atf animal task force

A European Public-Private Partnership

A Vision Paper for a sustainable livestock sector in Europe

Challenges, ways of progress and suggested priorities for research for Horizon Europe to enhance innovation and sustainability in the livestock production sector of Europe's food supply chains

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

About the Animal Task Force (ATF)

ATF 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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Abbreviations and networks

AMR: Antimicrobial Resistance
ASF: Animal Source Food
Cofund ERA-NET SusAn Sustainable Animal Production
C/N ratio: carbon/nitrogen ratio
CO_2: Carbon dioxide
COP 21: 2015 UN Climate Change Conference in Paris
DG Agri: Directorate-General for Agriculture and Rural Development (European Commission)
DG Clima: Directorate-General for Climate Action (European Commission)
DG Connect: Directorate-General for Communication Networks, Content and Technology (European Commission)
DG Envi: Directorate-General for Environment (European Commission)
DG RTD: Directorate-General for Research and Innovation (European Commission)
DG Sante: Directorate-General for Health and Food Safety (European Commission)
EC DGs: European Commission Directorates Generals
ETP Plants for the Future European Technology Platform
FoodForLife ETP: Food for Life European Technology Platform
EATiP ETP: European Aquaculture Technology and Innovation Platform
FACCE-JPI: Joint Programming Initiative on Agriculture, Food Security and Climate Change
FAO: Food and Agriculture Organization of the United Nations
GASL: Global Agenda for Sustainable Livestock
GHG: Greenhouse Gases
GMO: Genetically modified organism
GRA GHG: Global Research Alliance on agricultural greenhouse gases
HDHL JPI: Healthy Diet for Healthy Life Joint Programming Initiative
ICT: Information and Communication Technologies
IoT: Internet of Things
LCA: Life Cycle Assessment
N/P ratio: nitrogen (N) / phosphorus (P)
OH^-: hydroxide
PU: Production Unit
R&I: Research & Innovation
RRI: Responsible Research and Innovation
SCAR: Standing Committee on Agricultural Research
SCAR CWG-SAP – SCAR Collaborative Working Group on Sustainable Animal Production
SCAR Strategic Working Group AKIS - SCAR Agriculture Knowledge and Innovation Systems
SD: Sustainability Domains
SRIA: Strategic Research and Innovation Agenda
TP Organics: European Technology Platform for Organic food and farming
UN SDGs: Sustainable Development Goals of the United Nations

Background

In advance of Horizon Europe, ATF issued a Position Paper[1] in March 2018. In February 2019, ATF published a "Vision paper[2] 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". Then, in 2021, ATF published a Strategic Research and Innovation Agenda (SRIA)[3], which derives largely from the ATF Vision Paper and aims to provide suggested priorities for R&I within Horizon Europe towards a resource-efficient, sustainable, competitive and safe livestock production sector in Europe fostering more sustainable and resilient food systems.

- The present document is an update of previous documents which considers recent evolutions of the European context concerning the sustainability and the resilience of food systems. This concerns the re-emergence of food security.[4]

- **It sets out a new Vision on the future role of responsible livestock systems in sustainable agri-food chains and the pathways of progress.** The driving forces and the objectives to be achieved are analysed. It presents the role of R&I and paths for progress to up-scale the contribution of a diverse set of European livestock farming systems in providing nutritious, safe and healthy animal products and a range of goods and services fitting the numerous societal demands while remaining within the planetary boundaries. **An additional document (*Strategic Research & Innovation Agenda*) presents key areas and suggested priorities for R&I and their overall expected impacts**. This part describes priorities derived from the Vision Paper while considering recent and ongoing research and new instruments promoted by the Commission (missions, partnerships).

Introduction

The scope of the document is European terrestrial livestock, including herbivores (ruminants, horses, rabbits) and monogastrics (pigs, poultry). ATF considers the diversity of farming systems and agroecological based production systems without pre-conception as we need to improve the sustainability of the current European intensive systems, as well as promoting the growth of low input systems including organic farming. All these systems have their own strengths which can be further enhanced and limitations which can be reduced to fit the objectives while increasing the resilience of the whole sector and in close relationship with cereal crop and vegetables production. Interrelations between green and blue economies should be carefully considered to achieve a sustainable European food and farming system, as well as insect breeding and production for feed and processed animal protein (PAP) in the context of the circular economy.

[1] http://animaltaskforce.eu/Portals/0/ATF/2018/ATF_Position%20Paper%20towards%20FP9_final.pdf

[2] http://animaltaskforce.eu/Portals/0/ATF_Vision_Paper_2019.pdf

[3] http://animaltaskforce.eu/Portals/0/ATF/ATF_Strategic_Research_and_Innovation_Agenda_April2021.pdf

[4] European Commission, 2023. Drivers of food security, Commission staff working document

A vision for the future of the European livestock sector

The roles of livestock production systems to contribute to a sustainable and multifunctional food system in Europe.

Drivers of changes and challenge

Projections of how the world may develop over the next decades, point towards the unsustainability of exploitation of the earth resources, and predict irreversible changes to climate and biodiversity. Focus needs to be on agriculture as it uses 37% of the world's land, 70% of all fresh water, and 30% of the total annual global energy consumption. In addition to global issues, trend analyses reveal growing customer expectations about safe, healthy and nutritious products, environmentally safe and more sustainable production methods in Europe. To truly match the societal expectations, a full conversion of the agricultural sector would be required, and target nearly every aspect. Changes should be introduced across the entire agricultural value chain including behaviour of the end consumer. Living up to customer expectation should therefore be seen as a progressive process, possibly leading to increased prices for food at consumer level. Society can influence sustainable food production through the political system, but also through consumer choice.

