A European infrastructure
for farmed animal genotype to phenotype research

D 1.5 EuroFAANG infrastructure business plan

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Introduction

Domestic animals, both terrestrial and aquatic, play a key role in shaping the economy, landscape, culture and tourism of most European rural and coastal areas. Livestock production accounts for around 36% of the EU's total agricultural activity. Although European production systems are recognized as being among the best in the world in terms of environmental preservation and responsibility for animal health and welfare, farming systems and value chains for food production are undergoing a major transformation process at European and global level. This

is driven by a growing world population, climate change, environmental issues, and changing and increasing societal expectations on product and production quality, as well as animal health and welfare. In order to meet human nutritional needs and the demand for food of animal origin while ensuring high animal welfare and health standards, and sustaining agriculture and food systems, it is essential to improve the prediction of phenotypic expression and the genetic inheritance of phenotypic traits, for more targeted selection and resource-efficient management of farmed animals.
Farm animal breeding as major corner stone of farm animal production in Europe can increase knowledge on genome-enabled management practices, and designing the possibilities to breed for desirable phenotypes.

The EuroFAANG concept development project started in the beginning of 2023 with the aim of consolidating and harmonizing the G2P research in farmed animals, improving the FAANG data portal, developing approaches of in vitro cell models and farm animal biobanking, and bundling the capacities for genome editing in Europe.
One of the goals of Work package 1 is the expansion of the consortium, going forward in the development of scientific excellence. Therefore we have defined seven key areas to evolve the scope of the infrastructure and integrate suitable partners into the consortium. With the expansion of the consortium with Pheno-Live partners, we enlarged the scope of the infrastructure with capacities and expertise for multispecies phenotyping, less- and non-invasive methods to implement 3R principles and find a way to integrate large data sets of phenotypic data. The goals of the projects aligned sensibly, for example improving efficiency in farm animal production, redesigning systems towards a circular bio-economy and improving farm animal health and welfare and therefore acceptance of farm animal breeding itself.
Therefore, this deliverable builds on the structures developed within the EuroFAANG concept development project and adds the dimensions of the expanded consortium Genophenix and therefore an adapted scientific concept for the RI. This also influences other structures of the scientific case, e.g. data structures, data access and necessary portals and their management, but also pan-European relevance and overall the inclusion of new academic user groups.

This document shall outline the way to a shared business plan from EuroFAANG concept development project and Pheno-Live consortium for the application of the ESFRI Roadmap update 2026 under the name “GenoPHEnix”. The merging of consortia started in October 2024.

1. Mission of Genophenix

Genotype to Phenotype (G2P) research poses considerable challenges. On the “G” side, current FAANG efforts are progressively improving the genome annotation of terrestrial and aquatic farmed animal species. On the “P” side, existing research, bio-banking and phenotyping infrastructures work to gain more knowledge on complex phenotypic traits and their genetic architecture, and to provide access to *in vivo* and *in vitro* phenotype collections. In order to fill the gaps between the genomic and phenomic components to achieve accurate G2P predictions, it is necessary to gain the ability to refine and characterize highly complex traits as sets of intermediate informative phenotypes along the entire cascade from genome to cell, organism, environment, population and across different environments.

As such **the mission** of the Genophenix Research Infrastructure is to increase excellence and knowledge transfer for the European farm animal G2P research community, by:

- Consolidating the European Genotype to Phenotype (G2P) research landscape for farmed animals, defining capabilities, focal points for research, innovation and expertise and providing a framework to the community
- Reducing fragmentation of the G2P research landscape for farmed animals through harmonization of procedures, standardization and exchange of cellular models, gene editing, and other new and existing technologies, streamlining interdisciplinary synergies and enhancing collaboration
- Building capacity and establishing new ways to enhance data interoperability, usability and knowledge exchange with stakeholders in farmed animal breeding, health, welfare and biotechnology.

- Supporting incorporation of novel technologies beyond the state of the art, including Artificial Intelligence, and high-throughput *in vitro* functional screens into the G2P research landscape for farmed animals, thereby enhancing innovation and development.
- Within the framework of European strategies and on the basis of demographic, climatic and geopolitical factors, it is becoming clear that the importance and development of animal husbandry, its integration into the systemic bio-economy, the improvement of animal husbandry systems, the prioritization of animal welfare and thus an overall need to redefine animal husbandry as a supplier of high-quality protein, must be tackled as a strategic approach towards its systemic relevance. The safety and quality of the food supply along the agricultural value chain for humans and animals is increasingly confronted with the need for better husbandry conditions with increased animal welfare standards and the development of alternative protein sources for human (urban) nutrition. As part of the infrastructure, we can drive forward future research priorities and new technological developments and methods and thus promote research-driven, evidence-based livestock farming.
- Training and education of scientists at different career levels and enhancing cooperation with industry stakeholders.

This mission was established based on the combinations of the findings and expressed needs from different projects and scientific communities, which underlines its relevance and the scope of the pan-European RI:

- INFRAIA projects (SmartCow, PigWeb, AQUAEXCEL 3.0), taking into account their user communities
- FAANG community (Functional annotation of animal genomes)
- EuroFAANG concept development, taking into account findings from biobanking and technology surveys as well as recommendations from Think Tanks on in vitro cell models and genome editing
- EuroFAANG H2020 cluster projects (BovReg, GeneSwitch, Rumigen, Holoruminant, AquaFAANG, Geronimo)

- EFFAB scientific and industrial stakeholders of farm animal genetics

They identified unique challenges and missing structures within the current pan-European research landscape, especially catering to a higher necessary experimental capacity, especially for phenotyping the large variety of economically relevant farm animal species, model species, aquaculture and emerging farmed species. The following benefits (which can also be found within the science and innovation concept of the RI) **for a shared vision** were identified:

- Sharing best practices across species
- New technological developments and innovations for increased efficiency of procedures and transfer between species
- Development of a roadmap towards harmonized animal welfare indicators
- Development of a common data and biospecimen management and extending access procedures
- Providing opportunities for multi-species, multi-disciplinary experimental services (for example access on how combinations of different species can improve nutrient utilization in the food chain)
- Improvement of animal health, welfare, resilience and efficiency
- Improvement of ethical standards for animal research (3R principles)

Based on this derivation and the positioning of GenoPHEnix in context towards the challenges of the health and food sectors as well as positioning the RI in the ESFRI Health and Food cluster we extracted four main scientific goals to promote scientific impact and drive innovation within the transdisciplinary cooperation of this fields:

- To promote the sustainable management of farm animals, while improving their health and welfare standards and meeting societal expectations, by improving the accuracy of trait prediction, including for more complex traits such as robustness and disease resistance, as well as meaningful behavioural parameters, without losing genetic resources.

- To develop advanced technologies and better exploit animal variability for improved breeding and management through the development of sensors for phenomics and cellular models for genomics.
- To promote the 3Rs in animal research by developing appropriate models for in-depth phenotyping, combining in vitro and in vivo studies; the technological possibilities of reducing animal experiments to modelling relationships within cell-based model systems also take animal research to a new ethical level.
- To improve the understanding of genome function by integrating deep phenotyping data at the cellular, tissue, animal and population levels - providing tools and insights for precise, sustainable breeding and conservation of genetic diversity.

Potential of inter- and transdisciplinary cooperation

The aim of pan-European research infrastructures is to accelerate the transfer of knowledge and results through synergetic cooperation, the pooling of expertise, resources and skills, to promote scientific excellence and to publish research data in freely accessible data portals as part of the open data policy. The description of the services for the user communities already highlight that better utilization and faster test results can be expected by bundling test capacities. Fig 5. shows an example of a possible synergetic use of services, using and utilizing different capacities and experimental possibilities in the individual partner institutions.

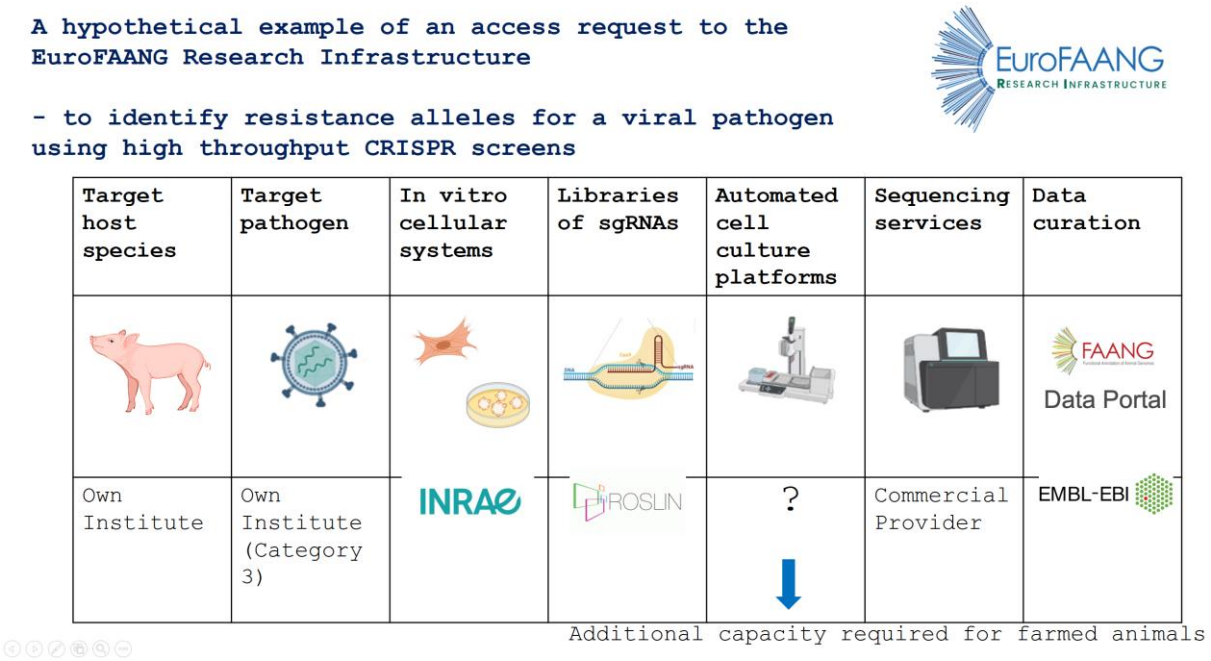


Fig 1. A hypothetical example of an access request; identification of a resistance alleles for a viral pathogen using high throughput CRISPR screens

As a result of the pooling of capacities, it is expected that research resources will be used more efficiently, and as a consequence it will be possible to react more quickly to current issues and better experimental design will also be possible across institute boundaries as part of the cooperation. Through transnational access, guest scientists can use experimental units from partner institutions and thus expand their own expertise.

Ability to adapt to new questions

The integration of the leading institutions in the field of livestock research with a focus on animal breeding holds great innovative potential, due to the range of research expertise to be integrated, the range of animal species included and the related key research topics with high innovative potential. The foundations of the strategic research orientation are laid within the framework of an RI in the General Assembly as the highest decision-making body. The GenoPHEnix consortium received 17 letters of intent, from European institutions, who want to participate as observer under the GenoPHEnix Consortium agreement with the possibility to

become members and enlargen the scientific consortium, expertise and resources of the RI. GenoPHEnix is also supported by seven ESFRI projects or landmarks (EMPHASIS, MIRRI ERIC, AnaEE ERIC, IBISBA, LifeWatch ERIC, EMBRC ERIC, INFRAFRONTIER), three scientific societies (European federation of Animal Science EAAP, European Aquaculture Society, Spanish Aquaculture Society), two networks (EUGENA-ERFP, EU-LI-PHE) and six research organisations.

2. User groups, needs and access conditions

GenoPHEnix plans on establishing new services, based on the scientific framework outlined above and the demand that was concluded from the different scientific and industrial user groups that could benefit and contribute to the RI:

1) Establishment of phenotyping options for farm animals and fish and harmonization of procedures
2) Data coordination and open access data repositories for genome and phenome data, including rich and detailed metadata
3) Access to biosamples of farmed animals, aquaculture and fish, domestic animals and procedures for sample sharing and open access to research results within a biobanking directory
4) Training and education for researchers of different career stages
5) Multi-lateral cooperation with European projects and consortia within the Health and Food domain

2.1 Expected demand

We have defined key activities for the various emerging services of the infrastructure, and added the user groups with their respective sizes for which these services, tools and expertise are of interest.

- Phenotyping
    - Define phenotypes of interest per species, taking into account current research questions within the national and European frame

and prioritize them based on scale (European impact, Previous resources and scope of results, possibilities for further capacity development), development of research capacities, timely dimension
    - A single stop shop to access defined traits and phenotypes for all economically relevant and emerging farmed species with regard to growth, efficiency, fertility, behavior, welfare, health, specific diseases, nutrition
    - Define areas of innovation for less and non-invasive methodologies within a multi species approach (3R principles)
    - Hosting of scientists
    - Service of transnational access to promote cooperative approaches, visibility of researchers and development of shared capacities
    - Enable open access to a high quality data portal, possibly in collaboration with FAANG under EMBL EBI data coordination and in accordance with FAIR principles

- Biobanking (TNA and JRA)
    - a single stop shop to access biobank catalogues of cellular models and animal genetic resources for research, promoting visibility of European partner biobanks
    - Training and mutualizing competences and equipments, which are needed to include novel technologies and procedures into the realm of partner biobanks
    - Increase visibility and knowledge transfer via group events, and exchange with Think Tank groups
    - Hosting of scientists to develop new models, new protocols
    - service of transnational access to promote research and expertise of scientists and increase usage of different biobank infrastructures
    - Cooperation with other Biobanking infrastructures, high synergetic potential with medical biobanking

- Think Tanks on *in vitro* cellular models and genome editing (Improving breeding, phenotyping and genomic technologies)

- Advancements of new technologies
- Exploration of synergies
- Expanding of networks of experts and collaboration
- Focus on expanding capacity for G2P research in farmed animals beyond the state of the art
- Exploring routes to application of EuroFAANG data e.g. building capacity for genome wide CRISPR screens for resistance to viral pathogens through sharing sgRNA libraries

- ELIXIR Focus Group on domestic animal genomes and phenomes
  - Promote and engage networking and discussion of scientists with the goal to have a fully developed ELIXIR community
  - Define future community needs
  - Explore data / technology solutions for addressing key issues in welfare, behavior, health, infectious disease, metabolism, nutritional efficiency & preservation of genetic diversity and environment
  - Inclusion of emerging species and definition of their community needs
  - Data standards and coordination
  - Data training and knowledge transfer events

- FAANG data portal (TNA)
  - Facilitate access to high-quality animal ‘omics and FAIR metadata through the EMBL-EBI hosted FAANG/GenoPHEnix data portal, and data and metadata repositories resourcing BioSamples, the European Nucleotide Archive and Ensembl genomes browser
  - Facilitated cohesion with ELIXIR standards, resources and infrastructure
  - Data management, workflow, FAIR data management, Open access, metadata enrichment

