current Importance of the European livestock sector for global sustainable development in territories and agri-food systems





## 1. Contribution of the livestock sector to the SDGs

The Food and Agriculture Organisation of the United Nations (FAO) affirms<sup>2</sup> that “livestock production can contribute directly and indirectly to each of the Sustainable Development Goals (SDGs)” defined by the

United Nations in 2015. **European livestock production contributes directly** to 7 of the 17 SDGs (Figure 1) as shown in the following sections.



Figure 1 : Contribution of livestock farming to UN SDGs (European case in blue, world level in blue and green)

European livestock farming has an important role in European and global food and nutrition security (SDGs 2, 3, 12). It contributes to securing the provision of protein-rich, safe and healthy food for European citizens while responding to diversifying demands and avoiding deficiencies in micro-nutrients. It has potential to lead the way in environmental and animal welfare stewardship and ensure socially responsible European animal production. It is key in generating added value from cereals, protein rich crops and crop residues (compared to export of grains), as well as utilising plants that are inedible by humans.

- The livestock sector contributes substantially to the European economy and to the vitality of many European territories (SDGs 8, 9). Livestock production is valued at €168<sup>3</sup> billion annually, representing 45% of the total agricultural activity.<sup>4</sup> It creates employment for almost 30 million people, either directly (in farms) or indirectly (upstream and downstream sector, transport, processing, retail). For regions less suitable for intensive crop production, it provides a viable activity and rural vitality. The EU is generally self-sufficient in high quality animal products and provides exports worth (€19.5 billion) to world markets in the form of products but also

<sup>2</sup> “Transforming the livestock sector through the Sustainable Development Goals”, FAO

<sup>3</sup> €187bn with forage plants

<sup>4</sup> INSEE from Eurostat, 2014



knowledge and know-how. European production standards are high compared to those from other parts of the world in terms of animal welfare, traceability, food safety, healthiness and the environment. Facing international competition on production costs, European products may find a competitive advantage in high quality food markets, where safety, ethical and societal concerns such as animal welfare are of high importance. **Livestock also contributes to human wellbeing via landscape heritage, gastronomy and tourism, especially in European grassland based landscapes.**

- Thanks to significant efforts to reduce greenhouse gas (GHG) emissions, **the livestock sector is starting to contribute to mitigating**

**climate impacts (SDG 13)** by developing and improving technologies and practices that effectively reduce emissions. Even though European systems have relatively low emission intensities, improvements have to continue.

- **Livestock are a key component of the vitality of many European territories (SDG 15). They are present in almost all regions of Europe across a wide diversity of production systems (Figure 2)** and local economic, geographical & sociological contexts, reflected in different local conditions and available resources within a territory, heritage, farmers' and suppliers skills. Their diversity stretches from fertile plains well equipped with efficient infrastructures, to marginal lands not able to produce plant-based products for human food.

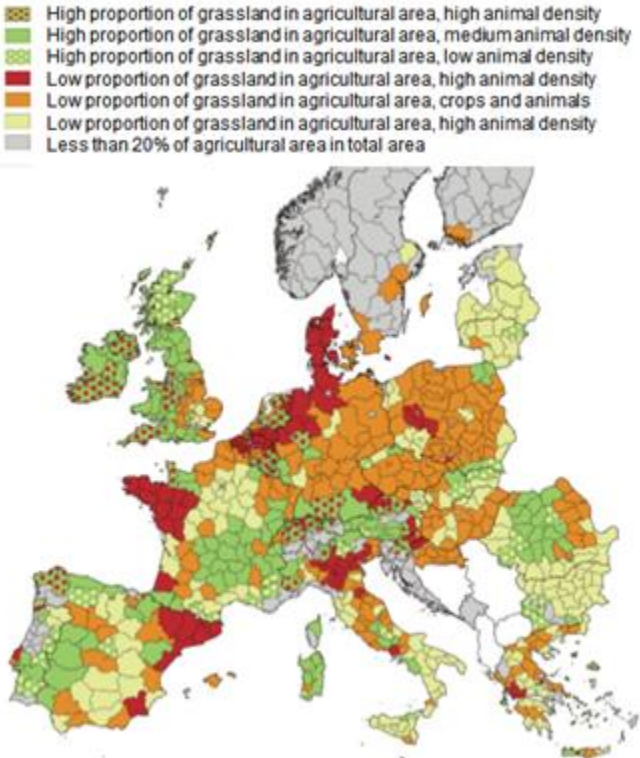


Figure 2: Typology of European livestock production areas (Source INRA based on Eurostat, 2010)

- **The diversity of production systems gives resilience to the entire European production sector and may satisfy a wide range of consumer demands** in terms of price of products and image of the production system. Indeed, intensive systems, low input/extensive systems and organic systems are able to offer different products, face different challenges and require different adaptations. In general, intensive systems provide high quantities of high quality safe food (far superior to that of mean imported products) at affordable prices, while ensuring high efficiency in the use of resources. They are mostly challenged by environmental and societal issues. Extensive systems, in less favoured regions, have lower levels of competitiveness on a standard market but they offer differentiated products (e.g. encompassing local products, labels, or ethical considerations) and contribute largely to preserving landscapes of high nature conservation value, culture and traditions. Even in intensive and urban regions, local food is also becoming a pathway to differentiation strategies. Organic farming fits some societal demand and some environmental challenges. Its market share is challenged by lower productivity.

- Since the 1960s, farming systems and breeds have co-evolved along with a general

strategy of reducing environmental heterogeneity. This has led to a restriction in the range of explored and implemented scientific, technological and economic solutions. Now that technical and technological barriers have been overcome, **the sector has the ability to move towards much more diverse systems that may combine with agro-ecological strategies relying on local solutions.**

- **In developing countries, livestock farming contributes to the SDGs mentioned above in a more decisive way. It participates in other SDGs that are less relevant at the European level.** Livestock systems contribute to the livelihoods of 70% of the world's rural poor. Livestock are essential to household economies as well as to reducing poverty and contributing to food security (**SDG 1 and 8**) among the 2.2 billion people coping below the poverty line. Livestock are important as capital stock and participate in agricultural activities through draught power. They contribute to gender equality and empowerment of women (**SDG 5**). Animal-based products are crucial to avoid malnutrition and micronutrient deficiencies for 800 million people worldwide (**SDG 2 and 3**). They also contribute to responsible consumption and production (**SDG 12**) by providing organic fertilizers (manure is the only fertilizer utilized in 40% of agricultural areas).

## 2. European livestock farming in a global perspective

Europe is both a significant importer and exporter of animal-sourced products<sup>5</sup>. Therefore, some key elements of a global

perspective have to be considered while looking at European livestock production.

<sup>5</sup> The EU is generally self-sufficient in animal products and sells on the world markets (€19.5 billion). The EU is a net exporter of pig meat (2.2 Mt), dairy products (€11.8 billion), poultry meat (0.5 Mt) and eggs

(0.14 Mt). It exports live animals of many third countries (around 0.2 Mt eq. carcass). The trade balance of dairy products is positive for all product categories (€11.8 billion). (Source ESCO INRA, 2016).

- **Global demand for meat and milk** is expected to increase considerably during the next thirty years in business-as-usual scenarios, driven essentially by a rise in consumption in Africa and Asia due to both population growth and increased living standards. To meet this demand, animal production has substantially increased in many parts of the world. Currently, nearly half of the world's 1 billion pigs live in China, 150 million in Europe (FAO) and huge cattle farms can be found in China, Australia, India and Brazil. Of the world's 1.4 billion cattle, only 89 million live in Europe.

- Given the current trade flows between Europe and the rest of the world, the small proportion of animal numbers reared and high environmental requirements in Europe, **Europe-only solutions are likely to have a minimal impact** on animal production's global footprint.