The European Green Deal[5] and related European strategies (Bioeconomy Strategy, Farm to Fork Strategy[6] and the Biodiversity Strategy[7] for 2030, Open Autonomy Strategy) draws the general framework and application to farming and food systems. Ambitious sustainability goals for agriculture are proposed, i.e.: moving towards a carbon neutral Europe by 2050, reducing the use of pesticides and antibiotics by 50% and nutrient losses by at least 50% (with a 20% reduction in fertiliser use), restoring ecosystems and biodiversity, developing deforestation-free value chains, reaching 25% of land areas devoted to organic farming, 10% of land areas with high diversity and agroecological infrastructures. Simultaneously, the Farm to Fork Strategy sets ambitious targets towards increased resilience in food systems to anticipate climatic, environmental, and health shocks. Animal welfare is becoming a priority with the EU promising to consider options for increased animal welfare, sustainability and nutrition labelling. In addition to the United Nations Sustainable Developments Goals, FAO Sustainable Livestock Transformation and the climate change and biodiversity COP commitments, these European policies open the way towards a rejuvenated agriculture that stays within the planetary boundaries and improves the socio-economical role of agriculture. The goal is to achieve a multi-performing, climate smart, resource efficient European agri-food systems that provide safe and nutritious foods along with a wide range of goods and services such as healthy soils, restoration of the quality of ecosystems and biodiversity, attractive landscapes, thriving rural communities, etc. and that provide fair livelihoods for livestock farmers. In addition, the European Commission committed, as part of the agricultural version of the Green Deal, to present a broad review of the regulations on animal welfare, dating back more than twenty years.

The political context has recently evolved. The Ukrainian crisis has brought to the forefront the urgent need to preserve our food sovereignty and at the start of 2024, the European agricultural crisis has caused a wind of hostility to blow against the measures of the Green Deal and its agricultural aspect. The

[5]Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal COM/2019/640 final

[6]Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM/2020/381 final

[7]Communication from the European Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions. EU Biodiversity Strategy for 2030 Bringing nature back into our lives. COM/2020/380 final

European Commission postponed its animal welfare reform project and just presented a minimal revision of transport rules of animals at the end of 2023. However, the medium-term objectives remain and they are clear and ambitious. We must maintain our food sovereignty while reducing the environmental impact of food systems through development and deployment of more sustainable production methods than today in a context of climate change. It is in this context that the future of livestock farming, its roles, services and impacts must be considered. There are numerous challenges but also opportunities.

Livestock farming is blamed for its environmental impacts and health issues that should continue to be reduced despite progress having already been achieved:

- The highly intensive and input-dependent agricultural systems have contributed to environmental pollution and the degradation of ecosystems. Notably, the livestock sector has negative impacts on the environment, through the consumption of resources and the production of physical flows that can affect biodiversity, human health and ultimately the functioning of the ecosystems upon which we depend for food production, notably in regions with unbalanced concentration of livestock with regards to nature's capacity

- The contribution of livestock to climate change is one of the greatest challenges facing the livestock sector today. The EU-28 agricultural sector generated 10% of the region's total GHG emissions[8], and the livestock sector is responsible for 81-86%[9] of the agricultural GHG emissions. However, most animal emissions are composed of methane, a gas that does not last long in the atmosphere, with a half-life of 10-12 years. This means that animal emissions do not accumulate in the atmosphere, but they tend to reach an equilibrium when animal population is stable. Therefore, Global Warming is only affected by further increases in methane emissions, i.e. by increases in the number of animals, which is not the case in Europe. New metrics for Global Warming have been proposed to account for the short lived GHG methane[10]. According to these new metrics, animal emissions are not responsible for Global Warming, at least in the last decades, in developed countries. However, even if animal emissions are not responsible for Global Warming, their reduction may contribute to accomplishing the "Methane Pledge", an agreement proposed at COP26 in Glasgow on November 2nd, 2021 and signed to date by 155 countries, and other entities such as the European Union. Furthermore, a greater understanding around methane's degradation in the atmosphere is needed as its main sink, namely OH- radicles, has been reducing because of rising pollutants such as carbon monoxide[11]. Further emissions arise through the production of inputs such as feed and fertilisers, including nitrous oxide which has a greater global warming potential than methane and is also not short lived in the atmosphere.

- The role of European livestock in imported deforestation, loss of biodiversity and in water withdrawal in a context of increasing water scarcity is hotly debated. The regional concentration of animal production causes diffuse pollution of air, water and soil. More than 80% of the nitrogen of agricultural origin present in all European aquatic environments is linked to livestock farming

[8]European Environment Agency, 2019. Annual European Union greenhouse gas inventory 1990-2017 and inventory report 2019. Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, 27 May 2019, EEA/PUBL/2019/051, 962 p.

[9]Leip A., Weiss F., Wassenaar T., Perez I., Fellmann T., Loudjani P., Tubiello F., Grandgirard D., Monni S., Biala K. 2010. Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS) final report: European Commission, Joint Research Centre, 323 p. https://op.europa.eu/en/publication-detail/-/publication/38abd8e0-9fe1-4870-81da-2455f9fd75ad

[10]FAO. 2022. Methane Emissions in Livestock and Rice Systems – Sources, quantification, mitigation and metrics (draft for public review). Livestock Environmental Assessment and Performance (LEAP) Partnership. FAO, Rome, Italy - Part 4, Metrics for quantifying Impact of Methane Emissions

[11]Skeie et al., 2023; https://doi.org/10.1038/s43247-023-00969-1 | www.nature.com/commsenv

activities[12] and livestock account for 90%[13] of ammonia emissions of the agricultural sector. Frequent inputs of liquid manures can cause phosphorus accumulation in soils as slurry has a lower N/P ratio (4.1 to 5.1) than that needed for crops (6.1 to 8.1). Feed vs food competition is also a challenge as livestock consume more than 50% of cereals produced, although a high proportion of crop by-products are also up-cycled through livestock, and more generally livestock systems competed with land and resources that can be used for plant-based food, energy production or used for nature conservation.

- European citizens' interest in animal welfare has been gradually affirmed during the last decades. According to the last European Barometer on Animal Welfare[14], a large majority of European citizens (91%) attach importance to animal welfare, 84% of them consider that farm animals should be better protected than they are now and 60% are willing to pay slightly more for products sourced from animal welfare-friendly farming systems. Animals are recognised as sentient beings at member state and EU level[15]. Nevertheless, only 6% of the respondents are in contact with farm animals and two-thirds (67%) would like to have more information about the conditions in which farmed animals are raised in their country. The perception and future legal framework for animal welfare will greatly affect the future of animal farming.

