A European infrastructure
for farmed animal genotype to phenotype research

Deliverable 8.3
Publication of design study and sustainability plan

Grant agreement no°: 101094718

Due submission date
2025-June-30

Actual submission date
2025-June-30

Responsible author(s):

Tina Hartwig, FBN Dummerstorf
Dr. Emily Clark, EMBL-EBI

Sensitive: Yes

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101094718. The content of this report reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

DOCUMENT CONTROL SHEET

Deliverable name	Publication of design study and sustainability plan
Deliverable number	8.3
Partners providing input to this Deliverable	FBN, EMBL-EBI
Draft final version circulated by lead party to: On date	Consortium, 2025-June-26
Approved by (on date)	FBN as coordinator, 2025-June-30
Work package no	8
Dissemination level	

REVISION HISTORY

Version number	Version date	Document name	Lead partner
Vs1	V1_25042025	D8.3 design study and sustainability plan	FBN
Vs2	Final_30062025	D8.3 design study and sustainability plan	FBN
Vs3			
Vs4			
Vs5			

Changes with respect to the DoA (Description of Action)

None

Dissemination and uptake

This is a confidential deliverable

Table of Contents

1. Executive Summary 4

2. Introduction 6

3. Defining the role of food and agriculture sectors as part of the European Bioeconomy 6

4. Summary of challenges 9

4.1 ESFRI Landscape of health and food cluster 10

4.2 European animal health and welfare research 11

4.3 Sustainable development of agri-food systems (Green Deal, Farm 2 Fork, Food 2030, green and digital transition) 11

4.4 Bioeconomy approaches 15

4.5 Strategy for Conservation of animal genetic resources 15

5. GenoPHEnix Demand analysis of scientific and industry partners 16

6. RI service offer 19

6.1 service offer 19

6.2 access conditions 20

6.3 resources 21

7. Sustainability of funding 22

7.1 GenoPHEnix proposal 22

7.2 possibility of other funding sources 26

8. RI solutions and conclusion 27

8.1 Defining the value of GenoPHEnix research for animal breeding and future food and health challenges along the lines of GenoPHEnix goals 27

8.2 Defining the role and value of farm animals within European Strategies 29

1. Executive Summary

Background	This deliverable is part of Workpackage 8 "Ensuring the sustainability of the EuroFAANG infrastructure embedded in farmed animal resources as part of the ESFRI roadmap". The overall context is to identify the necessary components and resources to sustain EuroFAANG funding and resources over the current funding frame, thereby implementing the RI structure in the larger ESFRI Health and Food Cluster. Technical, legal and societal challenges are outlined and possible scientific and organizational solutions presented.
Objectives	D8.3 will outline design components necessary for the RI to provide services that offer new solutions for a transformed farmed animal production landscape in Europe. It will describe available resources, stakeholder interest and support and also challenges for setting up a comprehensive infrastructure. In addition to the status quo, the deliverable will provide a sustainability plan, i.e. perspectives how the initiative will be operational beyond the lifetime of the current project.
Methods	An intensive literature review of relevant European strategies and policy frameworks was part of the Business plan design, and also relevant for this deliverable. To evaluate the demand of scientific and industrial users of the Research Infrastructure, a survey was circulated. Additionally, several surveys, e.g. on European biobanking and interfaces for sharing scientific and industry data were analyzed during EuroFAANG concept development phase. The results were included within this deliverable. To evaluate recent developments of farm animal G2P research and food and health-related topics, latest publications and an extensive network to other European Research Infrastructures of the Health and Food Cluster, relevant projects and institutions (EuroFAANG WP 7, WP 4,5,6 with scientific Think Tanks and GenoPHEnix proposal design) ensured a suitable currency of research demands, gaps and resources.
Results & implications	The results of the surveys shaped the demand description and proposed services within the RI design. Institutional resources,

	capacities and expertises could be combined towards a comprehensive RI service offer, scientific program, governance structure and sustainable funding proposal that ensures a high relevance to solve the diverse challenges of competitive food supply under One Health conditions, that were outlined through the analysis of strategic policy frameworks. In anticipating the potential and development of farm animal and aquaculture production towards a sustainable and high quality food value chain, the GenoPHEnix proposal can underline its claim to be a part of an excellence based solution towards improved farm animal breeding for a competitive, ethical and resource-efficient farm animal husbandry for human and animal nutrition.

2. Introduction

EuroFAANG concept development project was merged with INFRARIA projects SmartCow, PigWeb and AquaExcel as well as INFRA-SERV projects AgroSERV and AQUASERV towards a shared proposal “GenoPHEnix” for a dedicated farm animal and aquaculture research infrastructure in the roadmap update 2026 of the European strategy forum for research infrastructures. It was submitted by April 8th, 2025.

For the development of GenoPHENix scientific and innovation program and the evaluation of scientific demand from different communities and stakeholder groups an extensive environmental analysis (including innovation areas and policy strategies, which are influencing and might be influenced by GenoPHEnix) was designed. They describe the transformation potential and the role of farm animal and aquaculture for human nutrition, sustainable food value chains and the overall One Health approach. Therefor immanent challenges are outlined and the potential of GenoPHEnix as a central coordination point for scientific innovation development and possible connection point of public-private partnerships are described. The RI developed an extensive service-, TNA- and training offer (mostly excellence and market-driven access), based on institutional resources, reflecting on specialisations, research capital and innovation potential of involved partner institutions. Within the immanent challenges outlined towards the development of sustainable food value chains under changing external conditions and the establishment of suitable tools, methods, mathematical and bioinformatics procedures as well as analysis tools to develop farm animal breeding for farm animal, aquaculture and emerging species, define most relevant traits for future husbandry challenges, and develop strategies and knowledge for solutions of the One Health context, this deliverable will summarize solution approaches.
Based on the demand analysis of the scientific community and industry stakeholders, respective services and necessary resources were transferred towards a valuable service offer. This is based on the GenoPHEnix scientific excellence design study, demand analysis, resource and service allocation and the business plan.

3. Defining the role of food and agriculture sectors as part of the European Bioeconomy

- Hermann Schodesberger's position paper "Role of livestock in the EU Bioeconomy and FOOD2030 Strategy Stressing the importance of animal health and welfare,

A CWG AHW perspective to the EU Bioeconomy and Food 2030 strategies", published in January 2023

- A vision for agriculture & food, EC , 2025
- EU report agricultural outlook 2024-35
- Nowak et al., 2021, Significance of Agriculture for Bioeconomy in the Member States of the European Union

There is no universal common definition for the term bioeconomy, as it varies from country to country and includes different sectors, that contribute to the bioeconomy, but a shared viewpoint is to consider it as a concept from an innovative standpoint, including economic benefits, that can arise if it develops with purpose. Nowak et al., 2021 define it as follows: “Bioeconomy covers a peculiar processing and value-creating chain in which products from the sectors of original biomass production move across the processing sectors and exchange and distribution chains and reach end users as food and biomaterials for further processing and as industrial products and products for consumption creating an entire closed-circuit economic system” Jonsson et al., implement 5 main goals in their 2021 publication on “Boosting the EU Forecast on Bioeconomy: Market, climate and employment impacts” :

- Food and nutrition security
- Sustainbly managed natural resources
- Reduce dependence on non-renewable, unsustainable resources
- Limit and adapt to climate change
- Strengthen European competitiveness and create jobs

The task of agriculture within bioeconomy is to supply a “sufficient amount of food and biomass to a growing population” (Nowak et al., 2021), while at the same time keeping the functions of the described ecosystem and therefore stabilize biological diversity. This balance approach is necessary; it highlights at the same time the developing importance of biotechnology and its solutions.