- On Europe's doorstep, pig and poultry **production is growing fast in Ukraine and Russia. Europe's share in global production is shrinking<sup>6</sup>**. These systems produce milk and meat at prices at which European production cannot compete, albeit with much higher environmental footprint and much lower animal health and welfare status than in most European systems. This is both an opportunity and a threat to the European livestock sector: an opportunity because European milk and meat production for export can be of much higher quality with a lower environmental footprint; and a threat since European producers can be undercut in their own market by cheap low quality imports. Another challenge is to avoid massive imports of unsustainably produced meat from third countries, sometimes less equipped for surveillance of infectious threats, and with loss of local jobs. **Supplier industries to the**

**livestock sector are highly dependent on a critical mass in production in Europe.**

- European animal production systems are **amongst the best in the world in terms of environmental footprint, animal health and welfare status and sustainability**, as well as quality and safety of the final product. However, much more needs to be done, as outlined later in this Vision Paper, in particular, in order to address improvements and changes in farming practices and challenges like global warming, sufficient remuneration for every stakeholder and global trade of animals that are increasing the risk of exposure to pathogens and emerging diseases.

- In addition, the **livestock sector has to adapt to rapid changes in European consumer preferences** and expectations. Shared by European countries but not to the same extent by third countries, improvements in product quality achieved in Europe could provide a competitive advantage to European systems and products in markets in the near future. Developing exports without optimization of European environmental conditions in full compliance with animal welfare is not a sustainable goal because of ecological issues and European citizens' expectations. Preservation of production capacities of importing countries needs to be taken into consideration as well.

- **Europe can help to reduce the worldwide impact of animal agriculture by exporting its knowledge and knowhow** in terms of world-class research and innovation, verified quality assurance schemes and sustainable farming practices to lead to a change in the livestock systems of third countries, in the context of rapidly expanding production. In these countries, a very significant part of the farmer's income comes

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<sup>6</sup> ESCO INRA 2016

from livestock and emerging diseases threaten animal and human health to a greater extent. It is also necessary to support innovation in

livestock breeding for smallholders in their specific situation in least developed countries in order to improve their livelihood.

### 3. European R&I in livestock farming in a global perspective

Europe needs to place R&I at the heart of public policies to foster sector adaptation towards European sustainable and competitive livestock systems. European science is not isolated and research activity is heavily influenced by other continents.

- European R&I is still highly competitive and far advanced in addressing societal issues, like animal welfare, compared to the rest of the world<sup>7</sup>. However, European R&I is also highly dependent on a European livestock sector with a sufficient critical mass. **European livestock R&I needs an enabling policy environment providing a level playing field comparable to that of our competitors as a platform for knowledge development and application.**

- **Co-construction of knowledge and innovations with stakeholders and society is crucial to avoiding** resistance to innovation adoption.

- **Regulations for animal protection in animal experiments and research** may hamper incentives to research and implementation of innovations in Europe, in particular on New Breeding Techniques. Policy setting in this area should consider third countries' standards to offer a level playing field for actors. It should also challenge knowledge and innovations from other parts of the world (i.e. China, North America) that will be produced for systems that do not fit the expectations of European citizens (e.g. megafarms).

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<sup>7</sup> "Critical Role of Animal Science Research in Food Security and Sustainability", Committee on Considerations for the

Future of Animal Science Research National Research Council of the National Academies, USA, 2015

## Part.2: European R&I to accommodate a paradigm shift in livestock farming within European sustainable circular agri-food systems





**R&I has contributed substantially to making Europe's livestock sector as competitive and efficient as it is today** while producing a diversity of safe and nutritious food. We strongly believe that it will continue to play a major role also in the future. Despite large increases in efficiency and sustainability at farm and value chain levels, livestock production is now increasingly questioned for its environmental impacts, potential health risks and ethical considerations. A challenge is to **address consumers' and societal expectations<sup>8</sup>, environmental and climate impacts** (globally agreed 1.5 degree warming goal), **human and animal health and welfare,**

**protection of animal production by reinforcing global surveillance of emergence and transmission of pathogens while ensuring competitiveness and economic sustainability and safety** of EU livestock production on global markets. **This will require** (sometimes major) **improvements and changes in production,** with a possible effect on production costs and consumption patterns as well. Besides relevant public policies, **continued support for coordinated and integrated interdisciplinary R&I,** and its effective, proactive implementation into practice and policy making are **required to accompany this change.**

## 1. Towards a new paradigm for livestock in European agri-food systems

From an ecological point of view, livestock use plants to produce meat, milk and eggs, notably the part of plants which is not edible by humans (80% of animal feed is not edible by humans<sup>9</sup>). By doing this, **animals contribute to food security and upgrade the nutritional value of proteins** as the biological value of protein of animal origin is higher than that of plant origin. This is basically a virtuous circle fuelled by photosynthesis and solar energy.

**The Green Revolution has brought enormous productivity and production efficiency gains.** For example, compared to 1944, the production of 1 billion kg of milk in 2007 required five times less animals, three times less water, 10 times less land, and the C footprint of milk has been reduced by 2.5.

- **However, imbalances in parts of European agriculture have progressively appeared with livestock and crop production becoming more intensive, more specialised and often spatially separated.** Inputs of fossil energy, fertilizers and biocides (antibiotics for animals, herbicides, fungicides and pesticides for crops) have increased hugely, leading to air and water pollution. Livestock is no longer predominantly fed on material not suitable for human consumption or on feed grown on land unsuitable for growing crops (i.e. grassland). Many systems were optimized using animal genetics and feeding strategies towards a single objective of production efficiency. Sustainable approaches now have to encompass other traits like animal health and welfare. At the same time, food waste has

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<sup>8</sup> Also need to address consumer and societal concerns through clear, factual communication – misinformation is a big issue

<sup>9</sup> “*Livestock: On our plates or eating at our table? A new analysis of the feed/food debate*”, by Anne Mottet, Cees

de Haan, Alessandra Falcuccia, Giuseppe Tempioa, Carolyn Opio, Pierre Gerber, Global Food Security. Volume 14, September 2017, P. 1-8.



reached more than 30%<sup>10</sup> of the food produced which has only marginally been reused in food systems<sup>11</sup>. Actually, the Green Revolution was

based on a linear approach, assuming that resources were unlimited (*Figure 3*).

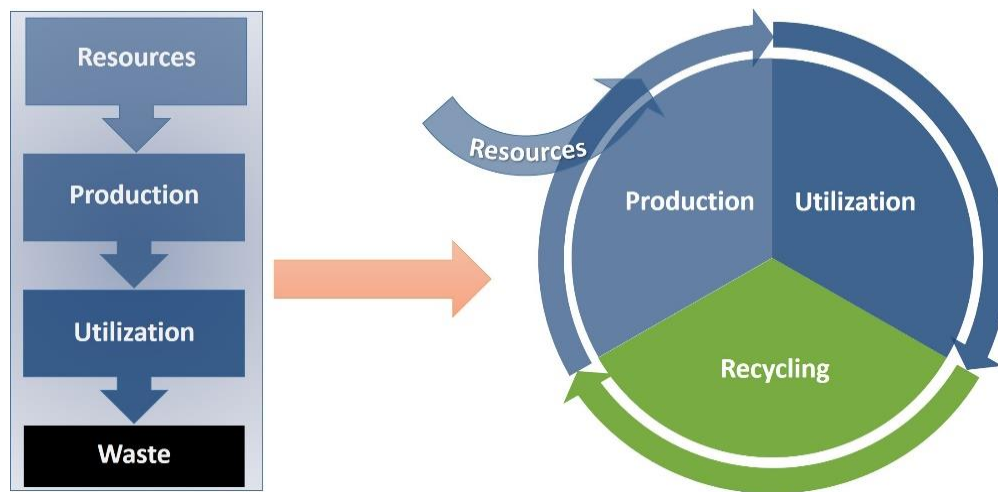


Figure 3: From linear to circular agri-food systems

- **Planetary boundaries and limited available resources require a paradigm shift from linear approaches of resource use to circular resource use with high efficiency at the agri-food system level** and to optimize the use of agro-biomass (incl. crop residuals, food waste, manure) to produce food. **This implies (re)connecting livestock and crop productions to achieve synergies and higher performance** based on new feed sources, fertilizers and biocontrol solutions, and soil fertility. **The European Bioeconomy policy<sup>12</sup>** aims to optimize the production and use of biomass using a circular approach that implies a use of biomass with cascading and recycling approaches in such a way that nothing is lost/wasted but transformed and valued towards more a resource-efficient agriculture. The cascading principle has a primary aim to

produce food (“Food first”) and feed to produce food, then maximize the development of various uses of the biomass, like bio-based products, to end-up with the production of bio-energy.