- Animal diseases and antimicrobial resistance can threaten human health[16]. Animal diseases (African swine fever, Influenza, foot and mouth disease...) can have a devastating impact on production levels and their prevention is essential to reduce the needs for unavoidable drastic control measures such as mass culling. Healthy animals are also a prerequisite for access to international markets. Animal health is closely linked to human health. It is estimated that 60% of emerging infectious diseases in humans are of animal origin and are classified as zoonoses (H1N1, H5N1 flu, HIV, Ebola, sudden acute respiratory syndrome -SARS-, West Nile virus, COVID19, etc.). Humans and animals share the same pharmacopoeia, so it is important to reduce as much as possible the use of antimicrobials to reduce the risk of resistance and maintain efficacy. In the early 2000s, it was estimated that antimicrobial resistance was responsible for around 25,000 Europeans deaths yearly and over EUR 1.5 billion of healthcare costs, and animal diseases can cause serious social, economic and environmental damage to animal farming and human health. The links between the health of humans, animals, including pets, and the environment have contributed to putting forward the concept of One Health.

- The consumption of ASF is under debate and a balanced consumption of meat is undoubtedly a driver to consider. Overconsumption of red meat (especially processed products) is associated with a higher risk of non-communicable diseases (NCDs).

[12]Westhoek H., Lesschen J.P., Leip A., Rood T., Wagner S., De Marco A., Murphy-Bokern D., Pallière C., Howard C.M., Oenema O., Sutton M.A. 2015. Nitrogen on the table: The influence of food choices on nitrogen emissions and the European environment. European Nitrogen Assessment Special Report on Nitrogen and Food, Centre for Ecology & Hydrology, Edinburgh, UK, 70

Leip A., Billen G., Garnier J., Grizzetti B., Lassaletta L., Reis S., Simpson D., Sutton M.A., de Vries W., Weiss F., Westhoek H. 2015. Impacts of European livestock production: nitrogen, sulphur, phosphorus and greenhouse gas emissions, land use, water eutrophication and biodiversity. Environmental Resource Letters 10, https://doi.org/10.1088/1748-9326/10/11/115004

[13]European Environment Agency, 2018. Air quality in Europe - 2018 report. EEA, Copenhagen, 88 p.

[14]Attitudes of Europeans towards animal welfare; European Commission, 2023, https://europa.eu/eurobarometer/surveys/detail/2996

[15]Registered in the Amsterdam Treaty of the EU in 1997

[16]http://www.euro.who.int/fr/health-topics/disease-prevention/antimicrobial-resistance/antibiotic-resistance

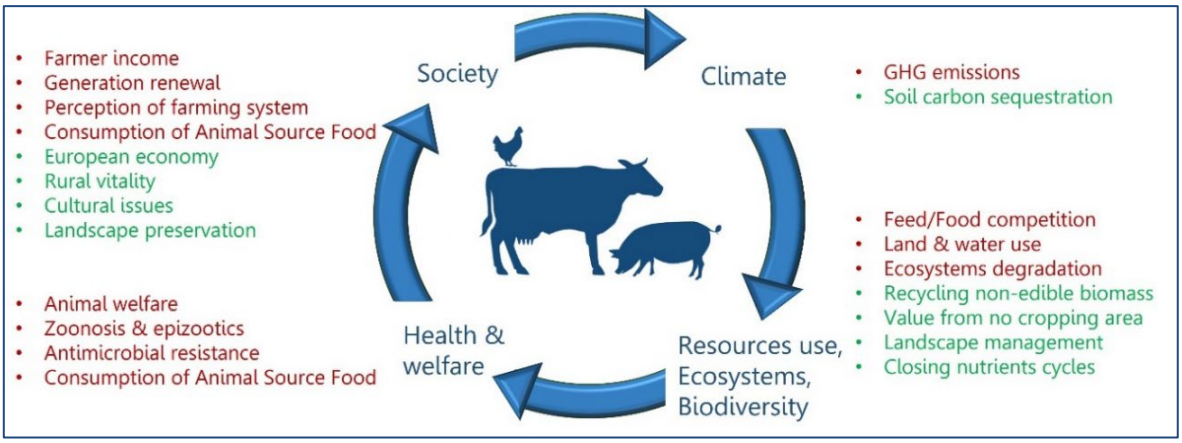


Figure 1. The negative (red) and positive (green) impacts of livestock farming

On the other hand, livestock have positive contributions to the environment, biodiversity and to the society in general that should be enhanced (*Figure 1*).

- Livestock can use or recycle biomass that is not directly usable for human food to produce food of high nutritional quality[17]. It should be noted that the main carbohydrates produced worldwide by photosynthesis are the cell wall constituents of plants which only herbivores can use to produce nutritional food. Similarly, many plant proteins (soluble protein from chloroplast) have no nutritional value or cannot be processed to contribute to food production. Ruminants also use marginal areas which otherwise could not be used to produce food. Smart use of manure is crucial for the transfer of fertility, the recycling of nutrients to avoid losses to the environment and to reduce the use of mineral nitrogen fertiliser and associated high fossil energy demand for their industrial synthesis. Manure with a high C/N ratio (compost, solid manure) has a generally favorable impact on soil organic matter content and soil biological functions[18]. Livestock also produce an array of by-products which can be used to improve circularity and reduce pressure on land resources for pharma, fibre and textiles, biofuels, fertiliser and feed production.

- Livestock (notably ruminants) can have a positive impact on biodiversity via the maintenance of permanent and sown grasslands. Important ecosystems services provided by grasslands have been identified and described[19] and the value of grasslands thus clearly extends far beyond their direct economic value for animal production systems[20]. Grassland and associated hedgerows contribute to the maintenance of habitats, flora, fauna and insects biodiversity, soil carbon stock and additional sequestration, water flow regulation, preservation of soil erosion. Intensity of GHG emission can be significantly mitigated.