Agriculture accounts for the largest part of biomass within european bioeconomy. Its position was evaluated due to the level of employment in 2008 and 2017 and the gross added value, as well as competitiveness on labour productivity. More than 50 % of all “bioeconomy workers” were employed in agriculture in 2017 (Table 1.) which accounts for an 18 % share in the bioeconomy turnover.

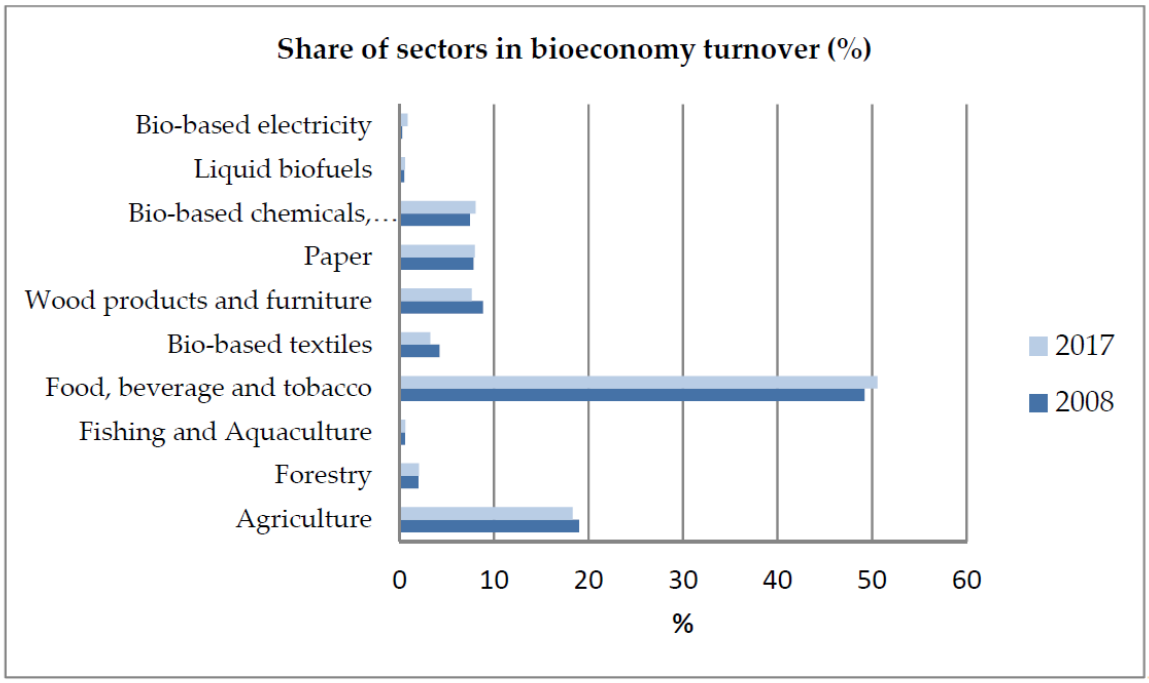
Table 1. Share of respective sectors in the total level of employment in the bioeconomy in EU-28 in the years 2008 and 2017 (%).

Sector	Share of Sectors in Employment in the Bioeconomy (%)		Change in 2008–2017 (in p.p.)
	2008	2017	
Agriculture	55.3	51.8	−3.5
Forestry	2.4	3.0	+0.6
Fishing and aquaculture	0.9	1.0	+0.1
Food, beverage and tobacco	22.3	26.1	+3.8
Bio-based textiles	5.0	3.9	−1.1
Wood products and furniture	8.7	8.2	−0.5
Paper	3.2	3.5	+0.3
Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)	2.0	2.4	+0.4
Liquid biofuels	0.1	0.1	0
Bio-based electricity	0.03	0.1	+0.07

Note: p.p.—percentage points. Source: Own elaboration based on Data-Modelling platform of agro-economics research.

Tab. 1. Share of respective sectors in the total level of employment in the bioeconomy in EU-28 in 2008 and 2017, Nowak et al., 2021

Largest sector (based on turnover: 50,5% in 2017 and employment) is the food sector, followed by agriculture (turnover 18.3% in 2017).



Tab. 2. Share of sectors in the bioeconomy turnover of the European Union in 2008 and 2017 (%), Nowak et al., 2021

Most targeted approach on agriculture in european bioeconomy would be the regional approach, since “countries of the EU show significant differences in the intensity of farming, use of yield-creating resources and the involvement of capital in agricultural production”.“Production performance is influenced by the diverse agricultural and climate

conditions, quality of agricultural production space, terrain relief and water regimes". Agriculture supplies also raw materials (by-products, waste-products), used to produce energy and fuels, which links to renewable energies. Nowak et al., 2021 state that the "most important sectors in the agricultural primary production are not well integrated into the bioeconomy value chain, playing more the role of biomass suppliers than of producers of bioproducts". Ireland, Germany and Austria have a relatively small share of agriculture in generating revenues of the bioeconomy sector, due to specific natural and climate conditions.
In general, it was visible, that Agriculture has next to the economic function also an equally important social function, which is visible in the number of workers (twice as many workers as the Food sector), whereas agriculture generated 20% less gross value and the share of bioeconomy turnover was lower by 36%.

All in all, Productivity is regarded as most reliable indicator of long-term competitiveness by the European Commission. The Gross added value shows the production capacity of accumulated and used production factors, which highlights the leading position of germany, frace, italy, spain and the UK.

4. Summary of challenges

Animal husbandry and aquaculture are undergoing a comprehensive transformation process in the course of which the valorization and prioritization of economic, ecological, geopolitical, demographic, climatic and political production conditions, parameters and influences must be weighed against each other and the sustainable supply of high-quality food to maintain human and animal health must be ensured within the framework of strategic preliminary planning in accordance with the real conditions.

In short, the overall strategic question and therefore the main challenge: how can a high quality production of nutritional products of animal origin can be combined with ongoing development of animal welfare and health as well as the compliance of high social standards for farmers and agricultural employees and sustainable security of global production and competitiveness levels while maintaining and expanding them.
To this end, developments that are already emerging, e.g. the increased global demand for food thanks to the growing world population (9.7 billion people by 2050), the associated need for even more efficient use of resources and the development of alternative food sources (competition between food components for human and animal nutrition) and the

consideration of climatic developments while reducing greenhouse gas emissions must be scientifically researched and underpinned with adequate and innovative solution strategies in order to underpin and expand economic productivity, technological sovereignty and thus state and European capacity to act.