- **This has to be achieved at a food system level. The European FOOD2030<sup>13</sup> initiative** promotes a boost in circularity and resource efficiency of food systems, stresses the necessity to adopt healthy and sustainable diets<sup>14</sup> and promotes a protein transition given the large carbon footprint of livestock farming. **Consumption of animal products, in particular red meat, is a matter of debate.** The overall consumption of meat per inhabitant is static or decreasing slightly, with a steady decline since the 1980s in beef and sheep meat and an increase in poultry meat (FAOSTAT data).

<sup>10</sup> <http://www.fao.org/food-loss-and-food-waste/en/>

<sup>11</sup> <http://www.fao.org/food-loss-and-food-waste/en/>

<sup>12</sup> “A sustainable Bioeconomy for Europe: strengthening the connection between bioeconomy, society and the environment: Updated Bioeconomy Strategy”. October

2018. European Commission Directorate-General for Research and Innovation Unit F - Bioeconomy

<sup>13</sup> EC-DG research and Innovation, 2017

<sup>14</sup> In Europe, 33 million people are at risk of malnutrition and 20% of the adult population is suffering from overweight.

- **A food transition with a great increase in the proportion of animal proteins in European diets has accompanied the Green Revolution.** Consumption of animal products has increased greatly since the Second World War. Today in Western countries, protein consumption far exceeds the minimum protein intake recommendations and the share of animal protein in human diets represents 60% or more of total protein.

- **A second food transition the livestock sector has to acknowledge is underway.** Following from nutrition science and policies aiming to achieve climate targets, nutritional recommendations now encourage a reduction in meat protein consumption and a shift towards proteins of plant origin (mostly legumes)<sup>15</sup> in some European countries. The World Health Organisation (WHO) recommends a 50/50 balance of animal/plant protein for healthy diets. In particular, depending on populations and their environment, a reduction in red and processed meat is recommended to avoid the risk of colorectal cancer. Thus, it is mostly

overconsumption of red meat and processed meat that must be avoided, but large parts of the European population are already far below the risk threshold (i.e. more than 85% of the European population). The recommendations are reflected in consumption: the market for meat and dairy alternatives have an annual growth rate of more than 10%<sup>16</sup>.

- **However, R&I is still required for an in-depth understanding of nutritional requirements.** Few studies take into account the differences in nutritional qualities between animal and plant proteins. Most studies overlook that animal products bring protein with higher biological value and nutrients supporting human requirements<sup>17</sup>. Grains are either completely lacking these nutrients (vitamins B12 and D, long-chain omega-3 fatty acids), or they contain them in very small quantities or in poorly available forms (vitamin B2 and B6, vitamin A, Iron, Calcium, Zinc). It is likely that more protein than the recommended minimum level of protein intake is required to meet all of the nutritional recommendations.

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<sup>15</sup> See for example McMichael, A. J., Powles, J. W., Butler, C. D. & Uauy, R. (2007) Food, livestock production, energy, climate change, and health. *Lancet* 370, 1253–63 and Tilman, D. & Clark, M. (2014) Global diets link environmental sustainability and human health. *Nature*

515, 518–522 (2014)

<sup>16</sup> DG Agri based in Euromonitor

<sup>17</sup> On the other side, expected benefits of legumes are low glycemic index fiber preventing diabetes, reduced cholesterol, prevention of colorectal cancer.

- ✓ The ATF foresees the future of European agri-food systems lies not on linear but on circular approaches, with an integrated and regenerative use of natural resources and associated agri-biomass.
- ✓ The ATF also believes that the share of protein of animal origin in sustainable diets that is nutritionally adequate, more respectful to the environment and culturally acceptable and affordable<sup>1</sup> must be evaluated considering a holistic approach of nutritional recommendations and environmental performances.
- ✓ A "business as usual" approach is not sufficient to meet the challenges, a paradigm change is needed. Livestock farming must be part of a circular agriculture aiming to optimise the use of resources at farm, regional, national and even transnational levels while avoiding leakage of resources or pollutants.
- ✓ Management of animal health and welfare in the concept of One Health is a prerequisite for well-functioning circular and sustainable agri-food systems.

Investments in R&I in livestock farming, in connection with the plant and food sectors, are fundamental for ensuring food and nutrition security, in contributing to "smart, sustainable and inclusive growth"<sup>18</sup> in Europe and in supporting transitions towards climate-smart, resilient and sustainable production. Therefore, the ATF endorses European R&I policies:

- **The European Bioeconomy strategy** action plan presented by the European Commission on October 11<sup>th</sup>, 2018 aims to develop further a sustainable and circular Bioeconomy, with an aim to **boost employment, growth and investment in the EU** and to develop a sustainable use of renewable resources to address global and local challenges without depleting the limited biological resources of our planet.

- **The FOOD2030 initiative** aims to better organise and scale-up R&I in support of a transition in European food systems. The key priorities are: 1. NUTRITION for sustainable and healthy diets, 2. CLIMATE smart and

environmentally sustainable food systems, 3. CIRCULARITY and resource efficiency of food systems, 4. INNOVATION and empowerment of communities.

- **The Strategic approach to EU agricultural research and innovation<sup>19</sup>:** the ATF supports the general objective to increase responsible productivity and competitiveness of the agricultural sector through knowledge creation and innovative approaches, and to improve the sector's performance with regards to resource efficiency, environmental care, climate challenges, and citizens' concerns regarding more sustainable agricultural production, including health, nutrition, food waste and animal health and welfare. Delivery on the ambition set out in the paper will largely be determined by the uptake of improved techniques, based on prioritisation of the most appropriate approaches or innovations, customised to the farm, system or region. Any R&I initiative must be supported by demonstration into practice ('what works'), involving the relevant end users, and associated to practical benefits.

<sup>18</sup> COM(2010) 2020 final: <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF>

<sup>19</sup> DG Agriculture and rural development, 2016

## 2. Rethinking the place and role of livestock systems in achieving sustainable European agri-food systems

The European livestock sector will have to achieve a new role and responsibility to face the grand challenges. Transitions are needed to contribute to circular sustainable and efficient agri-food systems, to produce food of irreproachable quality, respectful of the animal and environment and to deliver appreciated ecosystem services while limiting the risk of emergence and re-emergence of infection.

This requires efforts in R&I supporting a diversity of production systems and breeds to improve the sustainability of European farming and food systems as a whole, in order to maximise their benefits and minimise their impacts. EU-wide applicable innovations are best reached by ensuring synergies and collaboration between research groups and facilities across Europe.

The development of efficient circular agri-food systems requires R&I (Figure 4):

- **To improve livestock production** considering an efficient use of resources (feed, manures, animal by-products), improving animal health building on the massive advantages of preventive healthcare, controlling infectious disease and zoonosis, continue improving the already high level of animal welfare, reducing emissions to the environment, enhancing delivery of ecosystem services and exploiting digital technologies and precision farming, while maintaining job attractiveness to ensure generation renewal. The ATF consider that healthy livestock is a prerequisite for well-functioning circular sustainable agri-food systems, better prevention and management of infectious diseases expected to generate reduced losses in production, less curative use of drugs and healthier products for the consumer.