- Extension of given standards and exploration of improved data interoperability
- Expansion of capacity of the data portal to provide phenome data and metadata (link with EU-LI-PHE EU COST Action)
- Expansion to include catalogues of resources such as pre-designed sgRNAs for genome wide CRISPR screens
- Develop data and metadata standards for emerging technologies of importance in animal agriculture (link with INSECT-IMP EU COST Action)
- Coordinate development of analysis pipelines and workflow managers for standardization of ‘omics analysis, in close coordination with the nf-core community in animal genomics
- Ensure equitable access across Europe, assess uptake of data and metadata standards and community needs

- Transnational access priorities and solutions
  - Consolidate links with the global FAANG community, and other infrastructures for data, globally AgBioData, AG2PI and ELIXIR
  - Adapt the frameworks from existing infrastructures for TNA such as INFRAFRONTIER, EMBRC, PigWeb
  - Ensure equitable access across Europe and assess technological readiness, particularly Eastern European countries
  - Define units of access
  - Ensure equality, diversity and inclusion considerations are met for TNA
  - Define community user base for TNA, ensuring all of Europe is represented

- Cooperation with other European instruments
  - European partnerships: explore synergies and future funding opportunities, e.g. with European Animal Health and Welfare Partnership, particularly within the animal health space to build capacity and provide a route to application of EuroFAANG data.
  - COST Actions (e.g. EU-LI-PHE and Insect-IMP)

- Prototyping solutions to identify infrastructure gaps in animal agriculture genotype to phenotype space, building on the foundation and investment provided by the H2020 and Horizon Europe EuroFAANG projects

- Training and education

  - Relevant scientific fields:
    - Animal welfare (sensor based monitoring approaches)
    - Sustainable husbandry practices
    - Multi species breeding approaches
    - Behavior and adaptation (sensor based monitoring approaches)
    - Nutrition & emission

  - Relevant scientific methods, which have been identified at the current stage of planning:
    - In vivo phenotyping protocols
    - Ethics and 3Rs implementation in animal research
    - Utilization of biomarkers and sensors
    - Biobanking protocols
    - Data and metadata, including the use of the FAANG data portal
    - Use of the biobank directory
    - Production of cell-based in vitro research models
    - Organoid production and characterization
    - Advanced analytical services
    - G2P genetic analysis
    - Breeding applications
    - Genome editing
    - Analysis pipelines and specialized software

  - Within this fields, there can be sub topics, referring to experimental procedures, specifics for certain species, data coordination topics,

RDM and open access procedures, ethical considerations, legal framework and good scientific practice

2.2 Institutional and disciplinary diversity and internationality of users

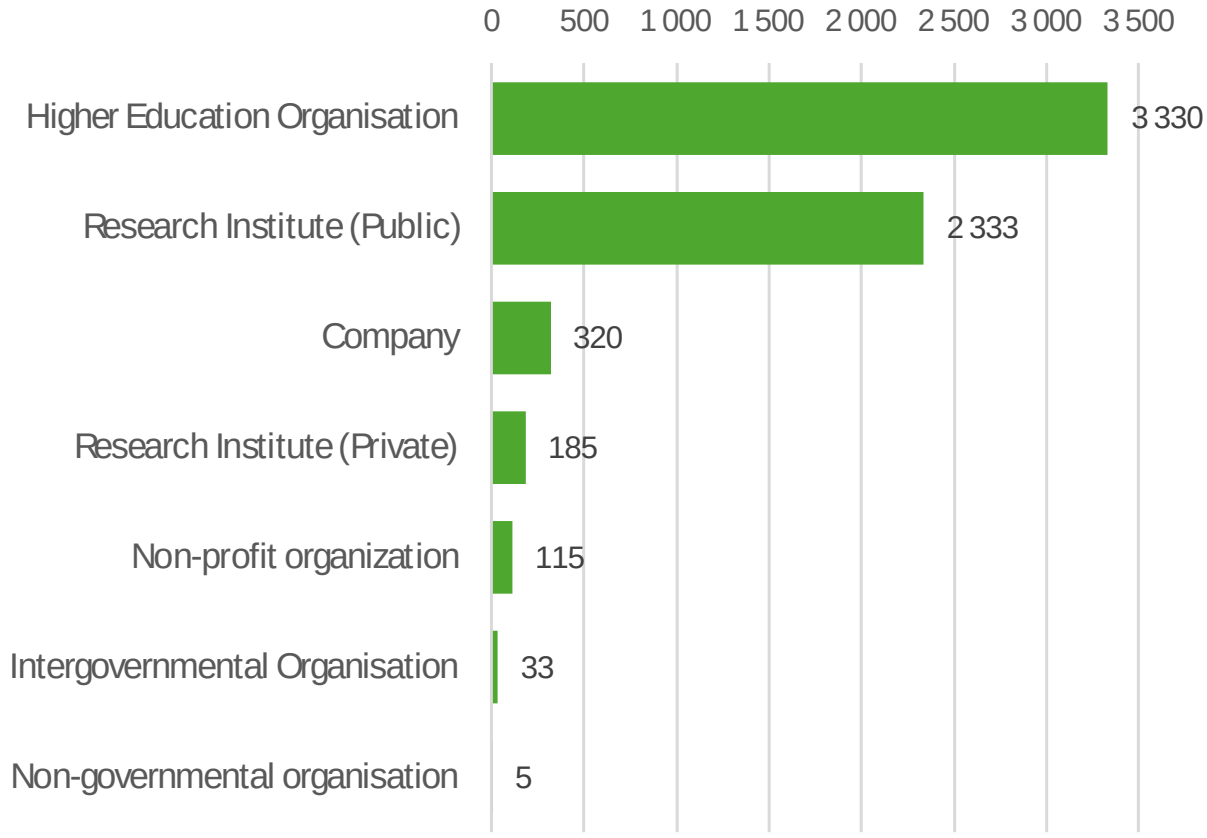
The main purpose of the infrastructure is to consolidate scientific resources of G2P research, make them usable and drive innovation and development forward. Scientists from genomics, phenomics, animal breeding, biotechnology and bioinformatics and similar areas are the main users of the infrastructure. Additionally we will expand the scope to industrial users of farm animal breeding companies as well as pharma- and farm animal health companies. The RI provides also valuable insights for politicians and funding agencies, experts of animal welfare and ethics and higher education providers, working in the realm of knowledge transfer.
In general, access to the infrastructure will be given via the central hub as a coordination unit, which controls the flow of information to all partners and the external environment and takes on the task of assessing external inquiries in order to determine the appropriate contact person or service offerings. Access to local laboratories, experimental units, IT structure and biological resources is determined and granted via the TNA procedure.

Users of GenoPHEnix can be grouped according to the following specifics:

a. Academic user, open access
b. Academic user, restricted access for use of the RI, for example within a collaboration between academic and industrial partners
c. Industrial user, open access
d. Industrial user, restricted access

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

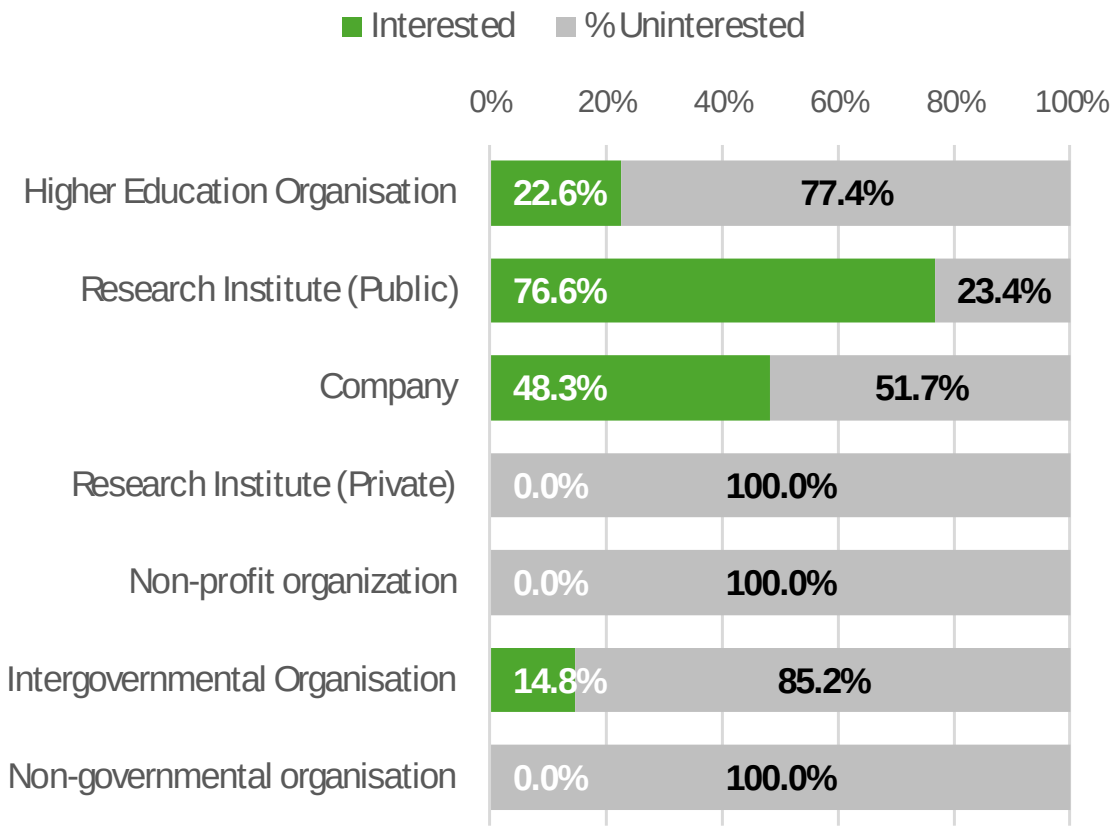
scientific disciplines. In the context of the survey, the respondents answered in the name of their organizational unit and (if available) should also state numbers on heads of senior researchers, post-docs, PhD-students, technicians and their interests towards the infrastructure. 106 respondents answered 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. 1 Representation of researchers, engineers and technicians within the different institutions and organisations

To measure the interest of participants, specific questions towards GenoPHEnix services were included in the survey. The quality of answering fully and comprehensively was seen as a more interest towards GenoPHEnix. Therefor the

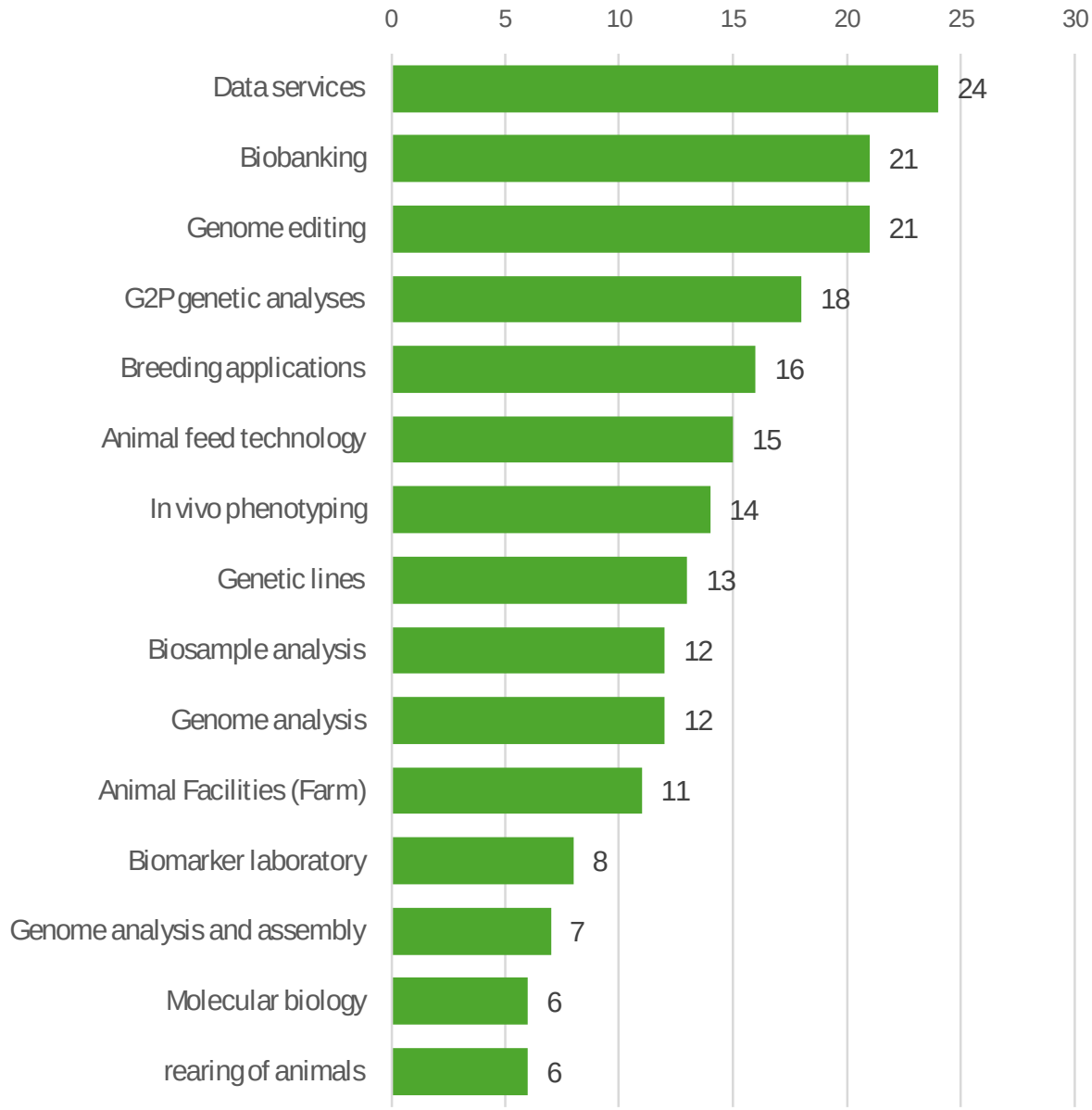
following table provides insights, for which type of organization GenoPHEnix offers potentially valuable services and research.



Tab. 2 Summary of Interest from organizations towards GenoPHEnix research and service offers

Within the survey 97 respondents provided answers on the question to identify the 5 most interesting services of genoPHEnix for their institution. Table 2 shows the answers in absolute numbers. Data services, biobanking, genome editing, genetic analysis and breeding applications were the 5 most selected. These results correspond to the outline of EuroFAANG concept development project, where the consolidation of the research landscape for biobanking and in vitro cell models, data coordination and public repositories and genome editing were main focus points. Combined with tables 3 and 4 this shows, that there is strong interest for different data analysis tools and open access towards research data as well as for farm animal biobanking for research purposes and genome editing as future technology from public research and private companies. This indicates a strong potential for the market.-driven access and can indicate a strong need to design

data portals, where industry access (under restricted conditions) and public-private partnerships can be nurtured.