In the following subsections, the detailed discussion of the challenges to be defined and the solution frameworks to be developed and suitable individual scientific, technical, methodological or political solutions are presented, resulting in derivations of action within the framework of GenoPHEnix in the conclusion.

European policy strategies

Within the GenoPHEnix business plan the main environment analysis for the RI is presented. Within this section the main challenges with relevance for GenoPHEnix will be processed.

4.1 ESFRI Landscape of health and food cluster

- antimicrobial resistance
- nutrition related diseases
- emerging zoonosis of worldwide importance
- pandemics
- livestock epidemics
- the resilience and sustainability (economic, environmental, societal and cultural) of the entire agro-food value chain
- food and nutrition security and safety, especially in light of shocks (environmental, economic, geopolitical)
- the circular bioeconomy

Europe has high ambitions to solve these challenges, even if they are complex and require a vast amount of time, resources and strategies.

In the context of prioritizing research infrastructures, ESFRI already reflects the strategic orientation of European funding measures. GenoPHEnix is able to influence the large-scale orientation, i.e. the variance of included species, bioinformatic methods and tools, specification level at genome, cell, individual or population level, linking of research and

transfer to application and market maturity, multilateral cooperation for genotype and phenotype research, cooperation with other RIs can increase the impact and speed of animal breeding and the use of genomic tools to accelerate genetic progress and integration into relevant populations as a holistically coordinated approach. The scaling of the infrastructure will do justice to the necessary use of resources (equipment, expertise, human capital, funding capital, new investments in research facilities).

4.2 European animal health and welfare research

- Farm animals as converters of low-value biomass to high-quality protein
- Animal infectious disease
- Animal production disease
- Animal welfare
- Food safety
- The circular aspects of Livestock, Food and One Health

All these areas influence each other and can be united under the approach of One Health, which incorporates the health and wellbeing of animals, plants, humans and all their environmental interactions. The prevention of zoonotic diseases and diseases with pandemic potential is of fundamental importance and more research is needed to explore pathogen pressure and the origin of reservoirs or possible unsafe human behaviors. Especially the monitoring and prevention of risks, the establishment of high standard biosecurity measures, preventive veterinary medicine and new forms of therapeutics. This must be based on a detailed definition of animal husbandry systems and food value chains, particularly with regard to global transportation systems.

4.3 Sustainable development of agri-food systems (Green Deal, Farm 2 Fork, Food 2030, green and digital transition)

The farm to fork strategy was adopted in 2020 and describes the food systems transformation in respect to planetary boundaries. It highlights Research and Innovation policy as a “key driver in accelerating the transition to sustainable, healthy and inclusive food systems, from primary production to consumption.”

In the report of the Food 2030 Independent Expert group, “Recipe for Change”, 3 missions are suggested:

- Improve dietary patterns and lifestyles for a 50% reduction in the incidence of non-communicable diseases (NCD) by 2030, while reducing the environmental impact of food consumption
- Create a resource-smart food system with 50% lower greenhouse-gas emissions by 2030
- Realize trust and inclusive governance for resilient and safe food systems

As was shown before, that long term strategic goals of these policy frameworks can be tackled within GenoPHEnix for a well-defined set up of impact areas, which in secondary or tertiary development contribute to large-scale goals of sustainable and resilient food systems.

The F2F strategy is the foundation how current food value chains can contribute to the Green Deal and its sustainability goals, contributing to the climate law, where Europe commits itself to be the first climate neutral continent by 2050, reaching a 55% decrease of emissions by 2030, referring to the value of 1990. Looking at the entirety of strategies, the scale of impact (local, regional, national, European, global) might be one of the main distinguishing factors. F2F takes into account, that “the EU is the biggest importer and exporter of agri-food products and the largest seafood market in the world. The production of commodities can have negative environmental and social impacts in the countries where they are produced.” Therefore, strategic goals evolve around the following topics and challenges:

  - Ensuring food security and food value chains with positive environmental outlook and restoring of resources
  - Ensuring food quality and nutritional value (securing animal and human health within the shift towards more urban diets and alternative protein supply)
  - Creation of market conditions, that incentivize sustainable food (make it affordable, while ensuring suitable pricing for the producers and promotion of fair trade)
  - Special emphasis on novel animal welfare (legislation), towards a safe food systems transition

In addition, Food 2030 has a special emphasis for promoting research and innovation on improving resilient food systems, which are climate smart, oriented towards nutritional improvement and food authenticity, also delivering into the bioeconomical approach on advancing local conditions for regional food systems and short food chains, thereby reducing greenhouse gas emissions.

Specific challenges refer to a socio-economic impact of GenoPHEnix. Enabling research on microbiome and collaboration with other infrastructures, contributing in general to food safety systems of the future, also by providing data solutions on farm animal and aquafarm genome and phenome data, reflecting their role as part of sustainable and high value food systems.

The developing databanks and data repositories are a reflection of quantity and quality of existing data of individual animals or cohorts, herds or populations. They enable a classification and categorization of relevant traits, genomic makeup, environmental contexts, geographical spread and influences of food based value chains around the topics of production parameters, welfare, resilience and efficiency in the context of sustainable animal husbandry. Looking at systemically relevant considerations, possibilities for application of data or prioritization of data and traits or correlations of different contexts, these data repositories collect and connect information of different breeds, scales, and methodological approaches as well as biomathematical models, giving input to detailed questions of environmental influence, genetic characterization at different levels, big data solutions or applications beyond fundamental research.

Food 2030 has a special emphasis on:

- climate change
- resources scarcity
- pollution and waste
- environmental degradation
- loss of biodiversity
- population growth
- malnutrition and diet-related non-communicable disease

One of the main pathways for impact is an improved collaboration between science, policy and the general society via interface solutions. GenoPHEnix can provide the communication procedures and impact pathways due to its implemented governance structures, where involved institutions act also as representatives of the member states. Based on the structural involvement of policy makers and fact based policy advice, scientific results of GenoPHEnix can build a strong resource for legislations and standards

around animal breeding and its impact on production, resilience and disease resistance, welfare and behavior, streamlining the transformation of animal husbandry under changing environmental conditions, food security aspects and sustainability of resources on different systems scales with socio-economic impact.
The green and digital transition promotes the connection and importance of measurability of relevant traits and impacts and data sovereignty of the sector, also through promoting the potential of combining research and industry data in relevant areas.
It also highlights the role of agriculture as one of five industries with the highest green-house gas emissions and the potential use of real-time tracking of suitable information as promotor for bio-economical approaches (circular resources and renewable resources). Data and data analysis are the main foundation for digital transformation, where GenoPHEnix can deliver high value data resources:

- ➔ Systems management as foundation for resources efficiency (promoting the role of farm animal breeding and latest big data approaches and technologies)
- ➔ Put an emphasis on the role of technological and data sovereignty, since the RI development enables sped up knowledge transfer and data solutions towards genome and phenome data and biosamples within a shared biobanking repository for farm animals, aquaculture species, domestic animals and model animals (eventually)

Within the strategy there are social, technological, environmental, economic, political factors and challenges outlined, that influence how that transition can be successfully manufactured. In the context of RI design and development, technological complexities and relevant data structures for access and interoperability, public-private partnerships, access conditions and technological readiness will be determining factors. To ensure a correct reflection of the diversity of market players and the relevant inclusion of industry data, the challenge might be intellectual property rights and data security aspects, which could be solved by data encryption strategies (other RIs rely on “expert centers” as single data processing points). Politically the creation of RIs secure a shared community development, free flow of researchers, sped-up knowledge transfer and a targeted deployment of funding and resources along a shared work program with equal voting rights of member states, funding the RI, where the market driven access ensures cooperation with relevant industry partners to streamline innovation and a certain technology readiness level.