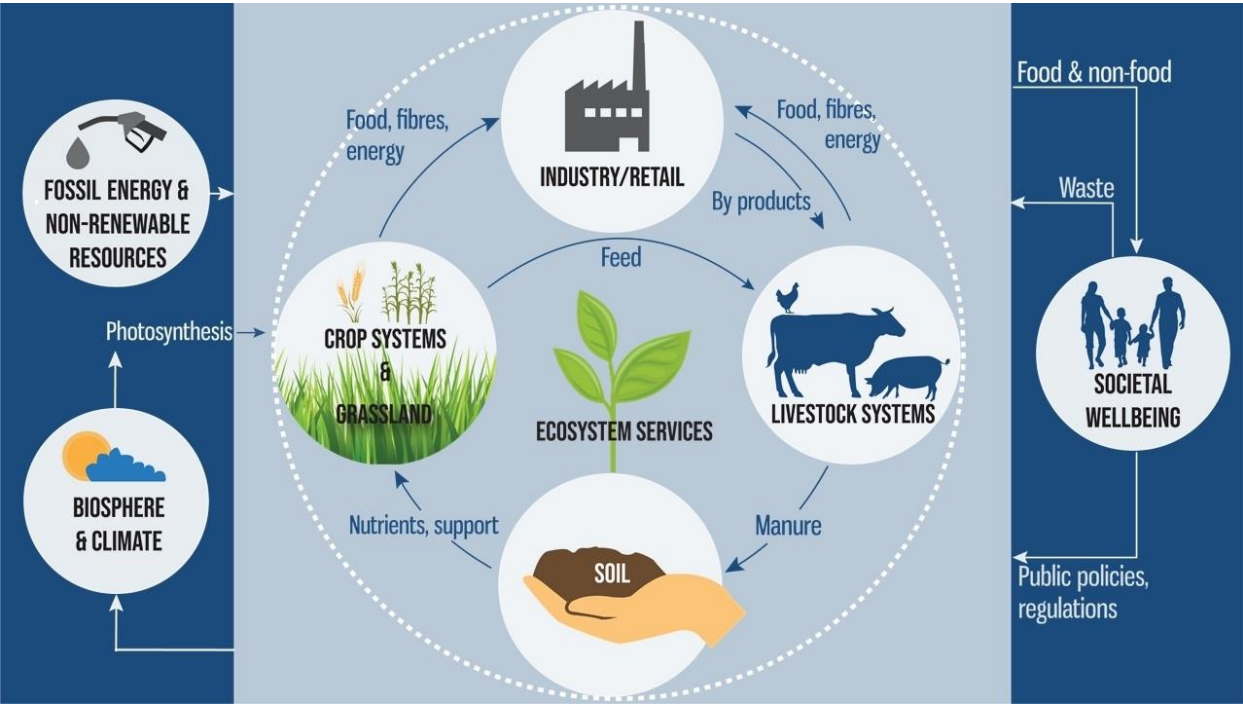


Figure 4: Livestock's role in realizing a European sustainable circular Bioeconomy

- **To rethink and reinforce the connection between livestock and plant systems to find synergies in the use of resources. The approach of spatially and procedurally isolating livestock and crop production as separate production chains is one of the main causes of ecological inefficiencies of the current agri-food system.** Future areas of improvement need to focus on closing nutrients cycles, livestock's contribution to soil fertility, and the valorisation of new sources of biomass. Improved integration of specialised farming systems could create synergies between monogastrics and ruminant production and between livestock and crop producers by facilitating enhanced cooperation between

individual farmers in terms of land use with diversified crop rotations and feed production. This requires not only technical solutions but also improved understanding of farmers' networks, motivations and other social factors necessary for collaboration.

- **To strengthen links between livestock production, food processing and consumption** to address the planetary boundaries and diverse demands of European citizens for animal-based food from the early stage of production to the shelf and to fit the nutritional recommendations, considering dietary requirements of specific populations and notably children and seniors.

### **3. Expected contribution of R&I to achieve the potential of livestock in contributing to circular sustainable agri-food chains**

**Livestock production has enormous potential to contribute** to a more sustainable circular agriculture and food system and support the creation of opportunities for European value chains. This potential needs to be boosted. **Livestock are recyclers by nature, and there is a need to strengthen this role and to better define the conditions under which livestock contribution can be decisive for more circular and sustainable agri-food systems.** This concerns the following areas:

- **Livestock provide protein-rich, safe and healthy food** for humans of high nutritional quality and safety, responding to an increasingly diverse demand. R&I will contribute to better determining the effects of production methods, food technology and food

system organisation on the characteristics of animal products, including their acceptability by consumers and the place and role of animal products for healthy and eco-friendly diets with low environmental impacts.

- **Livestock contribute to greater agriculture, food and nutrition security** with reduced environmental impacts by prioritizing the use of non-human-edible biomass for feed, such as by-products of the food-chain, former food, and waste<sup>20</sup>. Other sources of biomass are grassland, intercrops or new crops (i.e. legumes) contributing to the diversification of crop rotation and providing ecosystem services. In this way the potential of livestock to mobilize proteins from alternative feed stocks is achieved. Thus, livestock play a critical role in

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<sup>20</sup> In Japan, 52% of food waste from the food industry is now used as livestock feed thanks to adequate policies and a certification system.

adding value to this biomass and are mandatory to achieve an optimal utilization of biomass components across industries. R&I should contribute to maximising the benefits of such recycling by defining innovative supply chains ensuring high efficiency and unquestioned safety. This is important because some of these novel feed resources may contain anti-nutritional factors or chemical residues or contaminants and so it's critical to assess the social acceptability of current and prospective novel options for feed production and utilisation.

- **Livestock have huge potential to contribute to soil fertility** and the 4 per 1000 initiative<sup>21</sup>. The overarching goal of this initiative is to assist contributing countries and non-state organizations to develop evidence-based projects and actions towards reducing GHG emissions through protecting and increasing soil organic carbon (SOC) stocks, with the target rate of a 4/1000 (0.4%). It aims to avoid loss of organic matter from soils and enhance soil carbon sequestration with the ultimate goal of improving food security, adapting to and mitigating climate change. Expected contribution of R&I is the development of more appropriate manure management on arable land and grassland and the appropriate management and protection of permanent grassland as reservoirs of soil carbon.

- **Livestock provide raw material for renewable energy production** from manure and wastes from slaughterhouses, hatcheries and dairy industries (biofuel and biogas), thus contributing to the renewable energy transition and bio-refining of animal by-products. The question for R&I is to ensure a good balance between the production of

energy from livestock manure and their role in maintaining soil organic matter (OM) content.

- **Livestock produce valuable by-products as a basis for existing and future value chains via bio-based refining of materials of animal origin.** This concerns meat/bone/blood- meal, which are used in the production of pet food and gelatine, animal fat used for cosmetics, other products from the bio-based industry including innovative fertilizers, and fibre and leather used in the clothing and furniture industries. There has been very little recent innovation in this sector although opportunities exist. Expected contribution of R&I is the development of innovative products including bioactive molecules and functional ingredients. Biorefining of manure is another promising area for innovation.

- **Livestock provide a diversity of agro-ecological, social, cultural and economic services** linked to the vitality of a variety of territories, employment and activity in rural areas, preservation of diverse landscapes (especially in mountainous and marginal regions), biodiversity and cultural heritage. Expected contribution of R&I is to provide robust methods and indicators to evaluate all these issues that are not yet well documented and to develop more holistic evaluation methods of livestock production systems.

- **Domestication and breeding have led to a huge biodiversity of livestock breeds** adapted to different environments and production systems. These breeds do not only contribute to the production of high-quality foods, ecological services and economy of rural communities but they also represent an invaluable gene-pool for future breeding

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<sup>21</sup> <https://www.4p1000.org/> Soils for food security and climate initiative (also called "4 per 1000") has been launched at COP21 as part of the Paris-Lima Action Plan.



programmes. R&I programmes should contribute to the characterisation of this diversity and to the protection and maintenance of different animal breeds, especially those less numerous. Animal biodiversity ensures that livestock systems can adapt to different environments and changing climatic conditions.