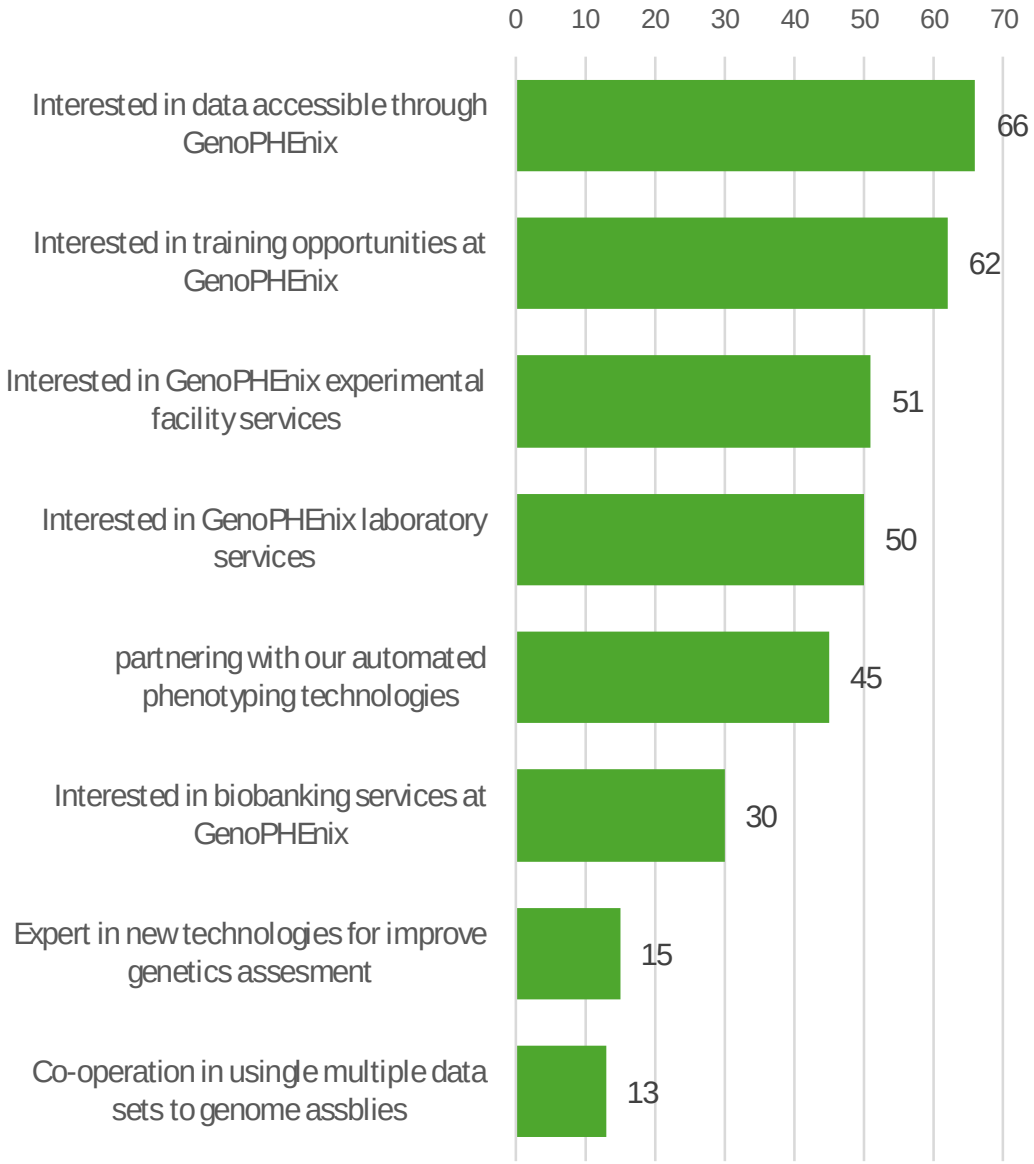


Tab. 3 Most interesting services from GenoPHEnix RI

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.



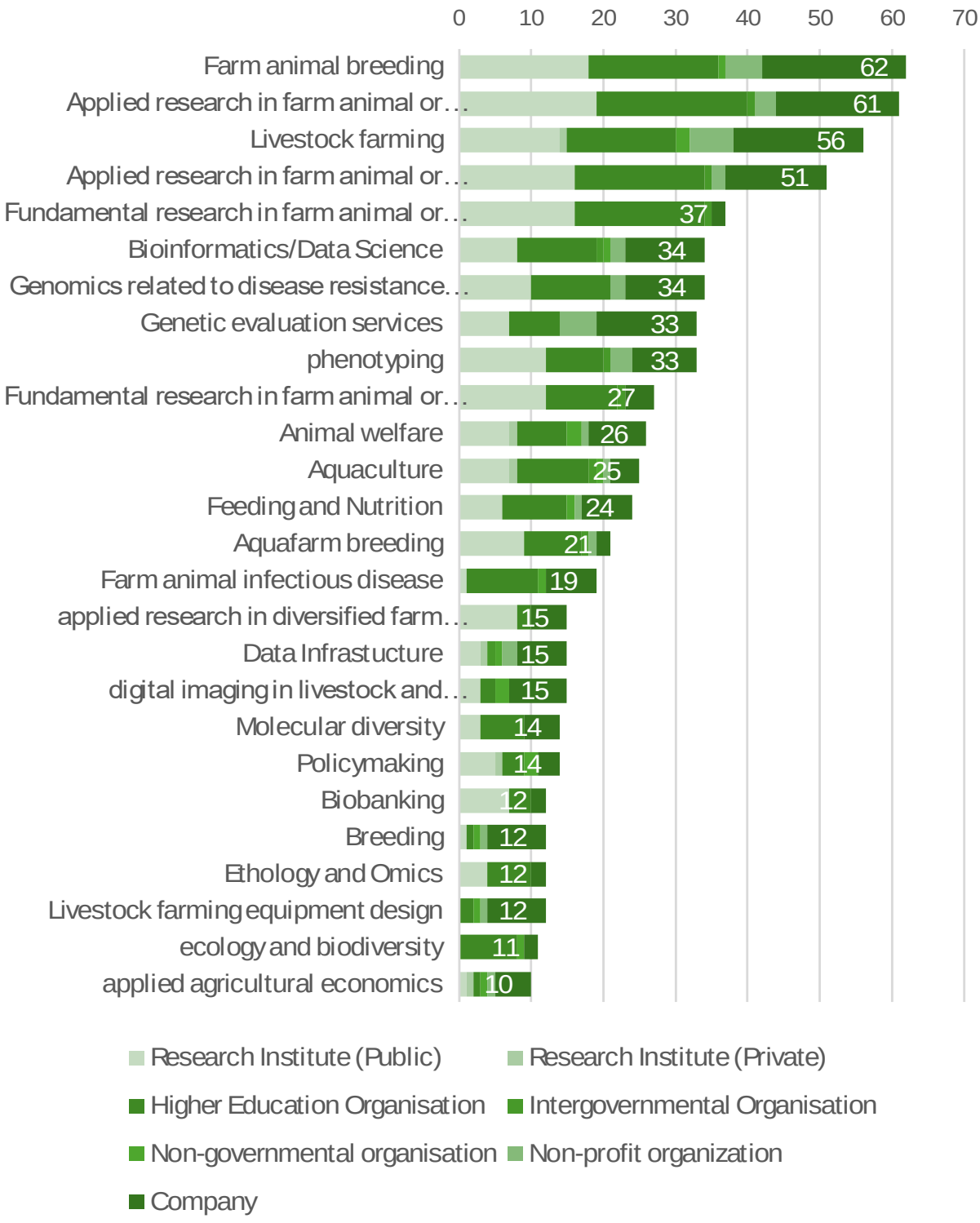
Tab. 4 Potential for GenoPHEnix collaboration

Expected user groups of Genophenix research infrastructure are:

- research & academia
- biobanks & laboratories
- sequencing and genotyping providers
- policymakers and public authorities
- Farm animal breeding companies and aquafarms
- Animal nutrition companies
- welfare and ethics experts,
- higher education providers,
- pharmaceutical companies

The main user group are scientists from the fields of genomics, phenomics, animal breeding, biotechnology, bioinformatics, data analysis and modeling. In the expansion of the consortium in the development of new fields of expertise and innovations, the following specialist areas are of interest:

- Robotics - high-throughput phenotyping
- AI, machine learning & digital twin technology
- Large scale automated phenotyping of sensors and other devices
- Testing of genetic combinations & screening of chemical components
- Big data and analytics
- Improved tools to understand animal breeding and production, also in a social science context (orientation and action knowledge for policy)
- Immunogenetics



Tab. 5 main activity of respondents (in absolute numbers) in different organizations.

Most respondents work in the fields of farm animal breeding, applied research for farm animal or aquafarm physiology (nutrition, metabolism, behavior, reproduction)

and applied research in farm animal or aquafarm physiology (nutrition, metabolism, behavior, reproduction).

To summarize possible user groups and their size (to evaluate a need of GenoPHenix services), the following user communities were identified within the EuroFAANG concept development project:

Academic User community	Scientific field	Origin	Sort	n
Researchers in Functional Annotation of Animal Genomes, that are mostly members of the FAANG community	Genomics, genome annotation, research data management	Global initiative, scientific lead in the USA (Iowa State) and Europe (Inrae)	academia	553 participating scientists in 52 countries; 57 publications from FAANG relevant data + 2096 data sets to general publications in this area, 160 researchers participate in 6 task forces to shape the priority tasks
Genome editing	Genome editing		academia	76 identified partner laboratories in Europe; 6

				industry partner; within the EuroFAANG survey 7 laboratories with 52 scientists provided more detailed information
In vitro cell models and Biobanking of farm animal resources and samples	biobanking	no central organisation, based within the individual institutions; Initiatives like EUGENA are based in France	academia	33 institutions from 29 countries are interested in GenoPHEnix EUGENA integrates 14 countries, 24 genebanks and 4.269.742 samples

Tab 6. Examples of possible user groups and size for GenoPHEnix

GenoPHEnix received answers from 29 different countries, of them 21 Member States (Austria, Belgium, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden), 6 Associated Countries (Israël, Norway,

Serbia, Switzerland, Türkiye, United Kingdom), and 2 non-associated countries (Australia, United States of America).

Short and medium term innovations of the RI:

- Fit for purpose in vitro models for farmed animals, including organoids and cell lines, including those derived from highly phenotyped animals.
- Use of in vitro models for pre-validation of in vivo experiments or instead of in vivo experiments, e.g. for disease challenges, environmental perturbations, contributing to the 3Rs.
- High-throughput cellular screens using CRISPR technology, for example, to screen 100's of a 1000's of potentially causal variants in appropriate in vitro systems.
- These would provide additional targets for genome editing, including multi-plexed edits for polygenic traits such as disease resistance.
- Improvements in genomic selection based on better knowledge of the genome particularly for difficult to measure/improve traits such as disease resistance.
- Artificial intelligence using high resolution phenotypes for model training e.g. for animal behaviour/welfare traits.
- Innovative for genomic and phenomic data visualisation tools including for pangenomes and for comparative genomics.
- Novel means of sharing proprietary data with breeding companies and other stakeholders e.g. via data encryption.

Longer term innovations of the RI:

- Generation of in vitro systems at scale from highly phenotyped populations from different environmental contexts.
- Pangenomes for highly phenotyped breeding populations of animals.
- Integration of desirable synthetic haplotype blocks in breeding populations using genome editing.

- High resolution phenotyping of genome edited animals in breeding programmes.
- Genome enabled management - highly phenotyped high value animals with reference quality genomic information for husbandry and management decision making.
- Integrated data brokering options for genomic and phenomic data, including partitioned data sharing options for breeding companies and other stakeholders.

2.3 Services of the Infrastructure

These innovations are transforming animal research and the role of research infrastructure in delivering services and capacity for both in vitro and in vivo experiments, increasing the need for networking, method harmonization and knowledge sharing.
The RI therefore plans to provide several services and develop new ones for the European community on farm animal science as part of the European Health and Food cluster:

- Through established TransNational Acess procedures to connect experts, institutions, local resources and samples with users, easy access to:

- Large experimental capacities for replication and validation of new concepts and solutions for animal breeding and management in a large range of GxE conditions;
- Less and non-invasive phenotyping methods (including in vivo non-contact methods and in silico models) to improve ethical standards of animal research
- Large-scale datasets and samples through standardization of animal traits and their ontologies, measurements and data formats, to avoid duplication and promote re-use of data,

- Build on the think-tanks of experts we have created to consolidate efforts in in vitro cellular models and genome editing and establish a dedicated ELIXIR community on farm animal genomes and phenomes
- Coordinate with Elixir in data infrastructure building capacity for expanding and extending the FAANG data portal and develop a biobanking directory & a roadmap for sharing biobanked samples, through the information stored in the BioSamples database. In parallel, we will also develop a catalogue of existing data and samples repositories, standardization, ontology, metadata and data validation possibilities for phenotyping data.
- Proof of concept for phenotype data integration, data management and a possible data stewardship and encryption solutions for working with industry stakeholders.
- Build a strong community network by providing links to other Infrastructures within the ESFRI Health and Food cluster, like EMBRC, BBMRI, MIRRI, Metrofood, EMPHASIS, AnaEE, and previous and existing infrastructures focused on animal health e.g. VetBioNet and infectious diseases more broadly e.g. ISIDORe
- Provide a roadmap for meeting the expectations of the 3Rs in animal research through enhancement and rapid sharing of novel technologies, including state of the art cellular screening technologies and in vitro models.
- Standardized phenotyping protocols across European RIs + training materials, taking on the results of earlier projects (SmartCow, PigWeb, AquaExcel)

The catalogue of services is established on different levels of maturity, depending on the status of the respective projects:

- INFRARIA projects SmartCow, PigWeb, AquaExcel with already active levels of TransNational Access Procedures and service provisions
    - SmartCow provides services in 17 different facilities
    - PigWeb provides services in 18 different facilities
    - AquaExcel provides 31 different services
- AgroServ and AquaSERV as INFRASERV Projects connecting services on Research Infrastructure level

    - AgroServ offers 143 services from academia and industry
        - 11 partner RIs: AnaEE, ELIXIR, Euro-BioImaging, EU-OPENSCREEN, EMPHASIS, EMBRC-ERIC, IBISBA, Lifewatch-ERIC, METROFOOD-RI, MIRRI ERIC, SmartCow
    - AquaSERV offers over 500 free services
        - Based on over 40 institutions, 6 Research infrastructures (Aquaexcel, AnaEE, EMBRC, ELIXIR, METROFOOD) in 16 countries
        - Aquaculture, fisheries, ecological restoration, blue economy, Biotech, environment, food/social
- EuroFAANG concept development project delivering a service catalogue of 7 partner institutions, e.g. on Biobanking, in vitro cell models and organoid capacities, animal testing facilities, genome analysis capacities

This variety in expertise, level of development and biological and experimental specifications makes it necessary to arrange a service catalogue with information on service, protocol readiness level, access type, access mode, service leader as contact point within the institution, description and technical precision, which ensures a uniform availability of information according to the “European Charter for Access to Research Infrastructures”, published by the EC in November 2024.