4.4 Bioeconomy approaches

- Renewable raw materials, biobased products for industry and consumers
- Production systems as ecosystems
    - Develop knowledge on bio-resources within the food value chain
    - Use robotics and AI for bioeconomical fundamentals
    - Develop the sustainable resource base, preservation of soil fertility
    - Regional value chains
    - Technology open research for breeding

In principle, the bioeconomy stands for more than the production of bio-based products within the framework of a sustainable circular economy with the aim of replacing fossil raw materials with biogenic and renewable raw materials. The systemic approach of developing resource- and environmentally friendly solutions for sustainable consumption is particularly interesting. In this overall context, livestock acts as a system component that competes with humans for food, can refine food and ecosystem-based growths by converting them into high-quality protein and using resources (soil, water, etc.) in the process. In the context of this process chain on a regional basis, but also beyond, an evaluation of possible biogenic resources and changed uses and potentials can include indirect effects and socio-economic effects in the context of sustainable resource management around livestock farming.
Precision farming approaches are an interesting way of measuring behavioral and animal welfare parameters using complete sensor and image data-based animal monitoring. The husbandry systems developed from this in the context of organic and conventional farming systems can redefine the role of animal husbandry in the context of bioeconomic solutions via renewable raw material components and utilization potential (also for energy generation).

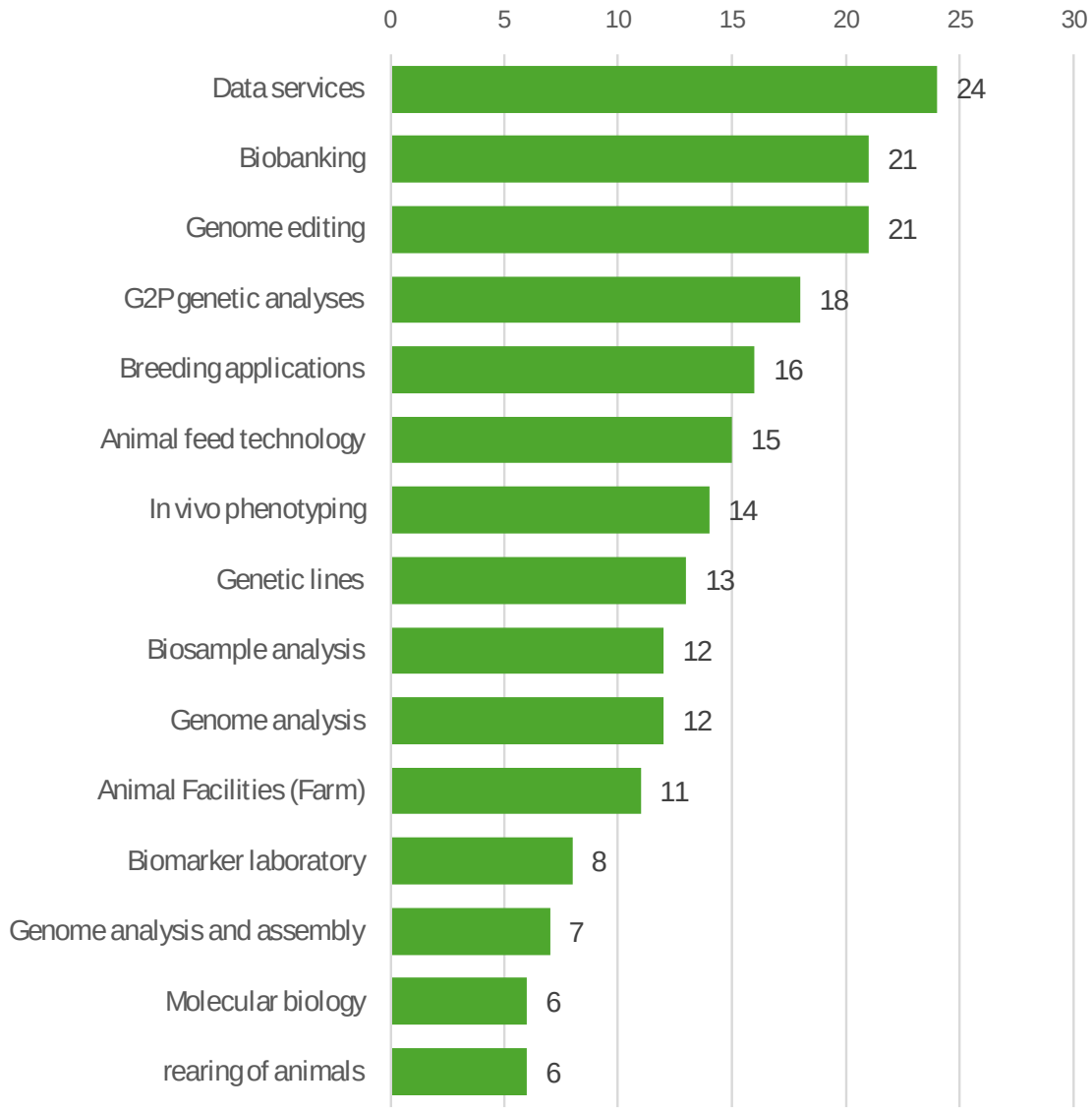
4.5 Strategy for Conservation of animal genetic resources

In 2021 the European Regional focal point for Animal genetic resources provided a document to inform about the strategy for conserving animal genetic resources.
Key recommendations on In Situ and Ex Situ Conservations are:

- "Develop and implement national strategies and action plans for integrated and complementary in situ and ex situ long term conservation strategies for AnGR, engaging all relevant public and private stakeholders in the process.
- Promote and support initiatives and collaboration for in situ and ex situ conservation of transboundary breeds.
- Strengthen the European network for in situ conservation and management of local breeds at risk.
- Support breeders' associations and farmers to implement breeding programs for local breeds at risk.
- Strengthen and promote the valorization of AnGR-related ecosystem services (e.g. landscape conservation) and livestock products.
- Increase the breeders' awareness of their role as key actors in the conservation of AnGR.
- Develop research towards better understanding of breed characteristics and features, in particular adaptation to specific ecosystems and farming systems."