**The livestock sector is also part of the solution by addressing its drawbacks.** The ATF considers that coordinated and integrated interdisciplinary R&I, and its effective, proactive implementation into practice can turn societal and environmental constraints into opportunities towards an evolution of production systems. R&I in the livestock sector can bring solutions to the political agenda.

- **Climate change mitigation:** International climate agreements, like COP21, have initiated a new era for climate policies. European livestock farming, as the main contributor to GHG emissions in the agricultural sector, is under pressure. Expected contribution of R&I in Europe<sup>22</sup> is to support the sector in achieving close to CO<sub>2</sub> neutrality for monogastrics and a 40% GHG reduction in ruminant production systems by implementing mitigation measures, enhancing carbon storage under grasslands soils, making better use of manure, generating energy from manure and other animal-based sources and reducing enteric methane production in ruminants by selecting low emitting animals and improving diets (feed additives, use of legumes).

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<sup>22</sup> The Food and Agriculture Organisation (2014) estimates that a -30% reduction of the sector's GHG emissions is achievable at world level by implementing best practices.

<sup>23</sup> Nitrate Directive (Directive 91/676/EEC)

- **Prevention of local pollution:** nitrate<sup>23</sup>, phosphorus and ammonia losses are reinforced by highly concentrated and intensive animal production (pork, poultry, beef, milk). Livestock concentration in some regions has developed due to favourable natural conditions, available technologies, agglomeration economies (advantages linked to geographical proximity among food-chain actors), farmers' skills and public policies. Huge improvements have been achieved in input use efficiencies at farm gate. The expected contribution of R&I for the next decade is the development of innovative solutions, especially based on technological, organizational and economic breakthroughs (e.g. local bioeconomies) and by fully including livestock farming in a circular food system to achieve a major reduction in local impacts on the atmosphere and water catchments.

- **Reduced vulnerability to health threats and risk of antibiotic resistance**<sup>24</sup> are fundamental for public health and livestock efficiency. This is particularly the case in the context of climate change that challenges the adaptive capacity of animals and contributes to the emergence of new threats. 60% of emerging pathogens in humans are of animal origin and more prudent use of antibiotics is crucial to ensure long-term treatment options. Farming practices with outdoor access for animals are gaining increasing market and consumer preferences but may increase the risk of emerging diseases that need to be properly anticipated. R&I can help to develop farming and food systems with reduced health vulnerability and an increased ability to face infectious challenges, for example by breeding

<sup>24</sup> In 2015, the World Health Organisation adopted a global plan to combat resistance to antibiotics under the "One World, One Health" conceptual framework. In June 2017, the European Commission adopted the new EU "One Health Action Plan" against antimicrobial resistance (AMR).

or prevention measures. In parallel, prudent use of antimicrobials (antibiotics, anthelmintic) requires that health and welfare be placed at the heart of innovative farming systems.

- **Animal welfare standards** are a growing concern for consumers and citizens. Society's vision of healthy animals as simply being exempt from infectious diseases (including zoonosis) has clearly evolved. Animals are now perceived to be healthy when they are in a state of complete physical, mental and social well-being. The concerns are reflected in legislation<sup>25</sup> and in industrial strategies. Striving for healthy and well managed animals responds to the ethical expectations of citizens. R&I should support integrated management of health and welfare and "sustainable animal stewardship" will provide a basis for achieving these objectives.

- **European protein security** is high on the agenda of the European Commission and the European Parliament with the ambition to stimulate European protein crop production<sup>26</sup>. It is encouraged by a scarcity of protein sources for food and feed, which might generate a risk for Europe with volatile and projected high prices of imported feed and food. European livestock farming is often criticized for its apparent inefficiency and its dependency on protein-rich feed resources that are imported and/or competing with human food production. Expected contribution of R&I is the development of high quality protein from mixed swards and other perennial crops (such as lucerne) via bio-refining which will partly replace imported soybean concentrates for

pigs and poultry without compromising feed resources for dairy. This would also have the advantage of allowing cash crop and cereal farmers to include perennial crops into their rotation as a commercial crop, which again will improve carbon sequestration and reduce nutrient losses and pesticide use in a win-win strategy. This is particularly the case for dual-purpose crops, where livestock use the non-edible part as feed (cakes for example after oil extraction).

- **Job attractiveness and livestock farmers' income** are a tremendous problem that policy makers want to address in order to preserve European agricultural production in rural areas and to limit urbanization and migration to the cities. The economic viability of small to medium farms must be ensured if we want to secure self-sufficient animal production systems in the EU and protect the vitality of rural areas. Resilience to short and long-term external perturbations such as weather, global input and output prices must also be enhanced. R&I will support the development of technologies and innovations in agriculture that can offer career opportunities for young people. To enable vibrant business and a rural renaissance, rural areas require a boost in infrastructure and the development of new market mechanisms and value chains. This includes smart precision farming on marginal lands, payments for securing ecosystem services, community-owned bio-refineries, and refineries for manure, slurries and other wastes directed towards energy and fertilizer production.

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<sup>25</sup> In May 2017, the "One Welfare" concept was launched to emphasize the links between animal welfare and human wellbeing and acknowledge that both depend on a well-functioning ecological environment.

<sup>26</sup> On 22 November 2018, the European Commission published its report on the development of plant protein in the European Union:  
[https://ec.europa.eu/agriculture/cereals/development-of-plant-proteins-in-europe\\_en](https://ec.europa.eu/agriculture/cereals/development-of-plant-proteins-in-europe_en)

## Part 3. A framework for innovation development in the livestock sector: mobilizing new concepts and approaches



The ATF proposes to develop an ambitious R&I European programme with innovative themes and integrated approaches, cross-fertilizing different scientific disciplines and levels of integration. Beyond improving livestock production systems which is a priority, we need to consider a larger picture extended to the whole agricultural sector, stressing the connection between plants and livestock and on the numerous contributions of livestock to soil fertility, landscape management and associated biodiversity issues. This approach has to encompass the whole agri-food chain (farmers, food industry, short supply chains, retailers and consumers). For developing a systemic approach, we consider that a system (animal, herd, farming system, group of farms, etc.) can be seen as a living organism whose metabolic function is to be optimized in a holistic way through multi-scale approaches.

The ATF has designed a framework of different pathways towards the adaptation of livestock systems into circular sustainable agri-food systems. This framework allows various approaches to be combined that offer a diversity of solutions to address the specificities of the large variety of European livestock systems. Different components should be mobilized independently or simultaneously to produce innovations. Four main levers are described as levers for improvement. Agro-ecology<sup>27</sup> and circular economy principles are key components for the development of livestock production systems that fit the goals of sustainable agriculture, food chains and territories. Technological advances in farming systems, biotechnologies and digital tools, as well as better governance of the sector will help reach the objectives (Figure 5).