With regard to the development of the different consortia, their timelines and developmental steps the consortium defined five service families of first order:

1) Biobanking
2) data and associated services
3) experimental services
4) laboratory services
5) training offers

For each category there are relevant subcategories of services, which are quantified in table 7 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. GenoPHEnix partnerinstitutions have experimental capacities in relation to multi-species (mammals, birds, fish, and 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

This enables relevant research on genotype-environment-interactions, measurement of defined and new phenotypes relating to performance-criteria, animal welfare and behavior, 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.

The inclusion and connection towards the scientific goals of GenoPHEnix is also visible within the scientific case and design study.

Another focus point are training and education offers for the different scientific communities, scientists of different career stages, laboratory staff or industrial stakeholder (could be with regard to innovation applications or scientific personnel). GenoPHEnix lists 37 services for those purposes, which include cross disciplinary expertise of institutions, scientific goals of the RI and planned focus topics in anticipation of training capacities of the member institutions. With respect to different training topics and goals, several formats for skill training and knowledge transfer are thinkable. These include laboratory workshops, online seminars and training course, especially with regard to data repositories and RDM practices, summer schools and events to connect scientific input and knowledge transfer with extensive networking opportunities.
Adaptable formats for target groups and webinars are thinkable and long term open access tools for knowledge transfer.

List of training domains (to be extended):

- Biobanking protocols, biobank management & workflows
- Biosample collection, storage, analysis, sharing
- Data and metadata repositories, its use and development (FAANG data portal, Biobanking directory,…)
- Utilization of biomarkers
- Organoid production
- Cell models (in vitro)
- G2P genetic analysis and breeding applications
- Genome editing
- Analysis pipelines and specialized software
- In vivo phenotyping, gold standard methods, development of SOPs for different species and productions performance traits, welfare and behavioral traits

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. 7 Categories of services as planned for GenoPHEnix (503 planned, 449 already in place)

2.4 Value proposition

The establishment of a research infrastructure dedicated to G2P research in farmed animal species offers significant benefit, with far-reaching implications for agriculture, animal husbandry and management:

1. Access to new opportunities for multi-scale (from cells to herd) and multi-species (livestock and fish) phenotyping capabilities. GenoPHEnix will enhance the harmonisation of phenotyping procedures *in vivo* by developing and evaluating innovative and non-invasive methodologies for phenotyping animals using biomarkers, proxies, imaging techniques and mathematical modelling of biological systems. The use of *in vitro* cellular models will provide the ability to validate the hypotheses generated by *in vivo* studies and to perform exploratory investigations (e.g. *in vitro* forward genetic screening of host responses to pathogens and nutrients) that would not be ethically and/or economically sustainable *in vivo,* and thereby

contributing to achieve the 3R (Replacement, Reduction, Refinement) principle.

2. Developing new predictors for complex traits: to facilitate better genomic selection strategies and potential targets for genome editing to improve complex traits, such as resistance to disease, in each of the farmed animal species, focusing on economically relevant criteria. This leads to advancements in breeding and genetics for enhanced productivity and efficiency.
3. Animal Health and Welfare: through providing a route to application of the data generated by the H2020 EuroFAANG project the infrastructure plays a pivotal role in enhancing capabilities, capacity and collaboration to tackle animal health challenges. Eventually this will enable developing models to predict susceptibility of animals to a pathogen; and will help anticipate the spread of infectious diseases. Healthier animals contribute to more sustainable and ethical farming practices.
4. Resource Efficiency: The research infrastructure aids in the more efficient use of both existing and new resources in animal farming. This efficiency is crucial for sustainable agriculture practices, ensuring that the industry remains viable and environmentally friendly. This has far reaching implications, also on sustainability of the entire food value chain, future availability and usability of food with regard to changing conditions due to climate change and geopolitical implications. Efficiency can also be optimized by optimization of traits, e.g. feed efficiency, modified feed compositions in connection with growth, performance or increased farm animal health.
5. Fundamental biology: By providing access to capabilities and capacity across Europe for G2P research, in in vitro cellular models and high resolution analysis of genome function the research infrastructure will link cell, tissue and whole animal scale knowledge.
6. Enhancing and conserving genetic diversity: The research infrastructure will provide access to biobanks and repositories for maintaining genetically diverse material from farmed animal populations to preserve genetic diversity. Sharing of data for the wide diversity of farmed animals through

the data portals will also help to build strategies to conserve and manage genetic diversity.

7. Genome editing: The research infrastructure will provide a European think-tank on genome editing in farm animals, connecting national ethics committees and infrastructures. Genome editing is a key route to application of FAANG data through i) functional validation of candidate variants using *in vitro* cellular systems) with high-throughput (HTP) functional screens and ii) generating targeted edits of the genome *in vivo* with the goal of using state of the art technologies for sustainably improving farmed animal health welfare and productivity.

2.5 General display of GenoPHEnix access opportunities

Research infrastructures as such provide resources and services to different scientific communities, to improve their research, speed of data provision and knowledge transfer and foster innovation.

Resources of the infrastructure

(already available)

a. Animal housing facilities
b. Laboratories with respective equipment of the partner institutions
c. Experimental facilities for research on nutrition, emission or behavior or other parameters
d. Standard operating procedures, as defined in FAANG (Functional Annotation of ANimal Genomes)
e. Biological material and samples, stored within the Partnerbiobanks or their laboratory units
f. Different scientific data, incorporated in respective data repositories belonging to the Infrastructure
g. Analytic pipelines and specialized software
h. Scientific expertise of researchers, participating in GenoPHEnix
i. ELIXIR focus group “Domestic animal genomes and phenomes” & Think Tanks with linked repositories and data collections
j. EuroFAANG/GenoPHEnix Webpage with links to all publically available resources

(planned development)

k. Biobanking directory
l. Data portal to integrate and give access to phenotypic data
m. GenoPHEnix RI management center

Access conditions

a. Local access to locally stored data of the infrastructure within the individual institutions or laboratories
b. Local access to locally stored biological resources within the individual institutions or laboratories
c. Online-access to use IT-infrastructure of the RI
d. Online-access to use data portals and repositories of the RI
e. Online-access to use restrictive units of data of the Think Tanks or the ELIXIR focus group
f. Local access to use IT resources of the RI
g. Local access and use of experimental facilities of the RI within the individual institutions or laboratories
h. Local access to scientists and staff of an institution for knowledge transfer and training purposes

Additionally, GenoPHEnix relies on the termini, defined by the European Commission, on access to research infrastructures. This includes the contacting of the Research Infrastructure and even more so the use of services and resources, which needs to be authorized by the RI itself via their internal and/or transnational access procedures.

Access can be given physical, remote, wide virtual (as provided via “communication networks”) or hybrid. Details on access units, respective conditions, procedures and contact points are fixed in the access policy of GenoPHEnix.
Access is also defined by legal obligations of the partner institutions or involved scientists and therefore the purpose defines the access mode (excellence-driven, market-driven, wide virtual, priority-driven).

To get access to all the implemented GenoPHEnix structures and services the first contact point is the central hub as central coordinating unit.

Functions:

- Single contact point for first entry into the infrastructure, accepts inquiries and measures along the lines of presented information, which contact/service/offer of the infrastructure is best suitable to fulfil the request of partners or projects
- Next to the administrative officers, there will also be a scientific officer as well as an orientation committee, to grasp the correct scientific measure and state of project maturity
- Coordinates flow of information between partners and external environment of the RI
- Coordinates administrative question with national nodes
- Gives guidelines for key areas, e.g. quality management in laboratories, access calls, training, these will be directed by the central hub
- Responsible also for overall management, implementation of ESFRI regulations after consultation with general assembly
- Implementation of a consistent strategy

2.6 User engagement strategy and access

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

Access to services

The advantage of a distributed RI is that it delivers expertise, facilities and resources in a combined effort, which allows for specialized services within an institution as well as synergetic approaches, to deliver high quality services and results to the scientific community and beyond. Within the access policy of GenoPHEnix the different access modes as well as user engagement, relevant for these services are outlined.

We expect **scientific excellence access proposals** towards the RI as the most common type of service request (estimated 63%), also to relate to the calculated annual costs for resources within the infrastructure. All proposals for experimental designs, research and transnational access will be monitored through a feasibility report, an evaluation and finally a scheduling process. During this process an in-house panel will review, if the research design and purpose fits with GenoPHEnix expertise and resources and shall comprise an evaluation of each necessary resource and the needed access units. After this step is successfully completed the proposal will be evaluated by the Research Program Advisory Committee (RPAC), hosted by the GenoPHEnix (ERIC), for scientific quality and fit-for-purpose status. Necessary criteria are: scientific excellence, socio-economic impact, track-record of the applicant, compliance with GenoPhenix commons and Interdisciplinary. Through a scoring process the scientific relevance is evaluated and grants, if successful, the access to the relevant resources.
With regard to projects like SmartCow, PigWeb and AquaExcel the consortium holds a high amount of expertise on transnational access procedures as a form of scientific excellence access mode. Within the EuroFAANG project, the consortium developed a TNA application prototype, which offers a more detailed and refined version for access. During the preparatory phase, these will be further developed towards a consolidated submission process.

TNA application prototype for GenoPHEnix, based on the EuroFAANG deliverable D2.1 as guideline for transnational access

Access via TNA is open for scientists of all nations, with a priorization of scientists, whose institution is located in an EU member state of an associated country. The share of these scientists in the overall context of RI, TNA has to be 80 % of accepted TNA proposals. Applications of non-associated third countries are welcome, but will need to undergo a special monitoring procedure. Focus areas of the national institutions are prioritized, next to the focus areas of the central coordinating unit.

Applications for TNA should be made based on the steps listed below:

- **Step 1: Expression of interest and Registration**

Applicants should consult the TNA catalogue and select the proposal of interest using the filters. In each filter, you can select more than one proposal. Users must first register in the TNA portal. Once registered, application should be completed using the TNA online tool available on the project website.

- **Step 2: Pre-proposal submission**

Applicants are requested to submit a pre-proposal, mainly providing information about:

- The rational: This describes the context in which the project fits, indicate the overall objective and assess the expected impact on the subject matter.
- The scientific quality: present the state of art, define clear scientific question to which the project should provide an answer, formulate the appropriate hypothesis and briefly explain the approach to be followed.
- The valorisation strategy: explains what the data will be used for, such as open data policy, scientific publication, patent or registration procedure.

- **Step 3: Full proposal submission**

Selected pre-proposals will be invited to submit a full proposal, which should be prepared in close collaboration with the Access Officer of GenoPHEnix. Full proposals should provide information about:

- The scientific and ethical soundness: resume the final scientific question, describe the design of the trial.
- Practical and financial feasibility including number of units of access, necessary approvals from ethical committee or other authorities, information on visit and /or participation of the applicants, and an overview of potential risks.

If participation by the TNA applicant is required during the experiment, it should be ensured that the person participating has the appropriate training and licenses.

- **Step 4: Evaluation of proposal and implementation of access**

Selection should be done in 2 stages. For first stage selection, the main criteria will be based on relevance, possible impact, scientific questioning, degree of innovation and valorisation potential. The main criteria for the second stage selection will include the scientific and ethical soundness of the proposal together with the practical and financial feasibility. In addition, the USP will assess the responsible use of experimental animals and the TNA provider will attest the feasiblity of the proposed work. Applicants will be notified of the outcome of each selection stage process after the submission deadline. Provisional approval will be granted pending possible approval of other authorities (for example ethical committee). In the event of a positive outcome, TNA applicants need to contact the Access Officer of EuroFAANG to apply for this additional approval. Without the approval of authorisation bodies, the experiment will not be able to start. Official documents regarding the approval by the ethical committee must be delivered to the Access Officer.

- **Step 5: Reporting**

To monitor and guide TNA projects, TNA users are expected to deliver concise reports at the start mid-way and upon termination of the TNA project. Reports should be submitted using the online TNA tool available on GenoPHEnix website and approved by the Access Officer. In addition, to further improve TNA programme, a mandatory follow-up questionnaire will be sent to all TNA users. This questionnaire is expected to be submitted together with the final report.

- **Step 6: Valorisation**

TNA users have owners‘ rights on the data obtained, but they are expected to valorise their result as soon as feasible (pending protection of intellectual property), preferable in Open Access publications, with due acknowledgement to GenoPHEnix.

- **Step 7: Reimbursement**

In the case of hosting services, GenoPHEnix can subsidize travel and subsistence costs of the TNA users. Either the TNA user or the infrastructure can make the bookings. It is expected to choose the most cost effective form of travel and

accommodation. In case TNA user makes the booking, the Access Officer must be contacted to approve the travel budget. Costs that exceed the agreed travel budgets cannot be reimbursed. In addition, without the submission of the final report, follow-up questionnaire, cost cannot be reimbursed. Boarding passes, travel agency invoices, original tickets, e-tickets must be submitted along the reimbursement claim form.

Another competitive-driven access towards the **infrastructure is the market-driven access** of industrial users, which we plan will make up for 14 % of access. Users pay a fee based on full costs + margin. Equal to the procedure for the scientific excellence proposals, users need to deliver a proposal before they engage with the RI and will be evaluated on well defined criteria: Technological readiness level which should be developed during the course of the service; proof of concept and how the technology will contribute to societal challenges; and technological track-record of the applicants. The access is granted via the Development and Innovation Program Advisory committee (DIPAC) as transparent market-driven access mode. It is possible to present materials and information to an in-house panel in private, to ensure the confidentiality of ideas and proposals.

As described before, **wide-virtual access is an on-demand access** to the infrastructure that gives access to permanent resources, mostly relevant for the e-infrastructure and data-portals. GenoPHEnix distinguished between three types of data: 1) data from sample collection and analysis collected by GenoPHEnix staff as routine activity; 2) personal data related to external users; 3) scientific data collected from user experiments. Data access cannot be granted without complying with GenoPHEnix data policy. It distinguishes between data collected on the context of scientific excellence mode and data obtained in the context of market-driven access proposals.

GenoPHEnix is building an own data portal which contains a threefold of data access, thereby building 1) on the foundations of the FAANG data portal (functional annotation of animal genomes) and the expertise of intergovernmental organization EMBL-EBI and of the collaboration with the life-science infrastructure ELIXIR. GenoPHEnix is fully committed to FAIR principles and generating data and

making it available in an open data repository. The data collected as part of the functional annotation of genomic data is made available and published in the FAANG data portal or directly via INSDC public archives. 2) Phenotypic data, e.g. quantitative measurements and images will be stored at the BioStudys database and the BioImage Archive. 3) As third component, a Biobanking directory delivers access on biosamples and biosample data in an open access repository. Research data management includes regulations on data sharing, the obligation to comply with the FAIR principles, long-term data management, data standards and metadata standards, as well as regulations on publication under Fort-Lauderdale & Toronto principles, data use and clarification of the role of the EMBL Data Coordination Center. GenoPHEnix RI thereby explicitly supports the multiple use of data, provided that they are correctly cited and referenced, GenoPHEnix is referenced and, in the case of the INSDC, the project identifier is included in the publication. Further details are visible in the GenoPHEnix Access policy principles and the data management plan. As an example for conceptualizing the access to biosamples within the infrastructure, a request procedure prototype has been conceptualized in the context of EuroFAANG, to give a centralized access option for European multi-species biosamples. This will be further developed during the preparatory phase of GenoPHEnix.