5. GenoPHEnix Demand analysis of scientific and industry partners

Within the GenoPHEnix design and ESFRI application procedure a survey was launched to measure the size of the user groups and deliver insights of the involved scientific disciplines. In the context of the survey, the respondents answered in the name of their organizational unit and (if available) should also state numbers on heads of senior researchers, post-docs, PhD-students, technicians and their interests towards the infrastructure. 106 respondents answered the survey, representing 6297 researchers, engineers and technicians of the respective institutions. 52.88 % were employed at higher education organisations, 36.9 % in public research institutes and 4.84 % in private companies (the rest answered for non-profit organisations, intergovernmental organisations, non-governmental organisations and one private research institute). Although the return rate of the Survey from companies was 32%, their demographic weight in terms of employed researchers is much lower.

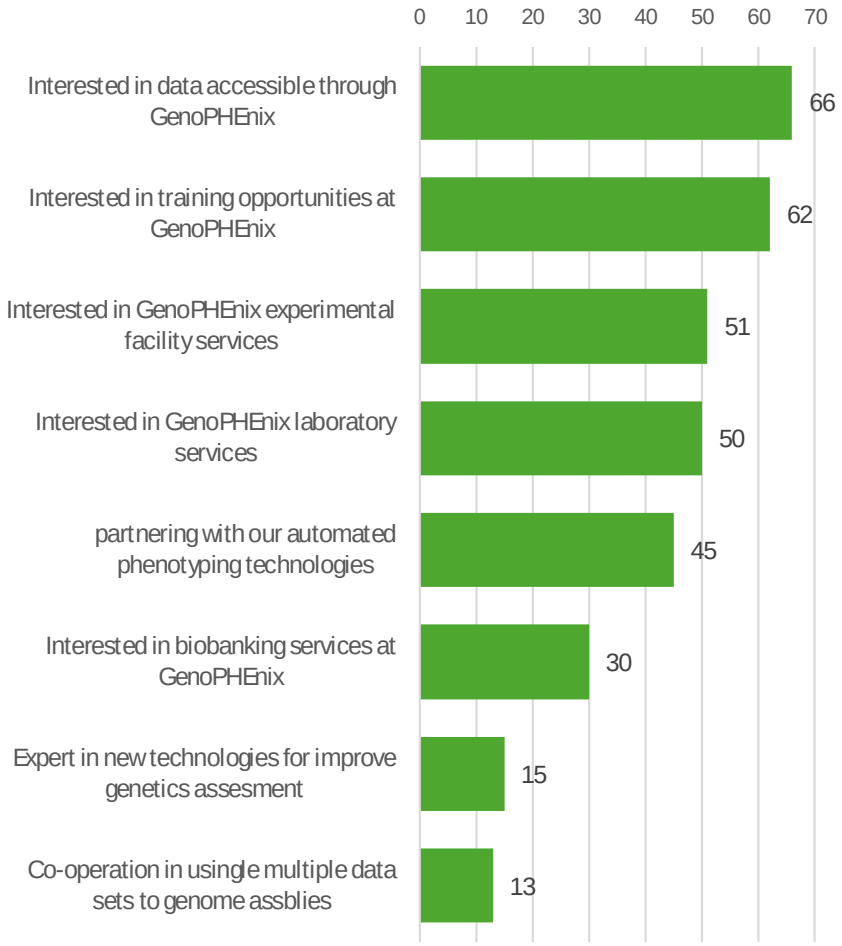


Tab. 3 most relevant services of GenoPHEnix RI, based on absolute numbers of survey return rate, 2025

These results correspond with results from EuroFAANG concept development project, where the potential to integrate genome and phenome information in existing or required interfaces for farmed animals was evaluated. Most respondents identified a strong possibility to achieve better research results through shared data between academia and industry, but identified at the same time the main barriers at the topics of data confidentiality and intellectual property concerns. A possible solution would be data encryption strategies, which will be further elaborated on within GenoPHEnix preparatory phase, if the proposal is successful.

The potential for future collaboration was also evaluated within the survey. Most respondents are interested in data collaborations and use of training opportunities and all services, where GenoPHEnix experimental and laboratory facilities can be used. An

interesting result, where a two-folded development can be derived: the development of open access research data and possible data analysis tools holds the strongest potential for collaboration between the European research landscape and industry. On the other hand, the fundamental research on large scale phenotyping options and big data analytics and mathematical modeling might be shaped by GenoPhEnix core members.



Tab. 4 Potential of GenoPHEnix collaboration

Both of these tables show what is reflected within the green and digital transition; a huge demand for suitable data repositories and solutions.

6. RI service offer

6.1 service offer

The extent of the whole service offer is a reflection of the scientific expertise of partner institutions and European focus points with a totality of 503 services. It also reflects on the scientific and innovation goals of the RI as well as on the framed demand of the different scientific fields and communities (see section demand-analysis). The great variety for big data analytics as well as possibly in-depth analysis, comparative observations and innovative methodologies and technological advancements is based in the experimental and laboratory resources of the facilities.

This enables relevant research on genotype-environment-interactions, measurement of defined and new phenotypes relating to performance-criteria, animal welfare and behaviour, nutrition, efficiency and emissions within relevant research areas. The size of the RI in terms of number of member- and observer-institutions, geographic distribution and relevant networks for cross-domain research, as well as the centralized structure for improvement of political and innovative development of important scientific disciplines ensure the establishment of a suitable governance-structure.

For the GenoPHEnix proposal as new RI for the ESFRI roadmap 2026 update the consortium listed a total of 503 services, thereof 241 services in relation to the experimental facilities and 151 laboratory services. Capacities evolve around expertise on cell models, biomarker, organoids, genome editing, image analysis, histology and spectrometry.

Breeding applications and further data services as well as genetic analysis are listed as dataservices, with a totality of 40 service offers.

Category of services	Number of services	Category of services	Number of services
Experimental services		**Data and associated services**	
Animal feed technology	9	Advanced Analytical Services for Cellular Models	1
Biomass processing	7	Breeding applications using G2P data	14
In vivo phenotyping of animal behavior	33	Data services	21
In vivo phenotyping of health & welfare	1	G2P Genetic analyses	3
In vivo phenotyping of nutritional efficiency and emissions through gold standard methods	76	Genome analysis and assembly	1
In vivo phenotyping of production performances	97	*Total*	*40*
Rearing of animals	18	**Biobanking services**	
Total	*241*	Biobanking	9
Laboratory services		Genomics	7
Advanced Analytical Services for Cellular Models	16	Sample management	8
Biochemistry, structural analysis	4	*Total*	*24*
Biology	8	**Education and Training services**	
Biomarker laboratory	1	Biobanking	2
Biosample analysis	11	Biosample collection and analysis preparation	2
Biosample collection and analysis preparation	20	Breeding applications using G2P data	1
Cell and organoid laboratory	14	Communication	1
Custom Cell-Based In-vitro Research Models	18	Data	10
Detailed molecular characterisation of organoids and/or tissue	2	Detailed molecular characterisation of organoids and/or tissue	1
Development of organoids	3	Ethics	3
G2P Genetic analyses	1	Genome editing	1
Genome analysis and assembly	11	In vivo phenotyping of animal behavior	2
Genome editing	6	In vivo phenotyping of nutritional efficiency and emissions through gold standard methods	6
Genomics	13	In vivo phenotyping of nutritional efficiency and emissions through proxies	3
Histology	4	In vivo phenotyping of production performances	9
Microscopy and image analysis	4	Laboratory techniques	6
Molecular biology	14	*Total*	*47*
Spectrometry	1		
Total	*151*		
Total			503

Tab. 5 Complete list of services for GenoPHEnix RI, April 2025, 503 services in total, 449 already in place

6.2 access conditions

In general there are different forms of access for different user groups and approaches. Physical and remote access is relevant for scientific excellence access and market-driven access as well as for training and education approaches and fast-track access.