- The livestock sector contributes substantially to the European economy and livestock production represents 40% of the total agricultural activity[21]. Livestock farming is of crucial importance for many European

[17]Mottet A., de Haan C., Falcucci A., Tempio G., Opio C., Gerber P. 2017. Livestock: on our plates or eating at our table? A new analysis of the feed/food debate. *Global Food Security*, 14, 1-18

[18]Diacono M., Montemurro F. 2010. Long-term effects of organic amendments on soil fertility. A review. *Agro. Sustainable Develop.,* 30 (2): 401-422.

http://dx.doi.org/10.1051/agro/200904

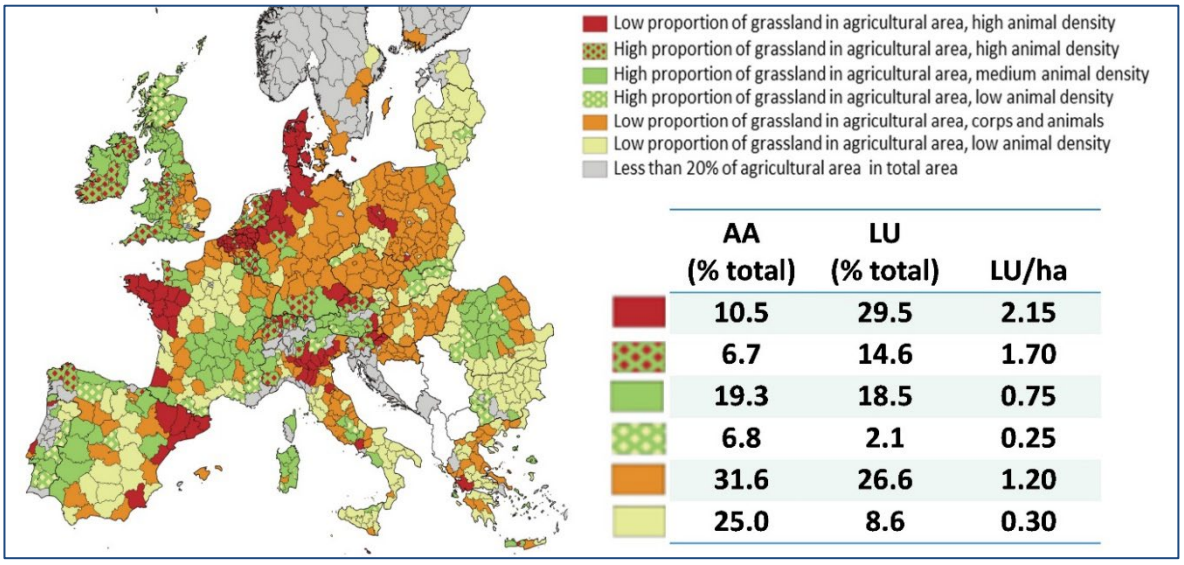
[19]MEA. 2005 Ecosystems and Human Well-being: Current State and Trends, Volume 1. 901p.

Huguenin-Elie O., Delaby L., Klumpp K., Lemauviel-Lavenant S., Ryschawy J. 2018. The role of grasslands in biogeochemical cycles and biodiversity conservation. In Improving grassland and pasture management in temperate agriculture. Edts Marshall A., Collins R. IBERS Aberystwyth University, UK.

[20]National Research Council (2005). Valuing Ecosystem Service: Towards Better Environmental Decision making. National Academies Press, Washington, DC.

[21]European Commission, 2018. Agricultural and farm income. European Commission, Brussels, DG Agriculture and Rural Development, 27 p.

regions and 58% of European farms hold animals. European livestock farms employ around 4 million people (salaried and non-salaried), 80% of whom reside in the more recent EU member-states.The EU-28 is also a net exporter on the world market and the international trade surplus in livestock commodities has steadily increased since 2000 in a context where global demand for meat, dairy products and eggs is expected to increase by 25 to 50% by 2050 according to the latest FAO scenarios[22].



	AA (% total)	LU (% total)	LU/ha
	10.5	29.5	2.15
	6.7	14.6	1.70
	19.3	18.5	0.75
	6.8	2.1	0.25
	31.6	26.6	1.20
	25.0	8.6	0.30

Figure 2. Diversity of livestock systems in Europe[23] (AA: agricultural area, LU: livestock unit)

- Livestock are a key component of the vitality of many European territories. 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. Local breeds are part of regional culture and identities. This diversity of production systems gives resilience to the entire European production sector and may satisfy a wide range of consumer demands. Livestock-based food products contain high quality protein and provide other important nutrients, such as micronutrients, in greater amounts or bioavailability than plant proteins.

- The potential negative health impacts of consumption of ASF (e.g. high consumption) should be weighed against their nutritional benefits. ASF provide very high-quality protein and other essential nutrients and micronutrients in greater availability and amounts than other protein-contained food and contain a great variety of bioactive components which can offer nutritional benefits[24]. Furthermore, there is rising evidence of iron anemia, especially in young women and sarcopenia in the elderly, which would support a greater intake of ASF,

[22]The future of food and agriculture – Alternative pathways to 2050 is available at: www.fao.org/3/I8429EN/i8429en.pdf

[23] 24Dumont B. (coord), Dupraz P. (coord.), Aubin J., Batka M., Beldame D., Boixadera J., Bousquet-Melou A., Benoit M., Bouamra-Mechemache Z., Chatellier V., Corson M., Delaby L., Delfosse C., Donnars C., Dourmad J.Y., Duru M., Edouard N., Fourat E., Frappier L., Friant-Perrot M., Gaigné C., Girard A., Guichet J.L., Haddad N., Havlik P., Hercule J., Hostiou N., Huguenin-Elie O., Klumpp K., Langlais A., Lemauviel-Lavenant S., Le Perchec S., Lepiller O., Letort E., Levert F., Martin, B., Méda B., Mognard E.L., MouginC., Ortiz C., Piet L., Pineau T., Ryschawy J., Sabatier R., Turolla S., Veissier I., Verrier E., Vollet D., van der Werf H., Wilfart A. (2016). Expertise scientifique collective : Rôles, impacts et services issus des élevages en Europe. Rapport Inra (France), 1032 p. http://institut.inra.fr/Missions/Eclairer-les-decisions/Expertises/Toutes-les-actualites/Roles-impacts-et-services-issus-des-elevages-europeen

[24]ADDMcAfee et al., 2010; doi:10.1016/j.meatsci.2009.08.029

especially red meat. In a Europe where the population is aging, ASF may regain interest.