Sample request procedure prototype, developed for EuroFAANG deliverable D4.2

Steps for sample distribution request

- **Identification/Registration on the data platform**

Create a user account using a company's or institute's e-mail account and log in.

- **Searching of samples**

The user can make a Simple Search using any word related to the desired samples (tissue, species, breed, project name), or make an Advanced Search using filters based upon the minimum data set pre-defined by the biobanking infrastructure.
In the case of GenoPHEnix, the minimum data set may include the quality control criteria of the cell line or the protocol used to derive the cellular model.

- **Initiation of requests**

Select your desired samples and prepare the request by using Add to Cart button. When you have added all of the samples you require to the cart, review your cart to check your order. Update the content of your cart, fill in the request to validate your cart and submit the request.

- **Evaluation by the Biobank**

Upon receipt of your sample requirements, the contacted Biobank will revert to you to handle your request via GenoPhenix portal. The Biobank may ask you for further information before sending an MTA agreement. It may also consult the GenoPHEnix Biobanking hub and send you a quote. Expert groups per species ensure the scientific expertise during evaluation. An email exchange zone is provided to enable you to ask any questions you may have.

- **Validation and implementation of requests**

Orders will only be validated by the Biobank after the completed and signed MTA has been received in duplicate, along with a signed purchase order if relevant. Indeed, if the request is covered by the TNA budget of GenoPHEnix, the quote will be null.

- **Confirmation and shipping**

The next step is for the biobank to send the invoice, samples and confirmation of receipt. The invoice will be paid directly to the Biobank, not via the portal.
It remains to be decided whether the payment will be made to the central hub of GenoPHEnix or to the national node hosting the biobank which is distributing the samples.

- **Steps for sample entry request**

To make a sample entry request, the user must also authenticate itself and follow the steps on the portal, as for a distribution request. It is possible to save an unfinished request if more time is needed to collect the requested information. In particular, biological material can enter a GenoPHEnix biobank only if it complies with the minimum data set.

At the end, the user is invited to submit a file containing the characteristics of the samples and any other files considered to be useful, such as the animal experiment permit, the protocol used to derive the cellular model, any permit related to Access and Benefit Sharing (Nagoya protocol), any document related to Intellectual Property, a sanitary certificate, etc.

Access to training and education is planned with 8% for infrastructure access. Details can be found under point 2.3. Regarding the access procedure users might have a long-term agreement with the RI or make an ad-hoc request. In any case, GenoPHEnix evaluates through a six-step evaluation procedure, if the program seems promising: 1) definition of curriculum, to agree on the activities for training, 2) an in-house panel evaluates the relevance for GenoPHEnix, 3) Resource check, 4) Scheduling, 5) cost and negotiation, 6) contract and agreement.
Fast track and emergency access might be a rare event, but it grants access to GenoPHEnix resource immediately, when two conditions are fulfilled:

- Proven scientific motive for immediate access
- Clear scientific interest, such as a relevant publication by a competing team

The access share is estimated with 3%.

3. Analyses of Environment of GenoPhenix RI

3.1 Policy landscape (Strategic European goals, ESFRI)

Livestock farming systems and value chains for food production are undergoing a major transformation process at European and global level.

The overarching goal of European **research infrastructures** is to consolidate and improve a certain key strategic priority area, which is necessary to keep excellent research as engine of innovation and secure the position of the European Union in a global context. GenoPHEnix aims at providing the animal genetics research and breeding sector with a framework to cluster expertise, data, resources and equipment to integrate basic research in the G2P area with technical innovations, advanced methods and data management systems on a pan-European scale.

The area of **farm animal breeding and genetics** is growing on a global scale because of an increasing demand of high quality animal protein by-a growing global population, which will reach approx. 9.7 billion people by 2050[1]. Livestock not only provides high quality animal protein for human nutrition, but also a range of services to human societies from landscape management to cultural activities[2]. Genomic tools can be used to speed up genetic progress, but also to maintain a diversity of genotypes for a diversity of farming systems. The increasing use of genetic technologies and services is intended to answer numerous challenges for livestock and to help anticipating impacts of climate change or epidemic diseases. Advanced methods have been and continue to be developed, to enable genomic breeding progress in preferred traits at individual, herd or population scale.

G2P research is the foundation of responsible and successful animal breeding and can enable recommendations for animal production as integral part of **European Agrifood Systems**, taking into account performance and efficiency as well as sustainability and responsible handling of resources. Additionally, the **green and digital transition** and the increasing public concern about **animal health and**

[1] UN, 2021: United Nations Department of Economic and Social Affairs, Population Division (2021). *Global Population Growth and Sustainable Development*. UN DESA/POP/2021/TR/NO. 2.

[2] H. Schodesberger, 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, January 2023

welfare shape the developments of the sector. GenoPHEnix' organization and well-set up structures has the potential not only to consolidate this research area and integrate new technological advancements on a harmonized pan-European quality scale, but also to engage all important actors of this field for increased knowledge transfer, visibility and transfer of scientific evidence into breeding strategies, improved animal husbandry and sound policy advice.

ESFRI Landscape of Health and Food

The European strategy forum for research infrastructures is the central strategic committee that provides an overview of the current RI landscape. ESFRI has set up the roadmap process to create and give transnational access to strategically important research infrastructures, and gives insights into the RI landscape, current trends and recent and future developments through its landscape analysis. The overview allows to also identify possible gaps and needed structures.

The Health and Food Cluster comprises the influence and interaction of environment, food, lifestyle and health especially in the frame of rapid urbanization of increasing population, where Europe is a key player in this global scenario.

Challenges of the Health and Food Cluster, according to the ESFRI landscape analysis 2024:

- the rising burden of common complex diseases such as cancer
- cardiovascular diseases
- antimicrobial resistance
- nutrition related diseases
- emerging zoonosis of worldwide importance
- pandemics
- livestock epidemics
- the affordability of the health care systems
- 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.
The Health Cluster is massively involved in actions aiming at, on the one hand, reducing the impact of non-communicable diseases to improve the overall health and wellbeing of European citizens and, on the other hand, at controlling emergent pathogens to develop pandemic preparedness. The European Commission is building a European Health Union (European Health Union - European Commission) with an integrated European Health data space.
Activities regarding Food policy take place in context of the Green Deal & Farm to Fork strategy to enable the transition into low greenhouse gas emission adapted and eco-friendly agro - food value chains.

The ESFRI cluster “Health and Food” consists of 12 established landmarks and 4 projects, where the infrastructures are in preparation for the operational implementation of their services and structures. They offer a huge range of expertise from access and analysis of life science data for public health challenges, to clinical research, drug design & development and creating models for disease on the “Health” spectrum. To approach the challenges surrounding the topic of nutrition there are infrastructures regarding ecosystem analyses and experimentation, plant/crop phenotyping, nutrition metrology or industrial biotechnological innovation.
If you look specifically for RIs for biological resources and production systems, there are five infrastructures, which range from marine biological resources (EMBRC), to metrology in food and nutrition (METROFOOD), to synthetic biology (IBISBA), to managed and unmanaged ecosystems (AnaEE) and plant phenotyping (EMPHASIS). Further RIs are in the scope of animal models (INFRAFRONTIER), human biobanking and biorepositories (BBMRI) and microbial resources & biodiversity (MIRRI). In the course of the EuroFAANG concept development we contacted all of them and interviewed them for collaboration aspects, sustainability aspects and risks, aspects and difficulties of connecting several institutions, access policies and funding structures.

Fig 4. shows the current landscape of European Infrastructure projects in animal science and the possibilities to create a strong network, building on the variety of scientific specifications.

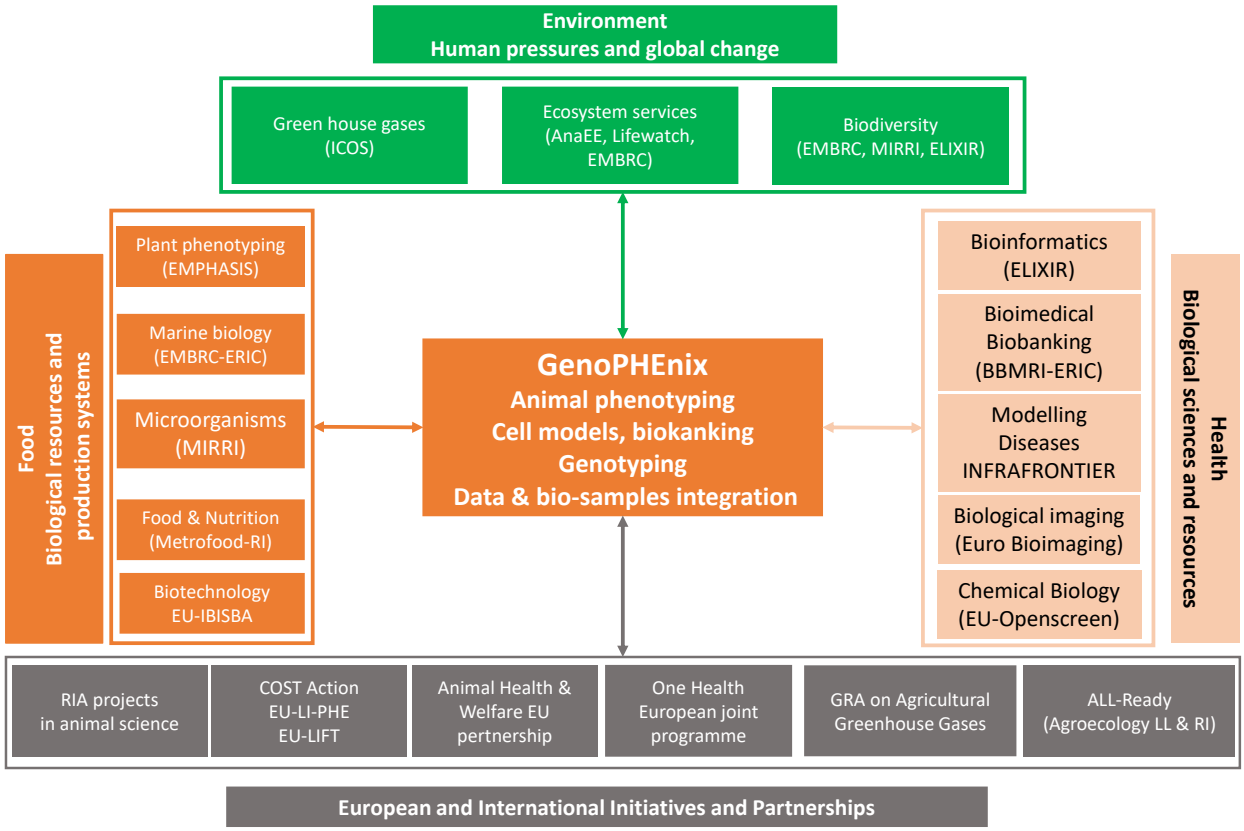


Fig 2. European environment of RIs and partnership relevant to GenoPHEnix

The EuroFAANG cluster projects and collaborations with other infrastructure projects have created a wealth of experience in biology, breeding, genomics, bioinformatics, modeling and open data, and involved scientists have been contributing to numerous events and publications.

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Despite the task of facilitating sustainable food systems in the face of climate change, no RIs on the diverse roles of livestock in the value chain were drawn up in the cluster's previous set-up. This was identified as a gap in the 2021 Strategy Report on Research Infrastructures Roadmap:

I. Concerted effort to continue bringing together national facilities at the pan-european level in the field of animal genetic resources, phenotyping and breeding, animal health is needed to contribute to address the challenge to produce safe, healthy and sustainable food

II. World-class facilities for the integration, conservation and coordination of national and international animal genetic stock and potential stock lines for adaption to climate change

To fill this gap, the GenoPHEnix proposal is building on years of research in the field of genome annotation and data analysis, based on the FAANG data portal, the results of 6 cluster projects spanning all economically relevant animal species and the cooperation with international consortia such as ELIXIR and AG2PI and the EuroFAANG concept development project. Synergies have been identified with INFRAIA projects in the field of animal phenotyping such as SmartCow, Pigweb and Aquaexcel.

Recently ESFRI has published its Research Infrastructure landscape analysis 2024, which highlights developments that further confirm the approach and direction of Genophenix:

- “In addition, an important gap identified is related to the phenotyping of biotechnological improvements for animal farming systems (livestock and fish), whose characterization is not included within the EMPHASIS portfolio. EMPHASIS does not have the required infrastructure to develop phenotyping studies in animals. So, there is a need to further develop and enhance EMPHASIS capabilities for animal phenotyping studies, including fish species used in aquaculture. Alternatively, this need may be covered by a new RI dedicated to animal farming studies.”

- “Is there a need to reconsider the business model of RIs? The current model seems ineffective for the private sector’s needs. Indeed, the services provided by RIs can be useful also for private companies. There is increasing pressure to provide more services to the industries. This is a trend and also a gap in the case of governments not keen to support infrastructures towards this type of users. In these conditions, a business model for services to the private sector needs to be implemented.”

The aim of the entire cluster is to maintain food security and sustainability by ensuring the efficiency and productivity of the sector. The necessary efficiency of

the production of primary animal products, but also of genetic services, will depend to a large extent on the ability to which Europe is able to integrate advanced technologies to accelerate and improve the quality of breeding progress and to translate the interrelationships between the influencing factors of changing environmental conditions and legal requirements of animal husbandry into measurable phenotypes under higher animal welfare standards. The scope of Genophenix is extremely complex and the bundling of biobanking, use and expansion of the database for genomic data, the development of the appropriate phenotypes that will shape future husbandry requirements and their integration into databases for better accessibility and acceleration of knowledge transfer is a crucial task in order to achieve the successful transformation of the food system with animal husbandry. Both the development of advanced methods and the further development of the corresponding database structures play a crucial role. In this way, the individual institutions and laboratories are brought together for new tasks according to their capacities and resources, and the synergetic transfer of knowledge and data is accelerated through the merger of think tanks and the open access provision of data. In addition to the economically relevant breeds, emerging trends in the food sector are also addressed.