Wide virtual access and emergency access are also relevant forms, but will be explained later.

Services can have different categories and ways, in which they are provided. GenoPHEnix distinguishes between Services, where the user is physically present (within a laboratory or an experimental facility) and has the opportunity to shape the outcome and quality of the service results itself and services, where remote access is granted. Users have no access to the service itself, results and quality are within the responsibility of the GenoPHEnix service leaders.

Services that combine both access forms are considered hybrid-access. Wide-virtual access is granted via the GenoPHEnix web page and/or data portals, respectively data portals that are managed by GenoPHEnix or its member

institutions. This is necessarily relevant for e-data services, in the context of open-data repositories as on-demand-service.
This section provides insight on service offers and relevant access to GenoPHEnix itself and its service offers towards the outside communities. Users can engage with the infrastructure for different requests, for example:

- Access to services
  - Scientific excellence mode – example on transnational access
  - Market-driven
  - Wide-virtual access – example FAANG data portal and other open access repositories, Sample request towards the biobanks
  - Access to training and education
  - Fast track-access

6.3 resources

GenoPHEnix relies on the expertise and advancements of INFRAIA projects SmartCow, PigWeb and AquaExcel as well as INFRASERV projects AgroSERV and AquaSERV, with more than ten years of experience in their field and also established procedures for transnational access and services towards the respective scientific communities.

Leading institutions of 11 member states give access to their experimental and laboratory facilities, as well as their experts and relevant training.
GenoPHEnix partnerinstitutions have experimental capacities in relation to multi-species (Mammals, birds, fish, insects) approaches, nutrition, energy and emissions:

- Dairy, Beef, (calves),
- aquaculture,
- sheep,
- poultry,
- laying hens and broiler,
- pigs for all production stages in conventional and organic farming
- Feed mill
- Biogas & new energy solutions

7. Sustainability of funding

7.1 GenoPHEnix proposal

GenoPHEnix is built on the foundation, results, services and structures from “legacy projects”, whose expertise and experience is now combined within the GenoPHEnix proposal. To ensure financial sustainability, the establishment of a research infrastructure within the European strategy forum reflects the scale and importance, and therefore relevance of funding within the goals of the European Research Area, of European Genotype to Phenotype research, farm animal and aquaculture breeding and the value of farm animals and aquaculture for high quality and sustainability of human nutrition and food value chains.

Member states, that deem the creation of the RI in line with their strategic goals and scientific and political aspirations towards excellence, innovation and sovereignty request the foundation of the research infrastructure within regulation EG Number 723/2009.

The RI approach in itself is based upon sustainable and long term planning and combines scientific expertise with a centralized government and structured communication.

GenoPHEnix submitted their application towards the ESFRI 2026 roadmap update in April 2025. RIs are planned within the roadmap process as lifecycle approach, which contains 6 stages of RI development and maturity. The next phases for GenoPHEnix are planned as follows:

- **Preparatory Phase**, scheduled between 2027 and end of 2030;
- **Implementation Phase**, scheduled between 2031 and 2032;
- **Operational Phase**, starting in 2033

For each of these stages, the eleven member states, that are responsible for the development of GenoPHEnix, were able to project costs and design a suitable funding framework, which combines different instruments for investment and operational costs and reflect also on the share of a market-driven access, where through the cooperation with possible industry-partners the RI generates a certain level of revenue (charged as service fees).

The project cost-book describes a well structured design of infrastructure resources from 154 facilities, 16 member institutions of 11 member states on 51 different sites over the time period from 2027 to 2049.

The totality of GenoPHEnix funding needs to be evaluated within the demands of the different developmental stages, evaluation of necessary investment costs or operational costs of already existing or planned resources, the establishment of a central hub structure and the GenoPHEnix legal entity, and the description of different funding instruments throughout the operational phase of GenoPHEnix.

Necessary investments for new buildings and equipment (where upgrades are necessary in regular terms) are scheduled between 2028 and 2034 with a total amount of 33 m €. Of 11 Member states, 5 MS invest in new buildings and 9 MS in equipment. This reflects on the one hand, that institutions already identified unused potential and how to mobilize new areas and specifications for research and, on the other hand, the maturity of planning and therefor the willingness to integrate those structures into the long term scientific program. In total, 37,47 m € are planned as GenoPHEnix investment costs.

With reference to the Public guide of the ESFRI Roadmap 2026, the financing of the preparation phase is defined as follows: “The preparation costs cover all real or estimated costs for the Preparation Phase of an RI, including the funding from a Preparatory Phase under the Framework Programmes and all other in-kind and cash third party contributions. Importantly, the preparation costs also cover all costs following a Preparatory Phase project until the implementation Phase.”

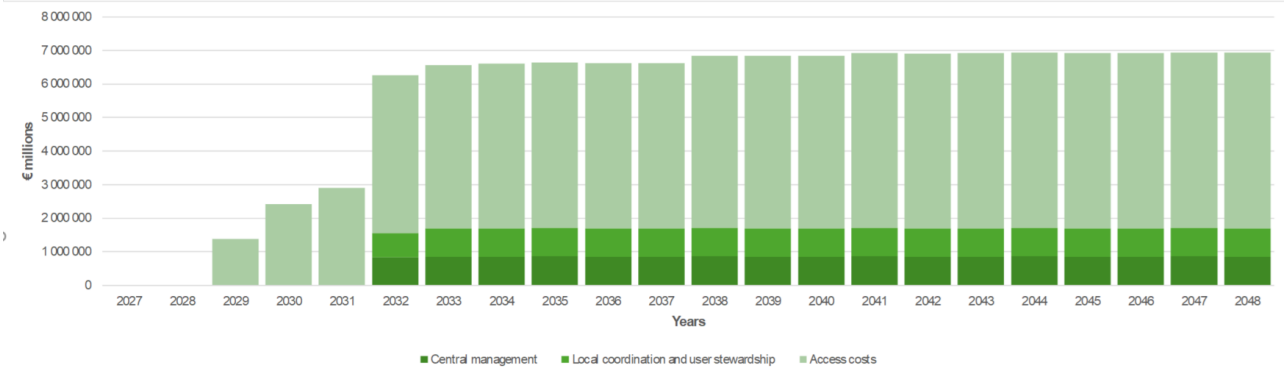
Main costs for the RI:

- Scientific, technical and managerial personnel costs, networking activities, joint research activities and transnational cooperation
- Non-physical assets; IT platform, cloud, virtual information technologies, data banks
- Costs for data management
- Personnel investment costs involved in construction and set-up phase not related to routine operation of the RI
- Consumables, utilities, other costs
- Start-up costs
- Replacement costs

GenoPHEnix partners will develop necessary structures during preparatory phase, which includes the further definition of the scientific and innovation program, including biobanking, phenotyping, data structures and suitable resources. Furthermore, with anticipation of implementation, necessary governance structures, preparation for establishing the legal entity, planning for staff and human resources, refinement of financial planning, ongoing commitment to engage relevant institutions for political support of the RI, risk management and networking activities, to implement the RI in the European research landscape and within the ESFRI Health and Food Cluster are necessary and part of preparatory work. Until the date of the proposal submission towards ESFRI, GenoPHEnix received 17 letters of intent (to become an observer and later possibly a member of the consortium) and 35 letters of support from other ESFRI research infrastructures, other European scientific societies and networks and research organisations.
GenoPHEnix plans with costs of 4.787.175 €, of which 93% or 4.3 m € are personnel costs, plus travel and other costs. We plan to attract funding under the Framework Programmes for Preparatory Phase. The partner institutions contribute their resources, since GenoPHEnix partners want to provide their services from 2029 onwards (503 services in total, of which 449 are already available).

With reference to the Public guide of the ESFRI Roadmap 2026, the financing of the implementation phase is defined as follows: “The implementation costs cover the value invested in the Implementation Phase of the RI, including hiring personnel, acquiring the site and goods, construction costs, legal costs, coordination of users’ communities, data management infrastructure costs, commissioning as well as pre-operation and startup costs. For some RI (cyclical surveys for example) implementation costs may occur periodically also during the Operation Phase. In the cases where major upgrades to the infrastructure are planned already at the proposal stage, these should also be included in the implementation costs.” For distributed RIs, the negotiation for political and financial commitment, reflected in the governance structure and the establishment of the legal entity are oftentimes more complex and need strong leadership and communication.
For GenoPHEnix, some of the investment budget, 124.400 € on travel and 3.177.674 € for personnel are necessary costs.
The consortium evaluated regional ERDF funds and the Smart Specialization Strategies or Research and Innovation Strategies for funding investments. The phase is financed by regional funds, national funds, foundation grants and in-kind contributions.

With reference to the Public guide of the ESFRI Roadmap 2026, the financing of annual operational costs is defined as follows: “The average annual operation costs cover all costs of running the RI for one year, operating users’ access and delivering scientific services as described by the project. They include all RIs’ costs (such as personnel, power, rents/mortgages, taxes, maintenance, continuous upgrade and replacement costs, users support, in-house scientific programme). Average annual costs should refer to the whole RI, including national nodes for distributed RIs.” We also refer necessary structures and costs of the central coordination hub that will be implemented in France. For the operational phase, users pay for the access towards the RI through ad-hoc credits by non-competitive national grants for excellence-driven, priority driven and training and education access mode.



Tab. 6 Annual cost estimation of GenoPHEnix, taking into account costs for management, local coordination and access costs, 2029 – 2048

Table 6 shows total operational costs of GenoPHEnix from 2029 to full operation until 2048. Access costs, which include access to facilities, databases, TNA, training and education, range from 4.8 m € in 2032 to 5.8 m € in 2048. The legal entity of GenoPHEnix is planned with 4.7 FTEs for personnel costs (General director 1 FTE, scientific director 0.5 FTE, data officer 0.5 FTE, industry liason officer 0.3 FTE, communication officer 0.3 FTE, secretary 1 FTE, legal advisor 0.2 FTE, financial advisor 0.2 FTE, ethical advisor 0.2 FTE). 30k € will be budgeted annually to secure travels to present GenoPHEnix within conferences or to invite speakers to GenoPHEnix events. The total annual costs for the legal entity are 86.000 €.

The infrastructure in itself is not implemented for economic gain and to generate large profits. GenoPHEnix plans on attracting 14 % of the access value through the market-driven access mode. It is immanent, that GenoPHEnix cannot finance their operational capacities or investments from own activities. Since the market-driven access and the

generated venues deliver increasing revenues over the years, the annual balance will be mostly positive over the years.

7.2 possibility of other funding sources

Though not streamlined at the moment, the general possibilities next to the RI planning would be to streamline national infrastructure funding, for example in working with ELIXIR and apply to their strategic funding possibilities.

New calls from the European Commission, calls for joint INFRA-SERV or INFRA-TECH projects and new research innovation actions projects to cluster 6 RIA (research and innovation actions) calls, where EuroFAANG could be linked to the EU missions, would be further possibilities to engage other funding sources.

8. RI solutions and conclusion

8.1 Defining the value of GenoPHEnix research for animal breeding and future food and health challenges along the lines of GenoPHEnix goals

1. **Building shared capacity for deep phenotyping of farmed animals, including identification of biomarkers for breeding, and management**
    a. Value: definition of relevant phenotypes, modelling of biological systems to be able to define the animal performance to develop new phenotypes, methods and tools
        i. In relation to the goal to create knowledge and in the long term conclusions for systemic adaptions of animals within defined production systems, extensive knowledge on multi-scale and multi-species capabilities with controllable and replicable methodologies for traits relevant for breeding and management shape the scientific knowledge foundation
        ii. In cooperation with farm animal breeding companies a relevant basis for discussion includes the opportunity to exchange relevant data, but initiate a larger scale process on including relevant development and traits and share essential results first hand
        iii. Define several different production systems
        iv. Share best practices
        v. Define procedures for higher level of harmonization and standardization at a pan-European scale

2. **Creation of a common data structure and access to genome and phenome data in farm animals**
    a. Value: creation and establishment and/or further refinement of data repositories as foundation for knowledge sharing, capacity building and network approach in a high scientific level
        I. Establishment of FAIR principles and open-data criteria, delivering also a relevant structural input in connecting to the EOSC Cloud, GenoPHEnix supports the EU policy on open data sharing to be a leader in a data-driven society

II. Evaluating relevant experience of other structures, like FAANG but also other data portals and services from different RIs, this is the groundwork for “big data” approaches, generating large amounts of comparable data, speeding up knowledge transfer etc., to solve relevant challenges relating to data fragmentation and lack of metadata and data standardization

III. In cooperation with industrial partners this holds high potential to combine efforts for a more targeted approach in sharing data, tools, models, methodologies