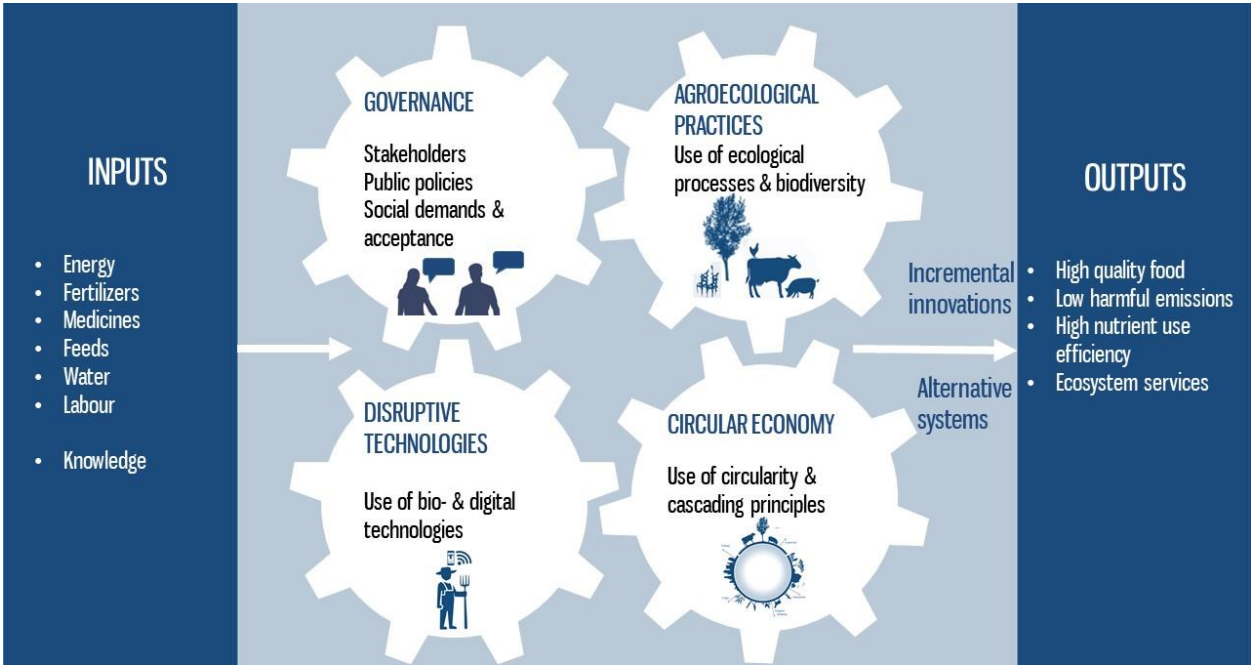


Figure 5: Framework for research and innovation to enhance the role of the European livestock sector in circular agri-food systems

<sup>27</sup> Agro-ecology includes “centrality of intensive use of ecological processes and preservation and use of biodiversity”

A circular Bioeconomy approach implies a shift from a focus on maximising the efficiency of single products to a focus on optimising the use of natural resources within the whole food system. **This requires us to deeply rethink research questions** from animal biology to the integration of production systems in the territories and food chains. It also requires novel partnerships for R&I and the development of new business models. Given the diversity of context specificities, we advise

to strive for a mosaic of territories with varying degrees of sustainable intensification, agro-ecological developments and circular economy, interacting with each other, and to work on pathways for various scenarios. In further sections, we describe our vision on the potential of each of those four levers to support the transition in livestock farming systems and consider the breakthrough from a research point of view.

## 1. Agro-ecological practices to increase the sustainability of livestock farming systems

The ATF recognizes that “Sustainable intensification” and “Agro-Ecology” are two complementary frameworks of ecological modernization of agriculture aimed at optimizing food production while preserving natural resources. The concept of **agro-ecology**<sup>28</sup> encompasses the broad application of biological processes and biodiversity at all levels of organization (animal, herd, soil, crop, system, region) to stimulate natural processes to allow for an agricultural production that is more efficient, more self-sufficient, more resilient, able to provide ecosystem services and to maintain ecosystems in good health. Biodiversity is seen as a resource that must be valued and preserved<sup>29</sup>. The goal of **sustainable intensification**<sup>30</sup> is primarily to increase food production from existing farmland in order to spare land while minimizing pressure on the environment. It strives to increase nutrient use efficiency to minimize negative impacts on the

environment. Planned improvement of practices and circularity are among major levers of action but the provision of ecosystem services is not a priority and biodiversity in agro-ecosystems is considered functionally negligible. “Sustainable intensification” is sometimes qualified as “**weak agro-ecology**”. **The main areas** of improvement reflecting both sustainable intensification and agro-ecological pathways are:

- **More efficient and robust animals able to cope with varied farming and climatic conditions without impairing product quality.** Breeding objectives are renewed. Genomic selection allied to knowledge on genetic, physiological, and behavioural capacities, defence mechanisms of animals and their interaction with the environment can now support the selection of efficient and resilient animals in a wider range of farming systems. The challenge is the willingness to renew the

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<sup>28</sup> Agro-ecology has various definitions: practices, political movement in response to the intensification of agriculture. In this document, agro-ecology is considered as an agricultural practice and not at all as a social movement.

<sup>29</sup> FAO, Biodiversity Group

<sup>30</sup> For the group on “sustainable intensification” of FACCE JPI, sustainable intensification is defined as “*focusing on the centrality of nutrient use efficiency*”<sup>30</sup>, mainly with the use of digital technologies (Concept note FACCE JPI).



breeding objectives and implement a new approach in animal biology, shifting from a short-term view to a long-term view on their life cycle. This will make it possible to evaluate and understand the ability of animals to manage disturbances (response and recovery) and to support these physiological processes by nutritional and health management. It will also enable us to study the allocation of resources and the flexibility of this allocation to acquire a resilience mechanism and to maximise agro-ecological efficiency (addressing ecological and economic goals) under given conditions during the lifespan<sup>31</sup>. Using this knowledge, advanced breeding goals must better consider genotype-environment interactions in the future in the prediction of breeding values of individuals.

- **Integration of health and welfare of animals at the level of the agricultural sector.**

A paradigm shift is needed which requires biosecurity measures such as vaccination and improvement of hygiene to be revisited. The aim is to achieve high-performing farming systems integrating biosecurity, sustainability and welfare. At the level of the animal, the challenge is to favour “natural” processes of pathogen regulation including competition between microbial communities (microbial ecology, biology of etiological agents), selecting animals for disease resistance and boosting the natural immunity of animals against disease and infections. It requires the development of new breeding programmes, innovative therapeutic solutions (pre- and probiotics, immunostimulants, etc.), biosecurity measures and exploitation of the interrelations between animal welfare and animal health. Innovation to improve animal

welfare should be developed from an integrated scientifically sound approach based on a good understanding of animal behaviour and perception of their environment and monitoring of health and welfare with valid welfare indicators. At the level of the production sector, the challenge is to rethink the farming system and trade-offs between production, health and welfare. At a global level, the challenge is to define new biosecurity and policy measures that should surround international animal trade to limit the spread of farm animal plagues. For some of these plagues threatening Europe, intervention strategies still have to be defined, including innovative research for the development of effective vaccines. Cooperation with third countries, including the low and middle-income countries, is required for improving the management (surveillance, prevention, control) of exotic diseases and antimicrobial resistance (AMR) issues in Europe.

- **Optimisation of the metabolism of agro-ecosystems with livestock.** This includes the search for greater food/feed self-reliance in European livestock, reduction of emissions (mostly GHGs), optimization of nutrient recycling (nitrogen (N), phosphorus (P), carbon (C)), increased contribution of livestock to soil fertility and carbon sequestration, and provision of ecosystem services. Finally, this includes the coexistence of different livestock and food systems in a territory and how the interactions can provide adaptive and innovative solutions to farms, sectors and landscapes. All these challenges require to develop integrated solutions considering options based on animal genetics, feeding and husbandry, manure and crop management,

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<sup>31</sup> Considering animal as system is a breakthrough for research. The comprehension of animal phenotypes elaboration require to understand the interaction between genome, epigenome regulation, microbiome,

central nervous system and the environment in early stage of development (from fecundation to the beginning of productive phase) as well as interactions between vital and productive functions in adult animals.



spatial and temporal organisation of landscape mosaic and optimal land management.

- **Use and preservation of biodiversity** which concerns the use and proper management of animal genetic resources for a variety of systems by mobilizing knowledge on genotype × environment interactions and how these can be optimised on-farm. This also concerns the valorisation of plants with interesting characteristics, especially legumes that contribute to nitrogen (fertilizer) and protein (feed) for livestock and might contribute to animal health thanks to some of their secondary metabolic compounds. It also includes the preservation of genetic resources and biodiversity (livestock breeds, plants, wildlife, habitats) to maintain options for adaptation to a variety of environments and contexts. It includes opportunities relating to

climate change, as well as to the development of local and/or labelled products appreciated by the consumer and with added value for farmers. Livestock production can make a contribution to wider biodiversity objectives and preservation of habitats. Appropriate metrics, at a variety of scales, and deployment of new technology to measure and manage biodiversity, are required.