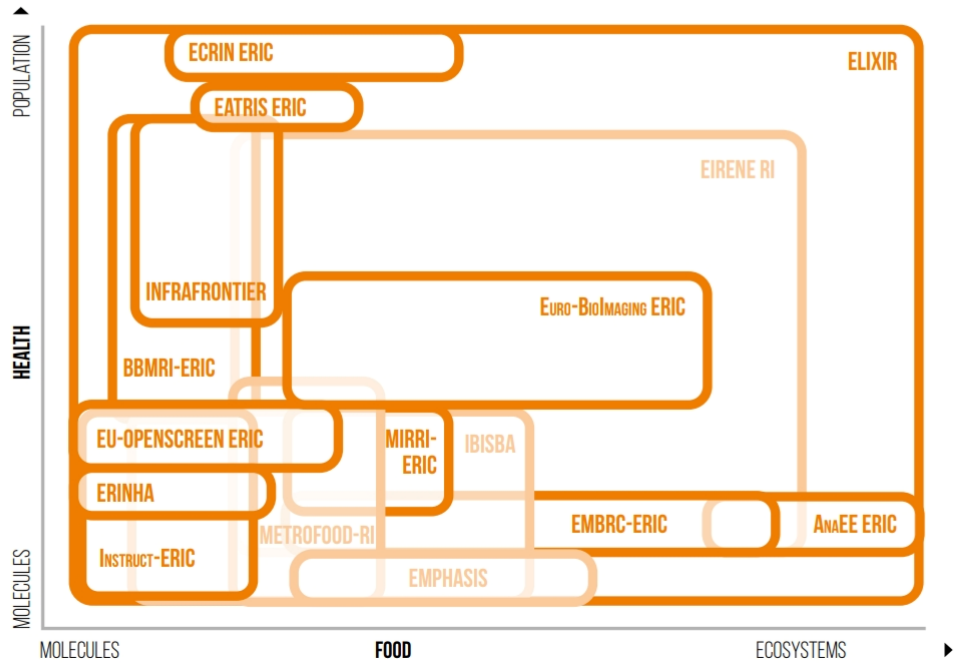


Fig 3. Positioning of ESFRI RIs to the different levels of organization in the Health and Food Cluster, ESFRI Landscape Analysis 2024

Within the European framework, ESFRI and relevant Infrastructures not only integrate within their own definition of clusters, but also as part of a larger European strategies framework. We are defining the contribution of Genophenix to the following political strategies: Livestock farming systems as part of the European Bioeconomy, European animal health and welfare research, sustainable development of Agri-Food-Systems with Farm2Fork Strategy, Green Deal and Food 2030, Strategy for Conservation of Animal Genetic Resources and Research and Innovation.

3.2 Livestock farming systems as part of the European Bioeconomy

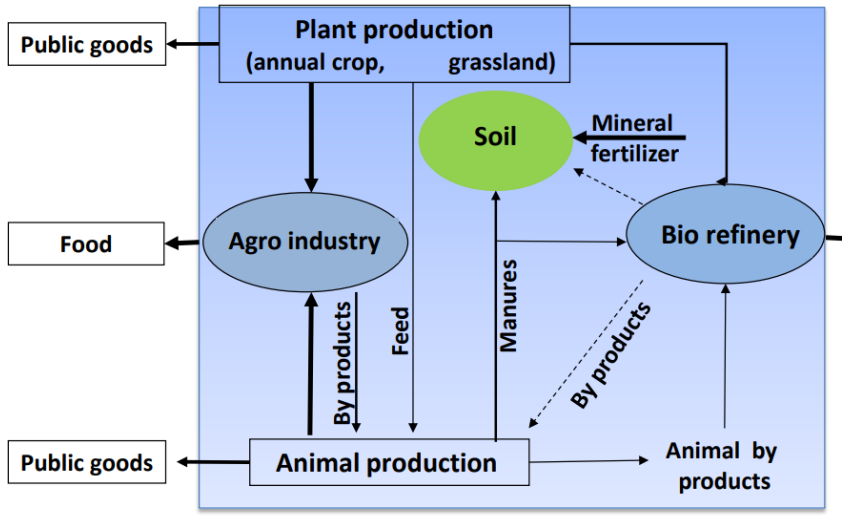


Fig. 4. From field to landscape – role of lifestock in the bioeconomy, Jean Louis Peyraud, 2022

Livestock farming systems and value chains for food production are undergoing a major transformation process at European and global level because of the growing population, climate change and legal regulations on animal welfare. This offers both major risks and enormous opportunities to shape an improved and adapted strategy for the role of Livestock in the EU Bioeconomy. The area of livestock farming in Europe is closely intertwined with many key topics that are considered priority areas in research and innovation in Europe. This ranges from climate

change to the creation of sustainable and resilient value chains in the area of human and animal nutrition as well as the entire network of health in Human, animal and environmental interactions (One Health Approach).

The value of animal husbandry for the ecosystem goes far beyond providing humans with high-quality protein. With climate change, there will be changes in the ecosystems both in Europe and as a member of a global market, which will make it both biologically and geostrategically necessary to produce more with fewer resources, i.e. to increase efficiency. The European Union is strongly committed to developing alternative sources of protein in the timeframe up to 2050. The logical consequence of this is that animal husbandry will be increasingly integrated into sustainable farming systems, which is increasingly reflected, for example, in the expansion of organic farming capacities.

The option of making lasting changes to livestock farming systems also offers the opportunity to incorporate changes in husbandry conditions in order to implement the highest animal welfare standards. It should always be borne in mind that stricter legal provisions that prescribe one-sided measures for more space or the use of additional materials often fail to achieve their actual goal, as smaller farms in particular are unable to undertake the necessary conversion measures financially or due to a lack of structural conditions. Accordingly, holistic and systemic incentives must be created that enable the triad of agricultural management, survival and successful production in a globalized market, including higher social and animal welfare standards.

Disease prevention and preventing the spread of animal diseases and other infectious, parasitic or microbial pathogens is another priority that will characterize the restructuring of livestock farming systems. To this end, the One Health approach is being adopted in the EU, which includes other disciplines in addition to the classic bio- and veterinary medicine research approaches and characterizes the connection between human and animal health, including environmental impacts.

The role of AI systems or less complex, but no less interesting, digital tools for various stages of the value chain should not be underestimated. It will make a decisive contribution to the development of new models based on large volumes of data. These technical innovations will make it possible to record, measure and influence characteristics that were previously impossible. For example, the health,

well-being and behavior of livestock can be better recorded and used in addition to the classic genotypic and phenotypic trait complexes, e.g. to provide an improved data basis for breeding decisions. For example, breeding for disease resistance becomes conceivable. However, the benefits of digital tools also become apparent in practical applications, e.g. it is possible to detect respiratory diseases at an early stage and prevent infection of the entire herd.

Contribution of Genophenix:

> will develop cellular and genetic models, compile data and develop AI systems in order to address the challenges of feed efficiency and disease prevention; eventually this can lead to the development of digital twins in order to model and predict the reaction of an individual or a population to a new challenge.

3.3 European animal health and welfare research

The European Partnership on Animal Health and Welfare is developing its strategic research and innovation agenda (SRIA), which also approaches the definition of the role of livestock in the current European landscape and in relation to the FOOD2030 strategy (see Paragraph on Green Policy).

Mutually influencing areas around farm animal production:

- Farm animals as converters of low-value biomass to high-quality protein
- Animal infectious disease
- Animal production disease
- Animal welfare
- Food safety
- Aquaculture and the marine ecosystem
- Conservation of genetic resources and diversity
- The circular aspects of Livestock, Food and One Health

Future developments of farm animal husbandry evolve in a field of tension between conflicting demands and needs:

1) The rising need to provide high quality animal protein to a growing global population, more and more engaged in an urbanized environment, which results in different diets and rising demands for welfare-adapted animal husbandry.
2) At the same time not only the efficiency of the production systems has to be lifted but also the ability to provide suitable housing systems adapted to the needs of the animals. This is made more difficult, by the decrease of available space for large farms. Here advanced breeding technologies can have a significant positive impact, for example by breeding desirable traits and influencing them on a larger scale.
3) In relation to the housing system there is a need to identify and prevent the risks for infectious animal disease or production diseases by implementing early detection mechanisms and safeguarding measurements for herd biosecurity.
4) Farm animal production is a strong foundation for food security. One major area for improvement is to reduce food waste. More research is needed for the preservation of food safety in the context of food borne zoonosis including antimicrobial resistance.
5) Next to terrestrial animal farming the marine ecosystem is a very special feature. When managing fish and seafood properly the food conversation rates are high and therefore these production systems help to secure protein availability.
All these challenges can be united under a new 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.

Contribution of Genophenix:

considers all terrestrial species, mammals, birds, fish and shellfish and will develop cellular and genetic models to meet the SRIA of the Partnership.

3.4 Sustainable development of Agrifood-systems

- Farm to fork
- Green deal
- Food 2030

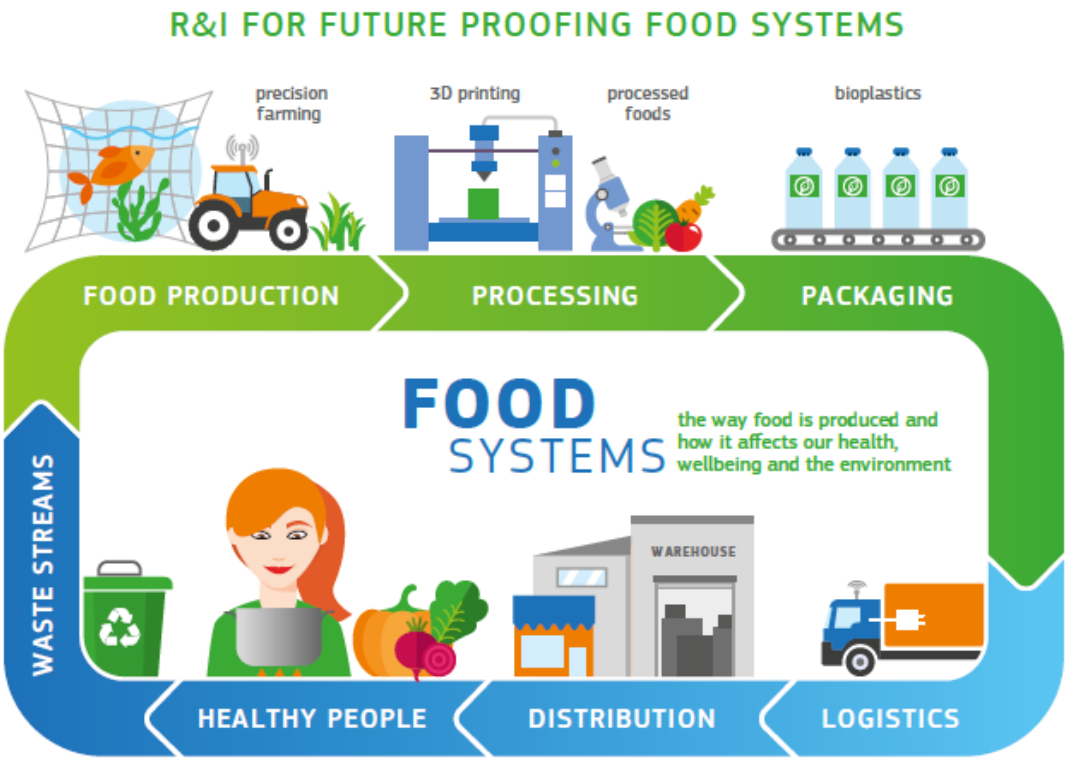
Sustainable and resilient food supply systems are a priority area of European strategy and Research and Innovation since critical dependencies in energy, food and trade call for future proof food systems. The increasing complexity of health (One health approach), climate change and environmental resource management influence food systems and underline the critical meaning of Research and Innovation.

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 Food2030 Independent Expert group, “Recipe for Change”, three 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

Figure 1.4 Food 2030 – R&I for future-proofing food systems



Source: European Commission 2023

Fig 5. Research and Innovation for future proofind food systems, Food 2030 – Pathways for action, Report, 1.12.2023, Directorate-General for Research and Innovation

Green and digital transition

Green Transition aims at being climate neutral by 2050, where Agriculture is among the five highest greenhouse gas emitting sectors. Also, as stated above, by 2050 the global population will rise to 10 billion people. This brings new needs in food demand and consumption, increased health consciousness and dietary changes. In consequence, sustainable agriculture and resilient food systems are key enablers for the Green Deal. One option to contribute to this overarching goal and implement new innovative structures is to define a community and certain key factors and traits that can be researched and incorporated into the scientific and industrial landscape. For this a farm animal research infrastructure can lay the foundation by creating and operating knowledge hubs, organizational structures

and transnational access to support and improve knowledge exchange for large farm animals including aquaculture all over Europe, integrated into one distributed but closely intertwined infrastructure.

Contribution of Genophenix

> GenoPHEnix will develop cellular and genetic models, compile and share data in order to address the challenges of feed efficiency and environmental impact; cellular mechanisms are at the basis of energetic and metabolic efficiency and will be unraveled by the development of tailored cellular models

3.5 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. In the light on a rather low priority of this topic, the landscape in this area was always rather fragmented and funding via national institutions was oftentimes insufficient. To counteract this development, the report provides recommendations on focus topics for In Situ and Ex Situ Conservation, the classification in respective European policy strategies and further measures to promote a sustainable development in this area.

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.“

The development of this area is incorporated into the frameworks of the European Green Deal and EU Animal Breeding Regulations. Long term management of these resources is only possible and successful in the long run if it is coordinated with common efforts in R&D, at best supported by innovative frameworks like European Innovation partnership (EIP AGRI). The ERFP recommends the establishment of an EU reference center for AnGR, to harmonize the methods used by breeding organizations and stakeholders and also integrate the authorities of the respective member states.
With this contact point of expertise the ERFP can build powerful cooperations and engage the whole farm animal breeding sector, stakeholders and institutions in a more collaborative approach together with actors in Research & Development, national strategies and action plans. Promoting the role of AnGR on a European scale and integrating its resources into the research spectrum will diversify its use and add to the perspective of sustainability.

Contribution of Genophenix:

GenoPHEnix is the only infrastructure project incorporating the EUGENA network of gene banks developed by European Countries for long-term preservation of genetic diversity, and proposing new approaches to characterize this diversity

3.6 Research and Innovation

The previous chapters demonstrate how strategic EU decisions on future topics and issues are linked to investments in research and development. These build on each other in many ways and create structural, human, institutional and data-based resources as a basis for further innovation. With this stable backbone, it is possible to react to rapid, dynamic crises (keyword: resilience) and to drive development in the long term. In this way, productivity and growth, scientific excellence and EU competitiveness in many industries and sectors are decisively advanced.

In the 2024 EC Report “The added value of European investment in research and innovation” it was demonstrated that the 80 billion euros invested in H2020 supported 35,000 projects with 40,000 institutions involved. The long-term projection (2014 - 2040) assumes that the annual growth contributed to EU GDP will be between 15.6 and 28.5 billion euros.

4. Market and user strategy

Market for agriculture and fisheries

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.