The livestock sector is also facing internal challenges. The number of livestock farmers is decreasing rapidly. This trend is linked to economic difficulties, attractiveness of the sector and dynamic of the renewal of farmers. Production is already decreasing in several regions or reduction targets have been announced in others to reduce environmental burdens. One of the consequences is a reduction in exports of animal products and an increase in imports for a larger number of products as consumption of ASF still remain relatively stable. Otherwise, a sharp decrease in ASF consumption, as it is sometimes promoted, can create a double penalty for farmers with a sharp reduction in their numbers due to lower production and a reduction in income due to reduced demand.

1. Looking to the future: The future role of responsible livestock in sustainable agri-food systems

*By "**responsible livestock**" we mean livestock farming contributing to circular and resilient agriculture ensuring food security while:*

- *keeping **resources use within the planetary boundaries**,*
- *promoting the **provision of ecosystem services and biodiversity**,*
- ***reducing the negative net environmental impact** associated with that production,*
- *ensuring **high health and welfare standards** for livestock,*
- *providing **better human health and well-being**,*
- *contributing to social and economic sustainability through **vibrant rural livelihoods**,*
- *enhancing the **resilience of the sector** by increasing its ability to withstand physical and financial shocks.*

We need to demonstrate how to maximise synergies and avoid trade-offs between those priorities knowing that what livestock sustainability means in a specific situation will depend on a large range of factors. To fulfil their roles, livestock systems should evolve to provide a range of responsible goods and services that are as large as possible, sustainable and compatible, rather than being guided by the single goal of commodity production[25]. In doing so, the livestock sector will contribute positively to the main ambitions of the European Green Deal, and to the UN SDGs.

A sharp reduction in EU livestock production is often proposed as a unique and short-term efficient solution for simultaneously tackling environmental and dietary issues. Even combined with measures towards a reduction of consumption of ASF, advocating a sharp reduction of animal production would most probably displace production (i.e. higher imports) and impact other parts of the world. In many cases, the EU has relatively efficient livestock production, so simply reducing European production while global demand for livestock products is increasing and European consumption does not decrease significantly, may lead to net increases in global environmental impact and a lower level of animal welfare compared to European standards. Innovations alone are insufficient; they need support from policy legislation offering clarity on progressively realistic rising standards and new business models rewarding more sustainable practices. We also need to avoid simplistic plant versus animal or extensive versus intensive positions. Instead, the EU needs to focus on promoting systems well adapted to the diversity of EU agriculture systems and landscapes which maximise all the synergies. At the same time, the food produced

[25]Manzano et al., 2023: https://doi.org/10.1093/af/vfac096

must meet consumer preferences, at prices they are prepared to pay. Furthermore, livestock farming is about more than food production; it contributes to many of the sustainable developments' goals, and it is the source of many non-food products (leather, wool, draught power in some regions of the world, manure for fertilisers and energy production, etc.)[26].

The question should therefore not be "How can we reduce livestock production?" but rather "How can we increase the net social and environmental benefit of livestock, while ensuring the costs are distributed equitably?" In all cases, we should remember that maintaining the sector's competitiveness is essential.

Redesigning the place and role of livestock within sustainable agri-food systems, with livestock as a key component of the solution.

The European food systems are not positioned to be sustainable in the long term, and a fundamental evolution, including livestock, is required[27]. Livestock farming is at a crossroads and must evolve in this scientific, social and legal context. Livestock have huge potential for contributing to resilient agri-food systems, matching economic and societal expectations, and thus recovering its full legitimacy. Pathways of progress exist to improve livestock sustainability by acting on its own components, notably climate impact, resource use efficiency and better animal health and welfare. However, the challenges go far beyond the livestock sector which is too often considered independently of other agricultural sectors. In a world of finite resources and with sometimes highly degraded ecosystems, a conversion of the agricultural sector is required that targets nearly every aspect to maintain agri-food systems within the planetary boundaries[28] (*Figure 3*).

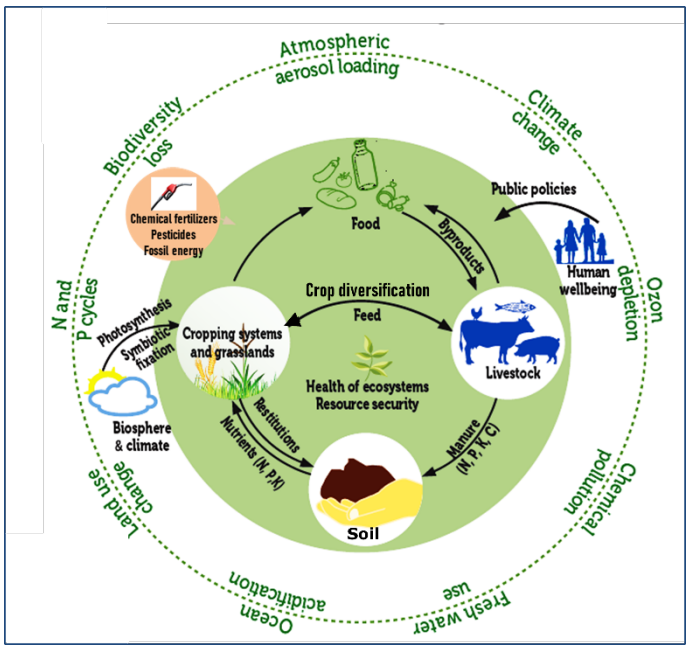


Figure 3. Role and place of livestock in balanced circular food production within planetary boundaries

[26]Eisler et al., 2014; go.nature.com/8d9vjx

[27]SCAR 2020

[28]Rockstrom J., Steffen W., Noone K., Persson A., Chapin F. S., Lambin E., Lenton T.M., Scheffer M., Folke C., Schellnhuber H., Nykvist B., De Wit C.A., Hughes T., van der Leeuw S., Rodhe H., Sorlin S., Snyder P.K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R. W., Fabry V. J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., Foley J. 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32. [online] http://www.ecologyandsociety.org/vol14/iss2/art32/

Closer integration of livestock and cropping systems offers new opportunities to manage resources in a more efficient and safer way. Circular agriculture in line with nature's capacity will favour an efficient and, as moderate as possible, use of non (or scarcely) renewable resources to produce healthy food at an affordable price. It will also eliminate losses by recycling biomass between sectors, reduce GHG emissions, and contribute to remove CO_2 from the atmosphere. Livestock will play an essential role in such circular agri-food systems:

- applying the ability of animals to recycle into food chains biomass that is not directly usable in human food[29]
- and the provision and use of organic fertilisers rather than synthetic fertilisers to close the nutrient cycles within the framework of agro-ecological approaches
- provide animal by-products which will reduce the pressure on land resources to produce pharma, biofuels, textiles, fertiliser and feed.