- **Organic agriculture and similar low external input farming systems** already make an important contribution to production and consumption across Europe and are expected to grow further. This provides a consumer-supported learning laboratory for the innovation of agro-ecological practices with potential impact in the wider livestock industry.

## 2. Circularity towards more efficient and healthy agri-food systems

**The concept of circular economy** is partly inspired by industrial ecology looking to prevent industry waste by fostering the use of residues as raw materials. Such an economy operates in a loop, avoiding wastes and leakage. Optimizing circularity and cascading effects between crops, livestock and food industry will help to produce animal products with fewer human-edible resources, fewer resources produced on cropland, and less wastage thus maximizing the global efficiency of food systems. Feed, fertilizer and soil sustainability are key in this change. The circular economy can be envisaged at different scales: internally at farms that have several production systems, between neighbouring farms, between neighbouring territories, between production basins (e.g. between specialized livestock breeding areas or annual

crops), even between countries. The exchanges concern all types of biomass (plant, livestock manure, animal transfer). The management of sanitary safety and the traceability of flows remain, in all cases, a major issue. The priorities are:

- **Full exploitation of the ability of animals to convert a diversity of biomass not directly edible by humans into high-quality food** has huge potential in the context of resource scarcity. This involves maximising the recycling of agri-industrial by-products, food left-overs, former foodstuffs, new by-products (e.g. from green biotechnologies), new protein-rich feeds produced by recycling unused biomass (earthworms, insects), aquatic resources (algae), single cell protein and yeast extracts from wood biomass into the food system. This requires improvements in

digestive efficiency<sup>32</sup>, enabling policies, support for local bioeconomies and reinforcement of food safety measures. Livestock farming also allows implementation of more diverse and more sustainable rotations producing local protein (legumes, intercropping, catch crops, grass) and reductions in the use of pesticides while producing more than one crop per year.

- **Full exploitation of manure and other animal by-products as valuable resources.** This concerns the benefits and risks of livestock manure, which is a source of carbon, humic substance and microorganisms but also medicine residues, for soil<sup>33</sup>. This also concerns the development of new technologies to reuse N and P in the form of standardized fertilizers after extraction, or the production of compost that can be transferred to specialized cropping systems whose soils are depleted in organic matter. Extraction of high value ingredients from manure and production of biogas are other additional alternatives although the trade-off with soil C content must be scrutinized in this latter case. Regarding animal carcasses, new developments are achievable in

the domain of production of protein with antibiotic activity, protein that can be used as a functional ingredient or protein having self-structuring properties that can be used as support for medicines.

- **Improved quality of animal products.** This requires us to develop a holistic approach to food systems from production to product processing and consumers' expectations and health. Progress will need to address the intrinsic quality of food of animal origin which includes its nutritional profile (e.g. micronutrients, content of functional components, including microbiota that may reduce the risk of lifestyle diseases), its variation according to production system and interaction with food processing. Furthermore, a better understanding of the effects of animal-based food on human health is required. Improving the extrinsic quality of food is another issue that fits consumer demand for less environmental impact and welfare issues. Deepening knowledge on the effects of animal products on human health will contribute to highlighting the controversies about meat consumption on a scientific basis.

### 3. Innovative (bio)technologies to enhance the benefits of livestock systems

**Disruptive technologies may support the objective of having the most efficient use of resources in agri-food systems and suitable animal and management methods.** The combined use of various biological and technological approaches is innovative and

also has potential to produce knowledge and renew predictive biology approaches bringing significant improvement in livestock breeding and management. Progress is expected in three domains:

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<sup>32</sup> The levers are animal genetics, use of feed additive and innovative feed technologies and new objective for plant breeding to enhance the value of plants along the value chain without impacting the primary product.

<sup>33</sup> Progress will come from a better understanding and quantification of the dynamics of mineralization of organic forms and effects of biological life of the soil according to the physicochemical characteristics of manure.

- **Advances in biotechnologies, the use of deep knowledge on the genome and high-throughput phenotyping approaches** will allow fine-tuned selection of complex traits of socio-economic interest such as robustness, adaptability, resource efficiency, easiness or product quality, while avoiding undesirable side effects. This will include technologies to monitor and provide early detection of animals that (are expected to) deviate from the norm. It will also unravel host-pathogen environment interactions, supplying a pipeline of new drug targets for better health. Moreover, genomic approaches can help to better assess infectious diseases and zoonosis. In addition, **mastering animal microbiomes and epigenomes and implementing early programming** (in utero, in ovo, during the perinatal period) will contribute to shaping animals that will be adapted to the specific conditions of the farming systems and to improving animal

efficiency (digestive microbiota), resistance to pathogens (holobiont), and adaptive behaviours as well as product quality. **Development of New Breeding Techniques** (NBTs) like Genome Editing will help to obtain biological understanding of the genes underlying complex traits. In conjunction with traditional breeding techniques and genomic selection, it might pave the way for a new era of breeding by speeding up the introgression process (incorporating alleles of interest from one breed to another), thus accelerating genetic improvement for more adaptive and resilient breeds without impairing efficiency.

- **Advances in digital technologies** bring a range of technologies into the agricultural sector, including sensors, robotics, precision farming, the Internet of Things (IoT), nanotechnology, biotechnology, next generation sequencing and block-chain. The precision farming market alone is estimated to

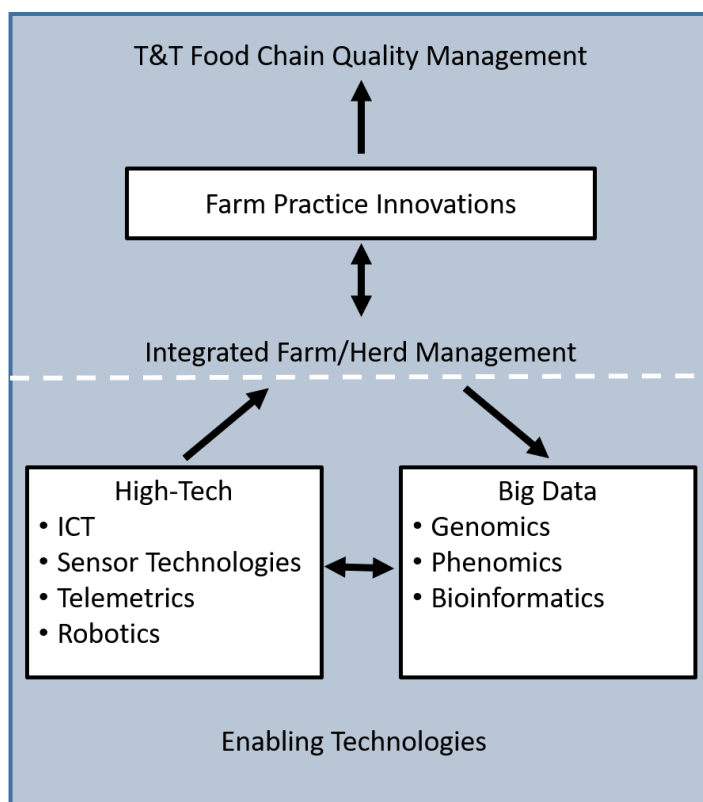


Figure 6: Implementation of Precision Livestock Farming at farm and food chain level

grow from USD 3.20 billion in 2015 to USD 7.87 billion by 2022<sup>34</sup>. **At the farm gate**, these technologies will provide new tools and concepts for the management of livestock by continuous, automated, real-time monitoring of an increasing number of parameters. This includes management of feed use and production, monitoring of circulating pathogens and management of health, monitoring of behaviour, and assessment and management of animal welfare and reproduction. Research should not miss out on this new panoply of techniques and information but should avoid the pitfall of getting bogged down by forgetting the real stakes for livestock farming. The efficiency of these devices to improve technical performance, the consequences on farmers' activities and profitability of investments should be carefully evaluated. **Beyond the farm gate**, enormous amounts of large-scale data on observed phenotypes, combined with genomic selection, will improve the precision of animal husbandry. Continuous and automatic handling of a huge amount of data presents new opportunities for quality management in food systems. It also provides a basis for certification and increased transparency in Business-to-Business

relationships, as well as an opportunity for consumers looking for information on the intrinsic quality of food. **Data processing** will play a central role and there is need to explore business models to ensure that information systems comply with the FAIR<sup>35</sup> principles and bring value back to data generators (producers and consumers).