Adding to this fact the OECD-FAO Agricultural Outlook 2024 - 2033[3] highlights the fact, that in 2033 in the Region European Union and Central Asia, 76 % of inhabitants will live in urban regions, with implications on education and possible eating habits and diets. They state, that in Western and Eastern Europe populations are decreasing (0.4 % and 0.7 %, respectively) until 2033, compared to the observation period 2021-23. Based in their very well developed economies, the average income “is more than double the global average”. Nevertheless, recent developments from COVID-19 pandemic and the war of the Russian Federation against Ukraine, like recession in 2021, energy price shocks in 2022 or the rising inflation slow down economic growth. Europe and Central Asia as regions contribute 15% of value to the global agriculture and fish production. Global output is anticipated to decline until 2033 to 14 %, as results of the Russian war against Ukraine and a higher need for internal sustainability. Livestock accounts for half of

[3] OECD-FAO Agricultural Outlook 2024-2033 | OECD

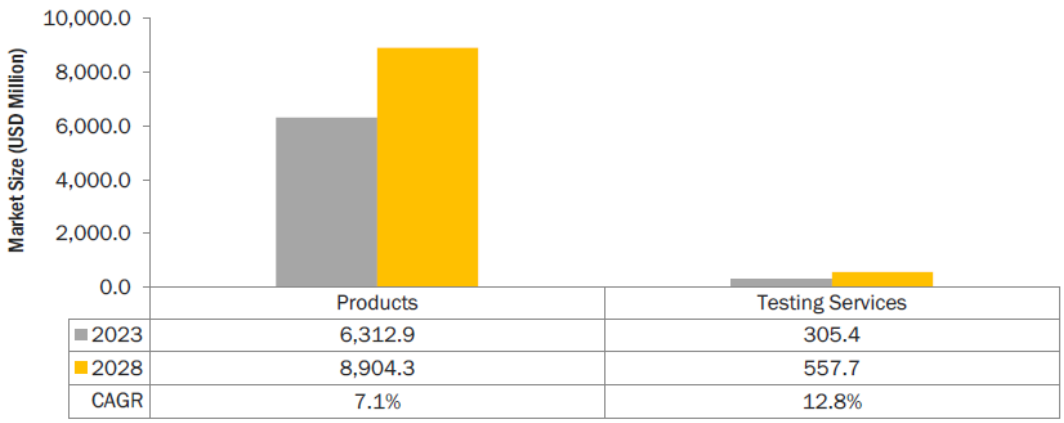
the total agriculture and fish production in these regions. Due to the development towards sustainability measurements and certain changes in production intensity and quality criteria (animal welfare, suitable housing conditions, breeding for traits of resilience and health), especially in Western Europe, where 60% of the livestock production value is generated. Until 2033 this number is expected to decrease to 56%. Next to meat and pork, which are the strongest sectors within livestock production, poultry accounts for most of the growth potential until 2033, with a share of 38% of totally produced meat. Fish production is also increasing, making up for 12 % of total agricultural output and an expected growth of 10% until 2033. The dairy market is stable (Western Europe accounts for 47% of Dairy production) and a decrease of livestock herds in Western Europe is compensated by other regions (Eastern Europe and Central Asia).

Market for animal genetics and animal genetics products

To evaluate the size of the animal genetics market, the following parameters will be taken into account (Schrobback et al., 2023, MarketsandMarkets Report on Animal Genetics Market, 2023):

- 4.1 Animal genetic products
  - 4.1.1 Live animals
  - 4.1.2 Primary products
  - 4.1.3 Genetic materials
- 4.2 Animal genetic testing services

Figure 1 shows the **global economic value** in 2023 for animal genetic products of total 6,312.9 Million USD and testing services of 305.4 Million USD. Both areas with their respective segmentations are projected to increase their value to 8,904.3 Million USD for products and 557.7 Million USD for testing services. The compound annual growth rates are 7.1 % and 2.8 %, respectively.



	Products	Testing Services
2023	6,312.9	305.4
2028	8,904.3	557.7
CAGR	7.1%	12.8%

Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), The Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Fig 6. Market size and development 2023 vs. 2028, USD Million

The market size can be described on the one hand by analyzing the numbers of animal heads and on the other hand value and price indices for live animals and primary products. Breeding and the technologies and services developed from it are a stable but innovative market with outstanding opportunities to achieve an acceleration of breeding progress through constant further development and thus to integrate particularly suitable traits into populations. Thus, to integrate animal genetic products and technologies as well as testing services into a market analysis, we integrated market analysis reports from Markets and Markets as a commercial supplier of such reports. As figure 7 shows, their data and information resource base is a complex of primary sources from research institutions, farm animal breeding stakeholders and distributors of primary products as well as key players from enterprises, like CEOs, Marketing or Business Managers. To provide a more comprehensive picture, reports and data bases as well as scientific publications and several scientific societies (e.g. EAAP, ISAG) are included in this market analysis.

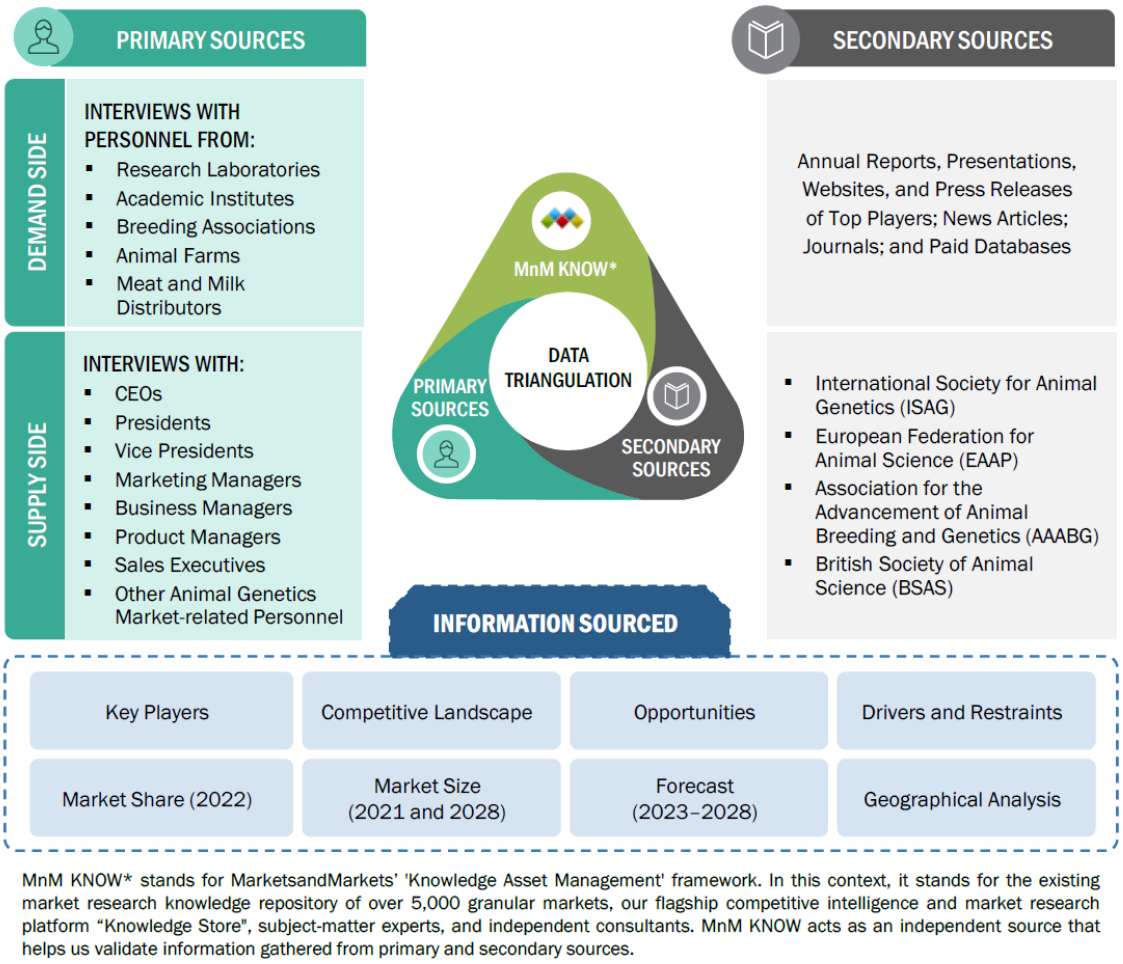
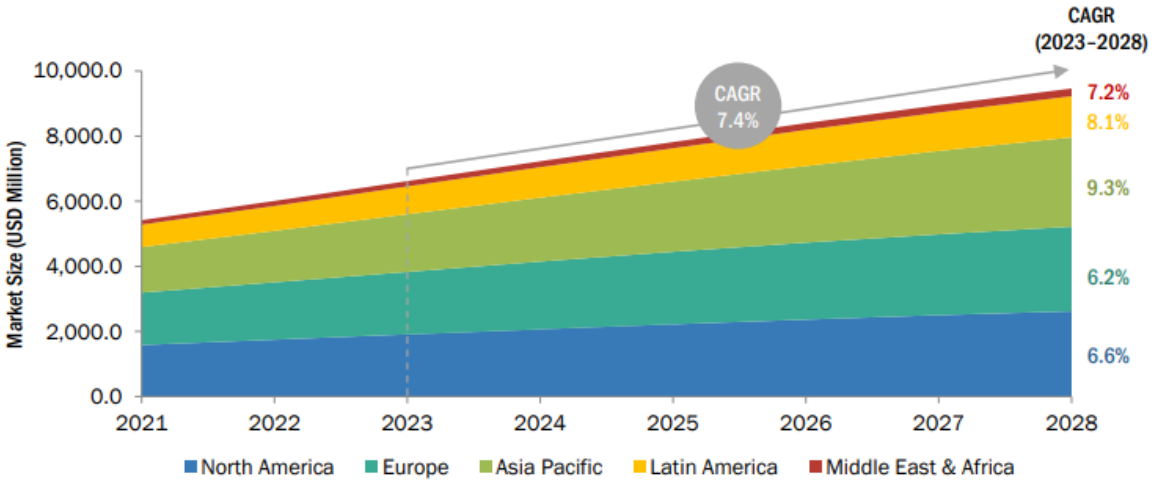


Fig. 7 Data and information sources of Markets and Markets Report

The **European animal genetics** market had a total market size of 1,925.8 Million USD in 2023, with a share of 29.4 % in the global market. Europe generally has a strong livestock industry, as several leading breeding companies are located within Europe and Europe having a high consumption rate of high quality animal protein. Primary products like milk, beef or meat are also exported to a high degree. Of the main European countries France shows the highest growth rates with a market value of 345.6 Million USD, growing by 6.3 % each year.



Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), The Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Fig 8. Animal genetics market of different global regions during forecast period 2023 – 2028, Compound annual growth rate

The animal genetics market is a developing market. The compound annual growth rate from 2023 – 2028 is 7.4 % globally and 6.2 % for the European market. Methodically there are several parameters to evaluate the total economic value of the farm animal genetics market. Figure 9 shows the total economic value and different use and non-use values.

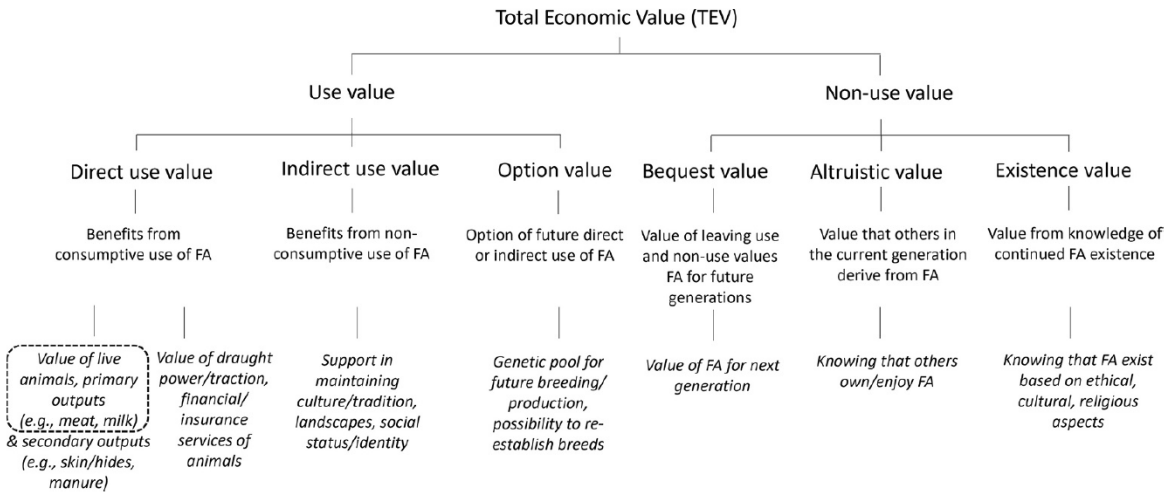


Fig 9. aus Schrobback et al., approx. the global economic market value for farm animals, Global Food Security, 2023

The impact of a research infrastructure goes far beyond economic measures and the need to consider societal values of research have been highlighted by Schrobback et al., 2023. Nevertheless, to give quantitative measures and to properly grasp the importance of the livestock market in its global extent, the measurement is based on the direct use value. With this framework, the context and value of animal breeding and how it influences the direction and speed on political and social developments can be measured appropriately.
As parameters to define the market for animal genetic products the number and value of live animals and genetic materials (semen for artificial insemination and embryo for embryo transfer) are taken into account.

4.1 Animal genetic products

4.1.1 Live animals

To characterize the livestock market in terms of size reference points are:

- the number of heads of the different livestock populations,
- prices for the live animals and their primary products.