Beyond efficient use of resources, these new synergies between livestock and cropping sectors will contribute to **biodiversity remediation** and restore ecosystem function. Thanks to its ability to use as feed many plant species, **livestock can contribute to the diversification of crops with additional benefits**, notably agrobiodiversity, soil water retention capacity, pest control, and pollination. Consequently, this improvement in biodiversity and agronomical parameters reinforces resource security and adaptation to climate change.

Livestock can also provide some ecosystem services more easily than the cropping sector such as employment in marginal rural areas, landscape management and habitat preservation with grassland and associated hedges and to some extent soil fertility. These provide new responsibilities for the livestock sector to achieve synergies.

Livestock farming in the "One World One Health" approach.

Agriculture and food are at the heart of interconnected challenges, including the depletion of natural resources, pollution, the erosion of biodiversity, climate change, and an increase of infectious diseases. As a consequence, it is important to continue to move beyond 'silo' approaches of health that mostly deal with disease vectors for animal health and the impacts of the environment on human health to a more holistic vision considering the multiple interdependencies between human, animal, including pets, and environmental health by distinguishing between agroecosystems (local scale) and global ecosystems (land, water, the atmosphere, biocenoses). The additional challenge is moving towards a deeper convergence agreement between society, policy makers, breeders, farmers, veterinarians and human health professionals based on the Global One Health (and welfare) approach.

2. The pathways of progress

The inclusion of a wider perimeter which considers livestock farming as one element of circular agri-food systems within the planetary boundaries opens new prospects for progress in addition to tracks already explored.

[29]HLPE, 2019. Agro-ecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by The High Level Panel of Experts on Food Security and Nutrition. Rome

De Boer I.J.M., Van Ittersum M.K. 2018. Circularity in agricultural production. Wageningen, Netherlands, Wageningen University & Research.

https://www.wur.nl/upload_mm/7/5/5/14119893-7258-45e6-b4d0-e514a8b6316a_Circularity-in-agricultural-production-20122018.pdf

Rethinking the pathways of progress with a systemic approach.

Many efforts have focused on maximising production per animal and reducing costs. Productivity gains have been rapid and steady due to improvement in genetic merit of animals for production, development of new husbandry practices based on the confinement of animals in buildings, development of high-quality feed and additives, balanced rationing to meet genetic requirements and improvement of animal health. The feed conversion rate of chicken has decreased from 2.2 in late 60's to 1.6 or less today while feed conversion rate of pigs has decreased from 3.80 to 2.37 in the same period[30] and milk production per cow steadily increased by 100 kg/year or even more to an average of 7,651 kg/lactation in 2022 [31]. Therefore, the same production requires 2 to 10 times less resources (feed, land, water) and has a dramatically reduced carbon footprint of milk[32]. This evolution was favoured by an era of abundant and cheap fossil energy but the paradigm has changed.

Beyond solving the problems one by one as they emerge, it is necessary to increase efforts on developing more holistic approaches for designing innovative livestock systems. It requires the deployment of new and better knowledge, responsible use of new technology and know-how, new understanding of social interactions within value chains, new business models with new value-sharing principles, as well as supportive policies and legislation. We propose a smart and coordinated approach based on:

(i) innovations and science-based solutions; and

(ii) transition to more sustainable systems and value chains supported by fair, inclusive and innovative governance.

These should be implemented in concert as avenues for sustainability improvement and not considered as each taken in isolation. Owing to the diversity of regional and local contexts, progress towards greater sustainability lies in the intensification of the use of ecological processes in some areas up to multifunctional extensification in other areas, notably in marginal zones. **This diversity requires solutions tailored to a regional or even sub-regional scale[33]; and precludes "one size fits all" optimal solution.**

Three pathways of progress should be investigated simultaneously:

- **Efficiency:** Improving biological efficiency can lead to reductions in (scarce) resource use and more globally in the physical flows into and out of the production system, and the associated negative impacts that arise from these flows. It is also a key element for farm profitability. This is the "sustainable intensification" approach. Efficiency can be considered at the appropriate level of a specific Production Unit (PU) that can be at animal, herd, field or at an even larger level such as the farming system considering internal recycling within the PU. While altering a single part of the system can improve efficiency, care needs to be taken to ensure that any improvements are maintained at the system level. Feed efficiency and animal health are key issues although new demands for animal welfare may constrain future gains in feed efficiency.

[30]Knap P.W., Wang L. 2012. Pig breeding for improved feed efficiency. In: Feed efficiency in swine. Patience J.F. (Ed). Wageningen Academic Publishers, Wageningen, 167-181.

[31]https://idele.fr/detail-article/chiffres-cles-bovins-2023-productions-lait-et-viande

[32]Capper J.L., Cady R.A., Bauman D.E. 2009. The environmental impact of dairy production: 1944 compared with 2007. J. Anim. Sci., 87, 2160-2167.

[33]Dumont B. (coord), Dupraz P. (coord.), Aubin J., Batka M., Beldame D., Boixadera J., Bousquet-Melou A., Benoit M., Bouamra-Mechemache Z., Chatellier V., Corson M., Delaby L., Delfosse C., Donnars C., Dourmad J.Y., Duru M., Edouard N., Fourat E., Frappier L., Friant-Perrot M., Gaigné C., Girard A., Guichet J.L., Haddad N., Havlik P., Hercule J., Hostiou N., Huguenin-Elie O., Klumpp K., Langlais A., Lemauviel-Lavenant S., Le Perchec S., Lepiller O., Letort E., Levert F., Martin, B., Méda B., Mognard E.L., MouginC., Ortiz C., Piet L., Pineau T., Ryschawy J., Sabatier R., Turolla S., Veissier I., Verrier E., Vollet D., van der Werf H., Wilfart A. (2016). Expertise scientifique collective : Rôles, impacts et services issus des élevages en Europe. Rapport Inra (France), 1032 p.

http://institut.inra.fr/Missions/Eclairer-les-decisions/Expertises/Toutes-les-actualites/Roles-impacts-et-services-issus-des-elevages-europeen

Increasing efficiency is not sufficient on its own because it does not guarantee the resilience of production systems to climate, health or economic hazards and does not reflect the ability of production systems to restore the quality of ecosystems and secure resources.