- **Advances in technological bio-refinery processes** enable the development of a circular Bioeconomy. This includes re-use of N and P from manure for closing nutrient cycles, replacing chemical N fertilizers and preserving P. This also includes processes to improve valorisation of a large diversity of biomass like organic waste streams, agro-industrial by-products, by-products from green biotechnologies, former foodstuffs, and new protein-rich feeds or n-3 fatty acids-rich resources (algae) as feed while ensuring safety and ethical quality of the products. The extraction of high quality protein feeds from grasses and perennial crops via bio-refining and subsequent use of the residuals for other valuable ingredients and for biogas provide new mechanisms for integrating livestock production in a circular Bioeconomy.

#### 4. Governance of the sector and cooperation among stakeholders

**Governance and cooperation** between stakeholders (consumers, farmers, advisors, industry, policy makers, interested citizens, scientists, innovation support organisations, NGOs etc.) are essential components for the successful implementation of healthy and sustainable agri-food systems that require new shared perspectives, new partnerships, new

business models and new social organisation. Stakeholders should be engaged within innovation processes and contribute to decision-making on the development path to be followed. Progress is expected in the following domains:

<sup>34</sup> <http://www.marketsandmarkets.com/Market-Reports/precision-farming-market-1243.html>

<sup>35</sup> FAIR : findable, accessible, interoperable and re-usable

- **Ethics in animal production.** Farmers are often stigmatized in urbanized European societies largely disconnected from the practical realities of livestock farming but with strong demands relating to the responsibilities of humanity towards domestic animals. We need to understand those growing trends from a historical, sociological and philosophical point of view. In addition, the definition and thus the measurement of animal welfare, as well as its legal and economic status, are problematic and require investigation. Is it a public good or an attribute of livestock products? Can it be promoted effectively by public or private standards or labelling. This knowledge will help make the required changes in practices and technical standards more practical and convincing.

- **Understanding of the development of controversies** about livestock systems and meat consumption and the **diversity of consumer attitudes** and expectations (based on region, demographic, etc.) may provide incentives for actors to build constructive dialogue and mutual understanding between rural areas and urban citizens. Finally, **the role of public policies and supply chains** in the choice of consumers and pattern of consumption of meat and meat substitutes should be highlighted. Supply chains dynamics are significant because they often move ahead of existing policy, mediate market signals from consumers to primary producers and influence new product development.

- **Evaluation and regulation of non-market effects of livestock farming**, whether

they be negative, such as GHG/ammonia emissions or more positive, such as landscape maintenance, employment, cultural and heritage effects of livestock farming, and the controversies arising from these different aspects. Finally, it is important to deepen the multi-criteria analysis to evaluate this group of performances (suite of services) that can act in synergy or in competition and evolve according to the spatial and temporal scales considered<sup>36</sup>. A key point concerns the analysis of the determinants of structural changes (size, number of farms) and their consequences on the different effects of livestock farming.

- **Design of new and consolidated public policies (Common Agricultural Policy and local/regional policies) and regulations aiming to guide and support efforts** towards improved environmental and societal performance. This is underpinned by the question of the monetary evaluation of environmental and social services (incentives) and negative environmental impacts (taxation)<sup>37</sup>. This also requires us to better evaluate the barriers and levers for uptake of innovations, adaptation of knowledge and adapting innovation to local contexts and the best tools to incentivize changes.

- **Increase in job attractiveness and farmers' income.** It remains a tremendous problem to keep employment in rural areas (not only farmers but new jobs oriented to technical farming), to secure economic viability of small to medium farms and to maintain self-sufficient animal production. Workload and work organisation are key issues, as well as attracting and retaining skilled labour. Beyond

<sup>36</sup> There are contradictions between the benefits and downsides of livestock farming relating to changes in scale. Geographical concentration and intensification of livestock is correlated with the highest agricultural incomes, better maintenance of regional employment, better export performance and reduced GHG emissions. However, this situation is unfavourable for employment at the European level, for the association between crops

and livestock and also for rates of local pollution, which require expensive management and are a source of conflict.

<sup>37</sup> In line with public money for public goods. This will involve developing indicators to evaluate performance and the provision of services, to prioritize, assess and balance objectives that may be contradictory.

the progress expected with digital technologies, innovative ways of cooperation among various stakeholders would create opportunities for attractive careers for young people and thus improve rural vitality.

- **Assessment of the livestock system.**

Assessment of the production system is important for monitoring changes over time against baseline or reference data, in order to be able to prove some of the current statements and also to improve. It will also be necessary to properly meet society and consumers' demands from the industry and to evaluate policy impacts. The methods should include predictive values/indicators to develop decision support systems to predict policy

scenario impacts on multi-dimensional aspects and to intervene sooner regarding circular and climate-friendly production. Research should be clear on the differences between creating scenarios and making predictions, especially in communicating with society and consumers. The assessment of these complex systems requires holistic approaches to capture the multi-dimensional aspects and to avoid wrong decisions based on a vision that is too narrow. This requires a review of life cycle assessment (LCA) methodologies which should consider all services of livestock production systems, including those that are hardly accountable at the moment.



## Part 4. Expected impacts of future livestock research and innovation priorities



Moving livestock production systems towards increased sustainability is a crucial objective to foster agro-ecological, social and economic services provided by the livestock sector. The following impacts can be expected from future R&I:

- **Maintain an innovative and efficient research base in animal production in Europe** which will sustain European industry and R&I leadership and independency, including on topics and methodologies that can be challenged by society in case of further developments in breeding and husbandry.

- **Promote a diversity of livestock systems** (size and modes of production including organic) adapted to territorial specificities and to consumer demand.

- **Increase preventive healthcare** to reduce the vulnerability of livestock production systems to extrinsic threats and notably to infectious diseases and allow for careful use of antibiotics.

- **Improve European livestock production autonomy** and maintain self-sufficiency in sourcing **by linking more closely plant and animal production**, by **valorising organic streams** that are not suitable for

human consumption, by converting losses from the food industry into ingredients for the feed industry, thereby keeping nutrients in the food chain, and by **developing alternative feed supply strategies** that reduce the EU's reliance on soy imports.

- **Foster rural vitality through the supply of agro-ecological, social and economic services** such as preservation of biodiversity and landscapes (especially in mountain and marginal regions), cultural heritage, attractive rural employment based on new practices and technology-based innovation.

- **Regain consumer confidence** by improving practices relating to animal welfare and health, environmental impacts, mitigation of emissions, product safety, enhancing traceability and nourishing a constructive dialogue with society at large (open innovation, participatory science).

- **Contribute to global food supply** either through export of high quality food products (nutritional, sanitary, organoleptic) or by transfer of knowledge and know-how, especially by highlighting the unique selling point of the European livestock sector regarding sustainability and responsibility.



**ANIMAL TASK FORCE**

Rue de Trèves 61 – BE-1040 Brussels

Website: [www.animaltaskforce.eu](http://www.animaltaskforce.eu)

 @AnimalTaskFrc

**SECRETARIAT**

149 rue de Bercy – FR-75595 Paris

✉ [info@animaltaskforce.eu](mailto:info@animaltaskforce.eu)

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