3. **Expanding Biobanking capacities, capabilities and access to bio-samples and cellular models for farmed animal species**
    a. Value: testing genetic modifications, allow fundamental research on farmed animals; collecting samples of different populations, environments and health status
        i. within the Infrastructure we will define procedures for storage, sample sharing, workflow procedures, quality management to approach the goal of a harmonized European Biobanking standard
        ii. define a relevant research sample base and species-specific genetic pool, with defined research purposes on traits relevant to the challenges of food and health cluster with the possibility of Transnational Access
        iii. in parallel conservation of genetic resources

4. **Connecting GenoPHEnix with existing projects and other RIs to consolidate European farmed animal research**
    a. Value: capitalizing on already established projects, structures and communities of different funding bodies with topics in farm animal phenotyping, genomics and genome annotation, and combining them with the larger context of ESFRI Infrastructures for Food and Nutrition (Metrofood), Human Biobanking (BBMRI), plant phenotyping (EMPHASIS), ecosystem services (AnaEE), Marine biology and resources (EMBRC) and animal models (INFRAFRONTIER)
        i. To incorporate the farm animal health space networks like VetBioNet and ISIDORE RI (infectious disease studies) contribute to the network of GenoPHEnix => strengthening research in

disease mechanisms, host-pathogen-interactions, biosecurity, etc. is of enormous value

ii. The use of analysis tools, bioinformatics, digital technologies and smart farming applications for collecting a large variety of data need a stronger collaborative effort of biology, veterinary science, bioinformatics and agriculture to combine efforts for actual data publication and coordination

8.2 Defining the role and value of farm animals within European Strategies

According to the position paper “Role of livestock in the EU Bioeconomy and FOOD2030 Strategy Stressing the importance of animal health and welfare, A CWG AHW perspective to the EU Bioeconomy and Food 2030 strategies” from Hermann Schodesberger, published in January 2023, the global population growth “demands a minimum of 60% increase in protein supply, while food systems now already consume ¾ of planetary water resources and approx. a third of planetary energy resources while emitting a considerable share of planetary greenhouse gases”. Taking this into account, and given the fact that the population in the EU is sinking while agricultural areas remain at the same level, there seems to be a potential to further strengthen the role of the EU as net exporteur for agriculture products (plants, crops and products of animal origin). Since feed demand is also sinking due to sinking numbers of livestock, this perspective should be elaborated on, taking into account timeframes beyond 2035.

GenoPHEnix delivers into several European strategy frameworks. The scientific and political outline of the RI within the health and food cluster not only touches the aspects of G2P research, but on a larger scale the role and effect of farm animal and aquaculture production in future production systems, taking into account changing diets, urbanization, challenges linked to climate change, animal welfare and resource efficiency for sustainable European and global food systems. This touches on the Green Deal, Green and Digital transition, the European Bioeconomy strategy, Food 2030 and conservation of genetic resources. Food 2030 identified four relevant areas, which also offer the classification and relevance of the RI and deliver reasonable justifications about the overarching contributions of GenoPHEnix to the European Food and Health cluster and its challenges (Antimicrobial resistance, Emerging zoonosis of worldwide importance, Livestock epidemics, Resilience and sustainability of the entire agro-food value chain, Food and nutrition security, Circular bio economy).

To this dimension, EU Food 2030 adds four prioritization areas:

- Nutrition for sustainable health and diets
- Climate-smart and environmentally sustained food systems
- Circularity and resource efficiency of food systems
- Innovation and empowerment of communities

The main value of livestock and its products is supplying high quality food as converters of raw biomass into high value nutrients. Indirect uses like landscape shaping, use for tourism and other socio-economic benefits are also important. The long-term goal must be to maintain food security under all circumstances and restructuring processes to ensure the appropriate quality of supply under changing eating habits. Modern livestock farming is still closely related to production systems and can improve efficiency and output system performance through improved breeding through better prediction accuracy, including more and more highly complex traits such as robustness and disease resilience, as well as meaningful behavioral parameters, without losing genetic resources.

The restructuring of livestock farming has already been visible and noticeable for two decades in the sinking number of livestock and the structure of European farms. The requirement to maintain the same level of production with a more structured use of resources, cycles of renewable and regenerative raw materials and to guarantee high-quality nutrition actually only allows one conclusion to be drawn. Animal husbandry and a systemic measurement of input-output performance, i.e. of farms or regions as an agricultural system, will shape the future of the circular bio-economy. GenoPHEnix provides resources and potential for basic research, as well as applied parameters for technological innovation and possible drug test series, and can thus actively contribute to safeguarding food systems. A special role is played by the consideration of production diseases and the systemic connection between animal and human health in a specific environmental context. To this end, factors such as stocking densities, herd sizes, hygiene requirements and infection pathways, biogenic factors and overall strategic management systems must be placed in context and chains of infection broken, and farm-based and smart AI-supported new procedures established. The potential to prevent these disease outbreaks is enormous, not only in terms of animal welfare ethics, but also economically. In principle, however, these necessary developments go hand in hand with the necessary developments to improve animal welfare, which can be achieved, for example, by providing more space, structured feed and bedding or similar. On a time scale, this will certainly entail the construction of new stables and adapted husbandry environments that meet the need for resource and production efficiency as well as very high hygiene

standards and animal welfare parameters, and thus meet the overarching goal of food security, provision of high-quality protein, adaptation to changing environmental conditions and consumer demands on animal husbandry and animal products. In this respect, the creation of GenoPHEnix at this point in time (implementation will be achieved in 2031/32) is indeed a strategic advantage, as the holistic bundling of scientific expertise and industrial partners under one large umbrella allows the definition of relevant phenotypes that safeguard production performance and animal welfare criteria in the course of foreseeable developments and, in the course of disease resistance, safeguard animal husbandry and thus systemic regional agricultural ecosystems in terms of health and economy. At the same time, the relevant data repositories can accelerate access to resources, data and results, strengthen European regions in Central and Eastern Europe and make bioeconomic cycle structures systemically recordable.
In this regard, GenoPHEnix plays into the conclusion of the European Animal Health and Welfare working group & the Standing Committee on Agricultural research, where the One Health Approach needs to include a large variety of scientific disciplines, going beyond the field veterinary science. “Ecologists, conservation and wildlife experts, field virologists, professionals in human health and epidemiologists, IT developers and specialists, authorities, farmers and food processors, mobility and logistics experts, economists and global development specialists, psychologists, communication experts, […] critical infrastructure management” are necessary to provide extensive knowledge and a profound perspective on this diverse challenge. The extend and also the impact of shaping the future directive of farm animal breeding, conservation of genetic resources and One Health require a centralized and well-coordinated Infrastructure, that GenoPHEnix can provide.

New potential evolves with bioeconomy approaches, where long-term development includes more and more reusable materials, fuels and systems for circularization of energy and material resources.
A stronger emphasis on regional conditions and local breeds with respect to shorter food chains is an interesting aspect to give a stronger relevance to local breeds and circular resource cycles. This development and integration into systemic approaches needs further research.
The technological possibilities of reducing animal experiments in context of the 3R principles in order to model relationships within cell-based model systems also takes livestock research to a new ethical level.
The development of this area is incorporated into the frameworks of the European Green Deal and EU Animal Breeding Regulations.