- **Circularity:** Beyond efficiency of a given PU, promoting exchanges between PU can lead to new opportunities. This can be considered at different scales both within a farm or between neighbouring farms, or even between regions. Circularity concerns the reuse of various resources (e.g. biomass) to avoid wastes, regeneration of ecosystems by closing natural cycles. Livestock farming plays a crucial role in circularity:

  (i) Animals are natural recyclers and a significant part of nutrients and biomass flows in agriculture are related to livestock farming. Thus, they can contribute to balancing nitrogen and phosphorus cycles by favouring organic fertilisers (new technologies around nutrient stripping and composting are required to increase efficiency and efficacy of use) rather than synthetic fertilisers and contribute to a more efficient food production by exploiting the ability of animals to recycle into the food chain non-edible biomass that is not directly usable in human food[34] (*Figure 3*).

  (ii) Due to the ability of animals to use a large panel of feeds, livestock can contribute to crop diversification notably with legumes (grains and forages) for fixing atmospheric nitrogen, Brassicaceae (to regulate weeds while providing high quality feed), dual purpose crops (food and feed simultaneously) with additional benefits for both sectors: less mineral fertilisers, reduced pest pressure, more agro biodiversity, increased protein autonomy, more local (and no GMO) food and feed, less land used for animal feed production, better soil protection and conservation.

  (iii) Livestock can provide some valuable ecosystem services more easily than the cropping sector, such as employment in marginal rural areas, landscape management and habitats preservation with grassland and associated hedgerows and to some extent soil fertility.

  (iv) Finally, livestock farming is also more than just food production. An important number of activities (bioenergies, clothing, human medicine, feed...) find their raw material in the livestock sector as by-products through the rendering sector. By maintaining the landscape, livestock farming is also beneficial to tourism, a source of income and a way of keeping rural populations in some areas, as well as reducing the risk of forest fires, a major source of carbon release into the atmosphere (including carbon monoxide - a major scavenger of OH- radicles, the main atmospheric methane sink). From the social point of view, livestock contribute to maintain a community between farmers at local, regional, national and European scales. Breeders who contribute to genetic improvement share the management of the breed as a common good, especially for ruminants where they manage the breeding organisations. The exchange of animals, for reproduction, between herds and regions is mandatory to manage the domestic biodiversity.

  These circular approaches can be considered at different geographical scales from a local level to exchanges between regions or countries.

- **Diversity:** Beyond the diversity of regional and local contexts that required

[34]HLPE, 2019. Agro-ecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by The High Level Panel of Experts on Food Security and Nutrition. Rome

De Boer I.J.M., Van Ittersum M.K. 2018. Circularity in agricultural production. Wageningen, Netherlands, Wageningen University & Research.

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tailored solutions, (bio)diversity plays a key role in all areas of sustainability. Diversity/diversification is both a means for increasing the performances of food systems, including their resilience when facing shocks and a goal (e.g. biodiversity preservation). Diversity must be considered at the different levels of organisation, including animal (and plant) genetic diversity (e.g. genome, breeds - including local breeds, species), farming systems, animal products, but also diversity of landscape and diversity of dishes, in relation to cultural habits. Diversity/diversification is a means of action for increasing functional complementarities between PU (circular approach) and relying on more nature-based solutions with additional benefits towards a more efficient use of natural resources, low carbon systems, reduced use of antimicrobials (and pesticides when considering the plant sector), vulnerability to animal diseases, adaptation to climate change, increased circularity between PU. Genetic diversity of animals is identified as contributing to health at the whole ecosystem scale including humans, as in the frame of the One World One Health concept. The diversity of animal products, from commodities to products under **brands** of quality, contributes to match the diversity of consumer demands and to creating value in less favoured regions. Considering biodiversity preservation, permanent grasslands are essential to maintain native flora and fauna, and food systems with livestock can contribute to creating a diversity of landscape mosaic, providing open habitats favourable for taxonomic and functional biodiversity and highly appreciated landscapes for tourism. Preserving genetic animal diversity, in both commercial and local/low-numbered breeds, by protecting and improving them is essential (some of these are at risk of extinction) because they might carry the potential to withstand future challenges, notably climate change mitigation and adaptation. It is also essential to secure and store microbiome biodiversity in the agriculture sector.

New digital technologies (sensors, robotics, internet of things, "block-chain") are already omnipresent in the world of livestock farming systems and more generally agriculture. They provide innovative tools and concepts for livestock farming. The contribution of these new technologies lies in the possibility of having a better knowledge on a real time basis of the animals, the crops, the environment and to improve traceability. Structured information systems will allow the usefulness of available information for decision making to be maximised. These technologies have potentially many areas of use to positively contribute to efficiency and circularity and to help to better manage more diverse systems. Artificial intelligence is designed to transform the ways we think, work, communicate and imagine. The possibilities are tremendous to better manage livestock farms. In research, artificial intelligence allows scientists to make the most of observatories and to combine different data sources to obtain new results or correlation and work on digital twins will complete experimental systems to acquire new knowledge. In this context, the question of Europe's digital sovereignty is essential to master solutions and not depend on opaque and/or non-accessible algorithms. This requires research that goes well beyond the livestock sector alone.

3. The importance of supporting R&I for sustainability and competitiveness in Europe’s livestock sector

Research and innovation have contributed substantially to the competitive, balanced and efficient nature of the current Europe livestock industry. Continued support for research and innovation in the livestock sector will be fundamental to meet impending challenges at a time when livestock farming is at the heart of several controversies but where it can also

contribute to strengthening the sustainability of our food systems. It is required to simultaneously reduce its negative impacts and to increase its positive contributions to the sustainability and resilience of food systems, by providing a range of goods and services beyond the single goal of commodity production and fitting the numerous societal demands. This implies major efforts in technological and organisational innovations within and between sectors, and to support the adoption and implementation of these innovations across the actors of agri-food systems. Interacting with breeders, farmers, animal feed producers and other actors, as well as citizens, consumers and policy makers to define common and accepted objectives and meet the expectations of the different stakeholders will be central (i.e. living lab approach). This requires coordinated and integrated, inclusive and interdisciplinary research and effective, proactive translation into practice and policy making.

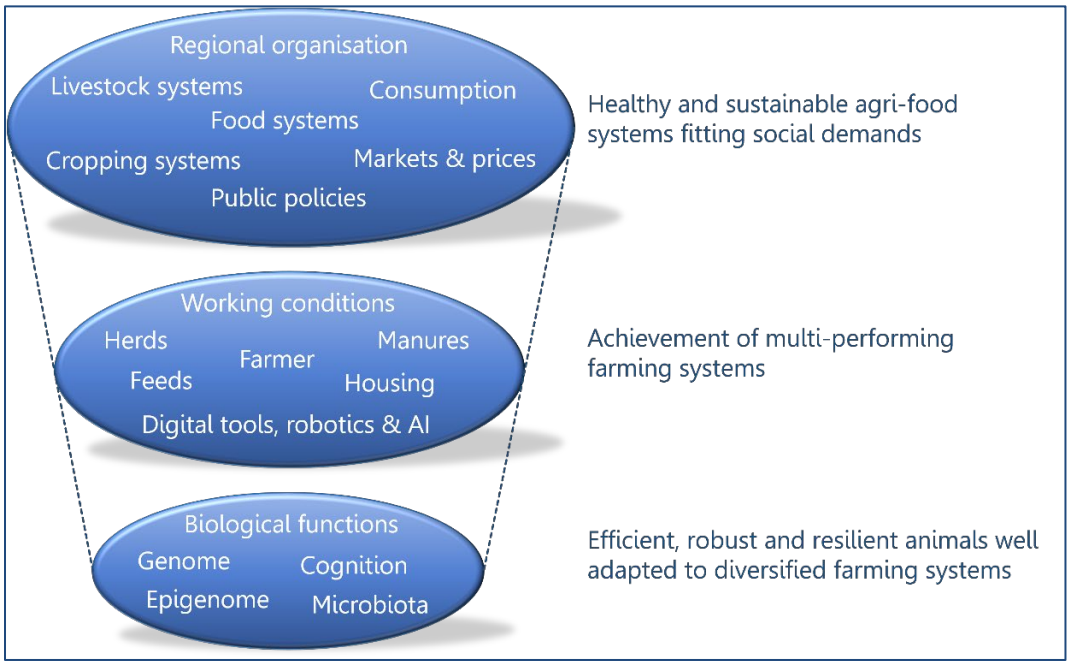

Figure 4: coordinated and integrated, inclusive and interdisciplinary research

The Animal Task Force:

- recommends horizontal joint activities between different Horizon Europe clusters and pillars as well as between recent initiatives (Partnerships, Missions) to reinforce the R&I sector for livestock farming and vertical alignment between the EU and national/regional fundings. This will help avoid gaps and overlaps, ensure better synergies and facilitate the wider agenda to support skills, innovation and research infrastructures.

- promotes interdisciplinary and multilevel research (*Figure 4*) bringing together research groups with complementary expertise at various levels of organisation (e.g. animal nutrition and feed management strategies, grassland production and management, impact evaluation, animal breeding and genetics, reproductive physiology, welfare and health, ICT technologies, food evaluation, feed processing, rendering, construction and engineering, emission measurements, modelling, economics, sociology, multi-criteria evaluation). The Animal Task Force supports involving stakeholders of agri-food and agri-non-food systems (farmers, agro-supply industry, machinery and robotics, dairy, meat and eggs industry, the rendering sector, non-food industries and consumers) and of the territories. Several areas of research are particularly suited for interregional international cooperation which encourages future development of livestock production systems in line with the provision of ecosystem

services together with holistic agriculture approaches. A greater integration between livestock and plant-based agricultural systems may allow better use and regeneration of agroecosystems and the maximisation of biomass of both plant and animal origin through strategic recycling and harnessing of the cascade approach. These holistic agricultural approaches also need to encompass the agroecological domain and circular bioeconomy and need to be consistent with the One Health One Welfare concept. They must support research policies that ensure and value the diversity of the livestock production systems that are considered the European treasure. To do that, it is also fundamental that researchers and research institutions in all European countries can be involved in production innovations and in proposing new solutions and advancements that are needed to support the diversity.

4. Expected R&I outcomes

The scale of the challenges outlined above is enormous, but so too is the opportunity for Europe to continue and improve its leadership in sustainable livestock production. Research and innovation (R&I) have played a huge role in the development of our modern livestock systems and undoubtedly will play a critical role in shaping future systems of livestock production.

This Vision Paper sets out R&I priorities for the future that are further elaborated in the SRIA.

At a high level, the expected outcomes of suggested priorities for R&I aim to foster:

- **More sustainable livestock farming systems with the following attributes**:
  - Low impacts on the climate and resilience to climate change;
  - Low impacts on water quality (groundwater, wetlands and coastal areas) and air;
  - High standards of animal health and welfare and responsible reduction and use of antimicrobials;
  - Efficient use of resources (land, soil, water, workload) and resource security;
  - Greater understanding and value of the role of responsible ASF consumption on human health, especially in the face of a rising elderly population in Europe with a high requirement for high value protein;
  - Reduced dependency on non-renewable resources and on imported proteins and use of "deforestation-free" proteins;

  Contributing to maintaining food systems within the planetary boundaries.

- **A diversity of livestock farming systems contributing to:**
  - Competitive and sustainable circular agri-food systems;
  - Resilient breeders and farmers as a key part of resilient rural communities;
  - Food and nutrition security with high-quality balanced diets at affordable prices;
  - Restoration of the health of ecosystems and biodiversity.

- **A strong European research and innovation system in animal production in Europe** and research on transformational changes.

- **A reinforced science-policy dialogue** in support of the establishment, implementation, and evaluation of evidence-based policies for more sustainable European livestock sector.

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