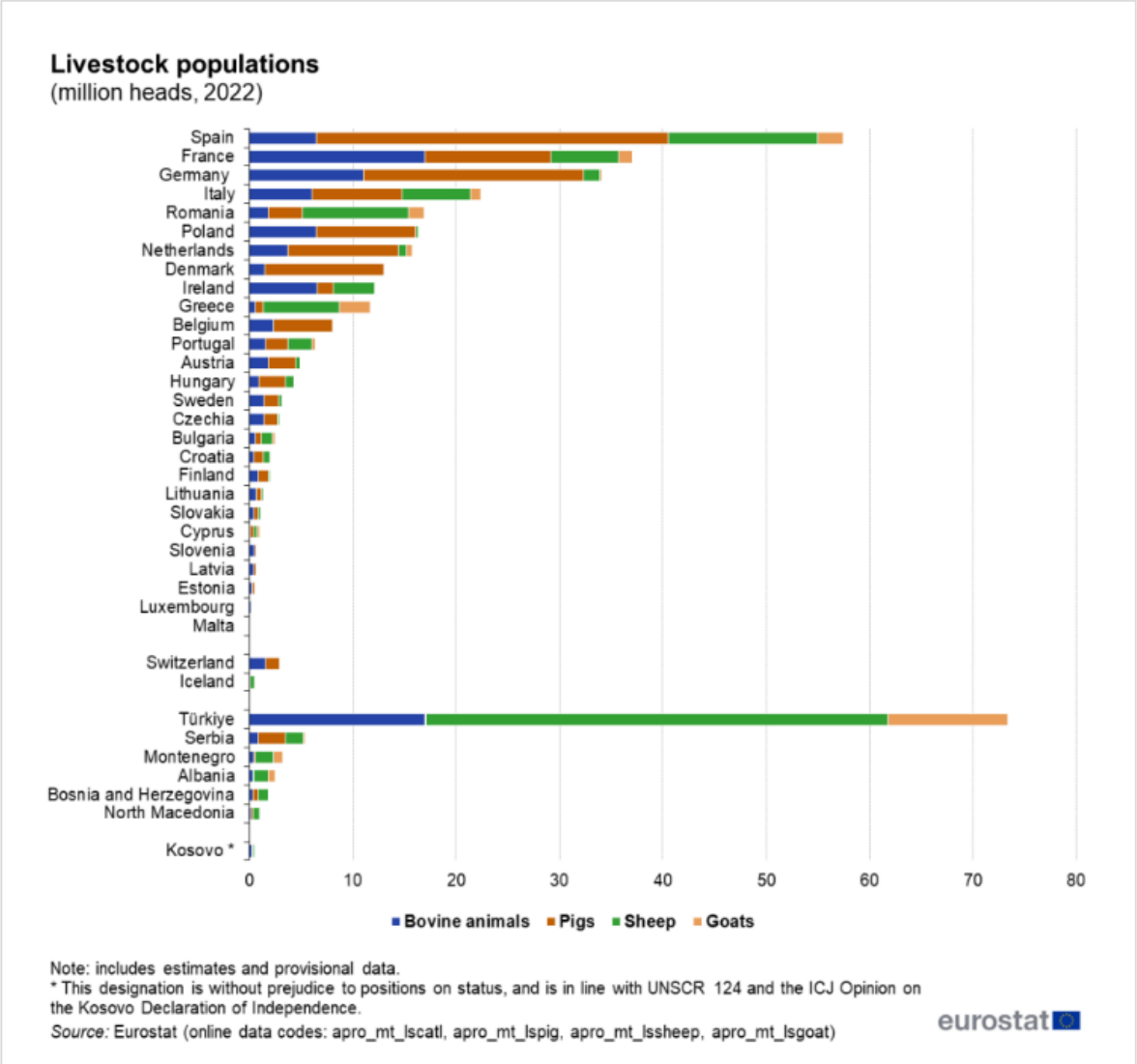


Fig 10. Livestock population of the European Union 2022, in Million heads

The European livestock population in 2022 had 134 Million pigs, 75 Million bovine animals and 70 Million sheep and goats. Main players with over 20 million heads in livestock population of the European countries are Spain, with 25.4 % of European Pigs, France with a high share of bovine animals (22.7%) as well as Germany and Italy. Several countries show a certain kind of specialization, due to historically evolved structures or agrarian conditions of climate and soil.

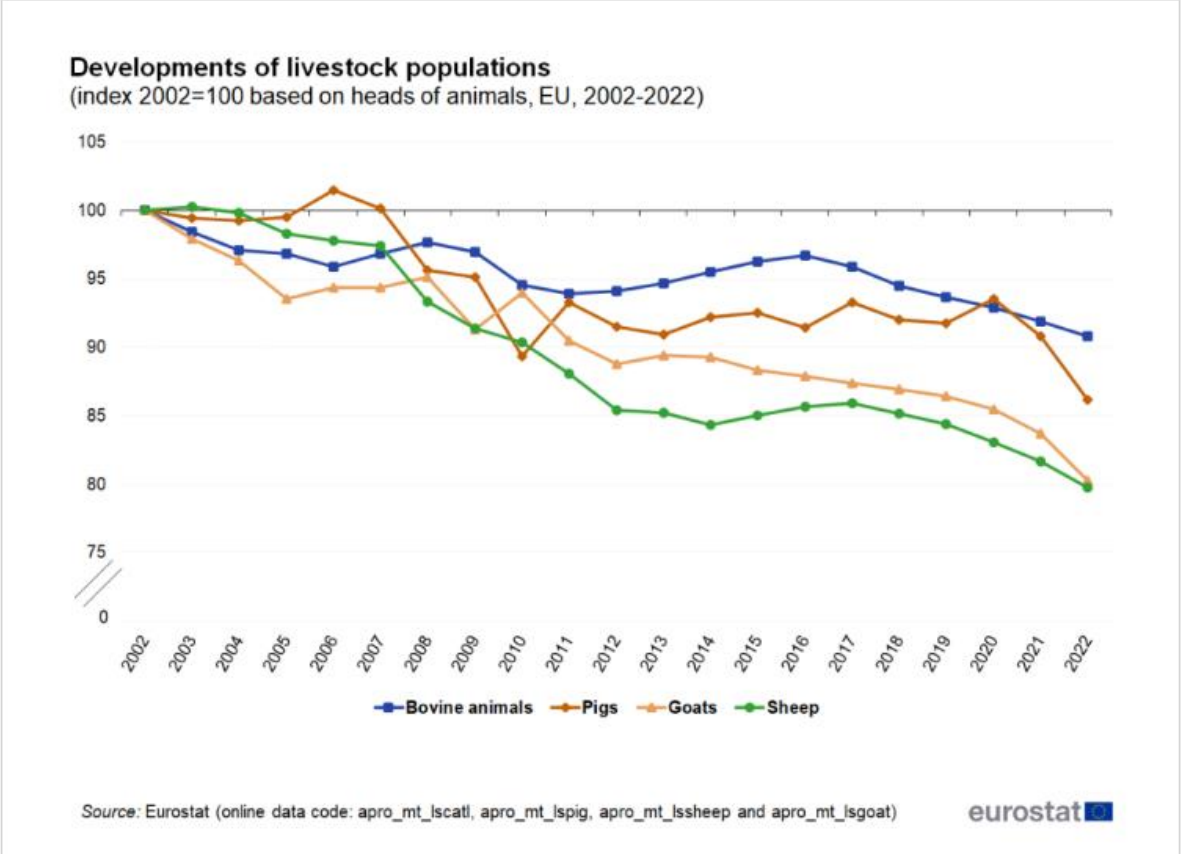


Fig 11. Development of livestock populations, EU 2002 – 2022, reference value is number of animals in 2002

The general trend analysis shows a rapid decrease of European livestock population during the last 20 years over all species. The proportion of goats and sheep kept falling by 20%, showing the strongest decline. Pig fell around 14 % and bovine lost only around 9 %. The reference value is based on numbers of animals in 2002. To fully grasp the effect of a decreased livestock population, the performance of livestock needs to be taken into account. This can only be done by measurement of primary products in the same timeframe, to show if a better performance could compensate the lower number of animals and had a positive effect on overall efficiency and therefore also resource efficiency, which is of primary importance.

Looking at output price indices of animals, the development since 2015 shows the typical strong fluctuations for pig, also known as the pig cycle. European pig producers were highly influenced by the Covid pandemic, due to problems during the production cycle, when animals could not leave the stable in time for slaughter. Another huge incision was the outbreak of African swine fever in China, which

influenced the market due to lost export capacities. Price developments for poultry, bovine, sheep and goats show a strong increase from Q2 2020 (sheep and goat) and Q2 2021 (poultry and cattle), respectively.

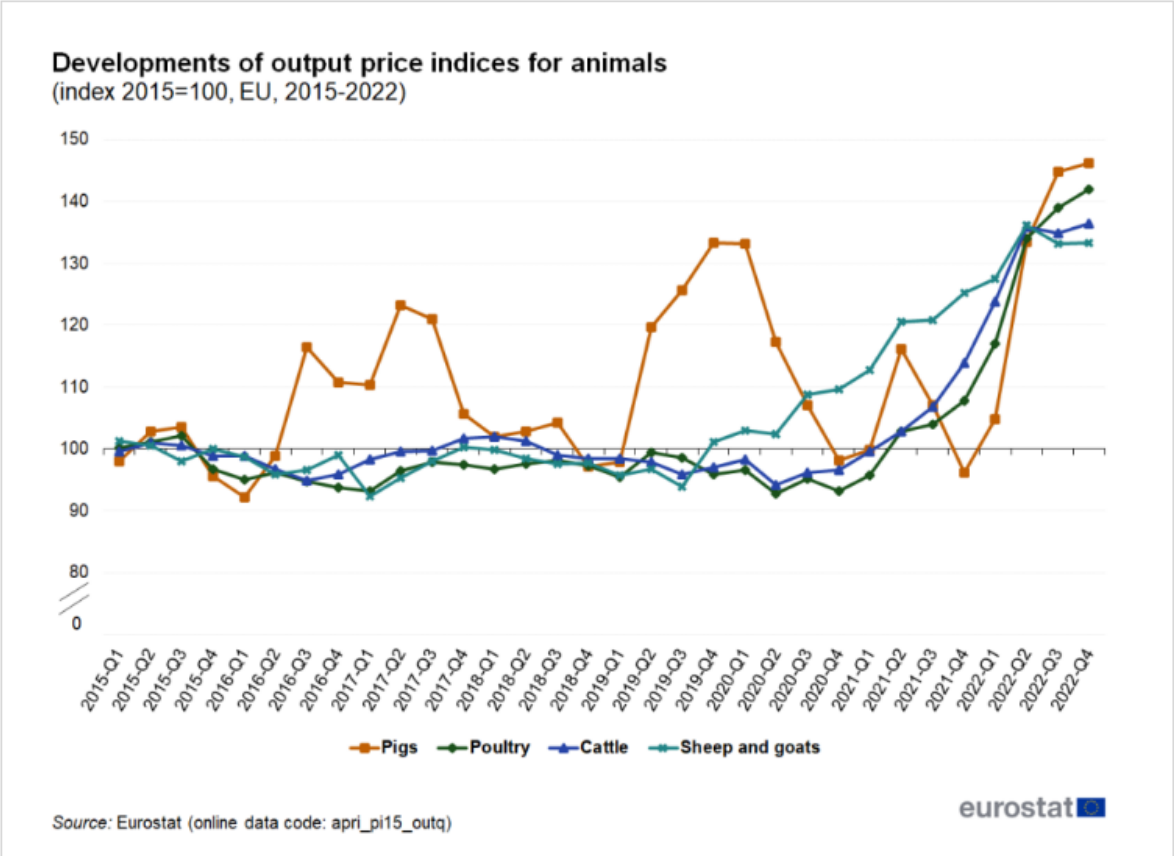


Fig 12. Development of output price indices in the European Union, reference value is the 2015 price index

Figure 7 shows the high relevance of poultry with a share of 41,4 % of the whole European live animals market in European farm animal husbandries assuring a stable availability in a European and global context. It is evenly demanded in developed and developing countries, due to positive associations of human health in contrast to red meat and can support the nutrition and supply with high value protein of an increasing population in developing countries. Globally poultry meat is expected to be the fastest growing segment of the meat production chain because of poultries high feed efficiency and low environmental impact.

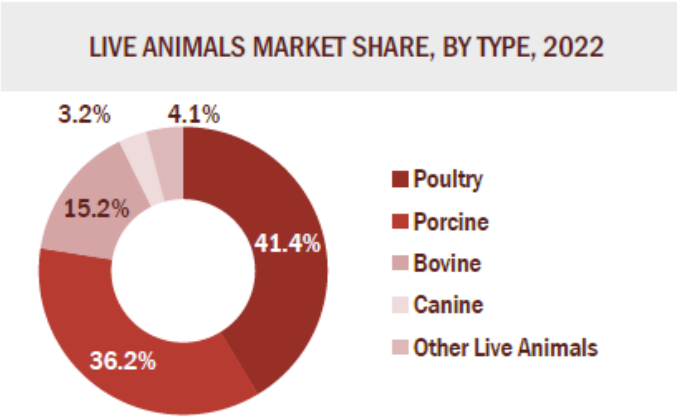


Fig 13. Live animals market share of the different species in 2022, in %

Trade analysis of import and export

Analyzing the value of live animals in Europe in terms of imported and exported unit numbers shows a positive trend in 2021/2022 for Live Bovine, Live Poultry and Live Horses. The value of Pig is decreasing, compared to 2018/2019/2020, which in reference to table 3. is more caused due to a decreased import in unit numbers, not price developments.

European Imports

	2018	2019	2020	2021	2022
Live Bovine (USD Billion)	3.37	3.12	2.92	3.23	3.71
Live Swine (USD Million)	2,980.02	3,301.53	2,978.82	2,360.50	2,422.91
Live Poultry (USD Million)	2,229.15	2,063.36	2,010.68	2,210.71	2,522.56
Live Sheep and Goat	244.46	214.81	212.62	318.71	295.64

(USD Million)					
Live Horse (USD Million)	1,301.52	1,340.74	1,428.81	1,378.71	1,562.76

Tab 8. Trade analysis, Value of live animals, characterization of direct use value (Animal Genetics Market Report 2023)

European Exports

	2018	2019	2020	2021	2022
Live Bovine (USD Million)	4,656.23	4,325.26	4,189.23	4,499.57	4,462.15
Live Swine (USD Million)	3,012.69	3,486.28	3,294.72	2,652.43	2,653.90
Live Poultry (USD Million)	2,531.13	2,397.50	2,226.72	2,466.71	2,584.20
Live Sheep and Goat (USD Million)	600.71	661.46	600.71	751.93	743.03
Live Horse, Asses, Mule, Hinnies (USD Million)	1,818.39	1,807.46	1,692.54	2,302.71	2,291.36

Tab 9. Trade analysis, Value of live animals, characterization of direct use value (Animal Genetics Market Report 2023)

In 2022, the live animals segment accounted for 56.9 % of the animal genetics products market.

Europe's Market growth potential develops possibly due to an increased consumption of a growing global population, while integrating different diets of its more and more urbanized consumers.

The development of the market value for the main species of primary products is listed in table 10. These include next to live animals the use value of animal genetic products and testing services.

Type	2021	2022	2023	2024	2025	2026	2027	2028	CAGR (2023-2028)
Poultry	364.8	398.5	431.7	463.7	493.1	520.3	544.4	564.6	5.5%
Porcine	317.6	348.4	379.0	408.9	436.6	462.6	486.0	506.2	6.0%
Bovine	137.0	146.0	154.2	161.6	167.6	172.6	176.1	178.2	2.9%
Canine	28.6	30.6	32.5	34.2	35.7	36.9	37.8	38.5	3.4%
Other Live Animals	37.1	39.4	41.5	43.4	45.0	46.2	47.0	47.5	2.7%
Total	**885.1**	**962.9**	**1,039.0**	**1,111.9**	**1,178.0**	**1,238.5**	**1,291.4**	**1,335.0**	**5.1%**

Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Tab 10. Compound annual growth rate of main species in Europe, Live animals market, 2021 – 2028, USD Million

All species show a stable annual growth rate, with lowest rates for other live animals including sheep, goat or horses (2.7 %) and bovine animals (2.9%). Poultry (5.5%) and porcine animals (6.0 %) show the most stable annual growth rates from 2023 – 2028.

4.1.2 Primary Products

Global meat production

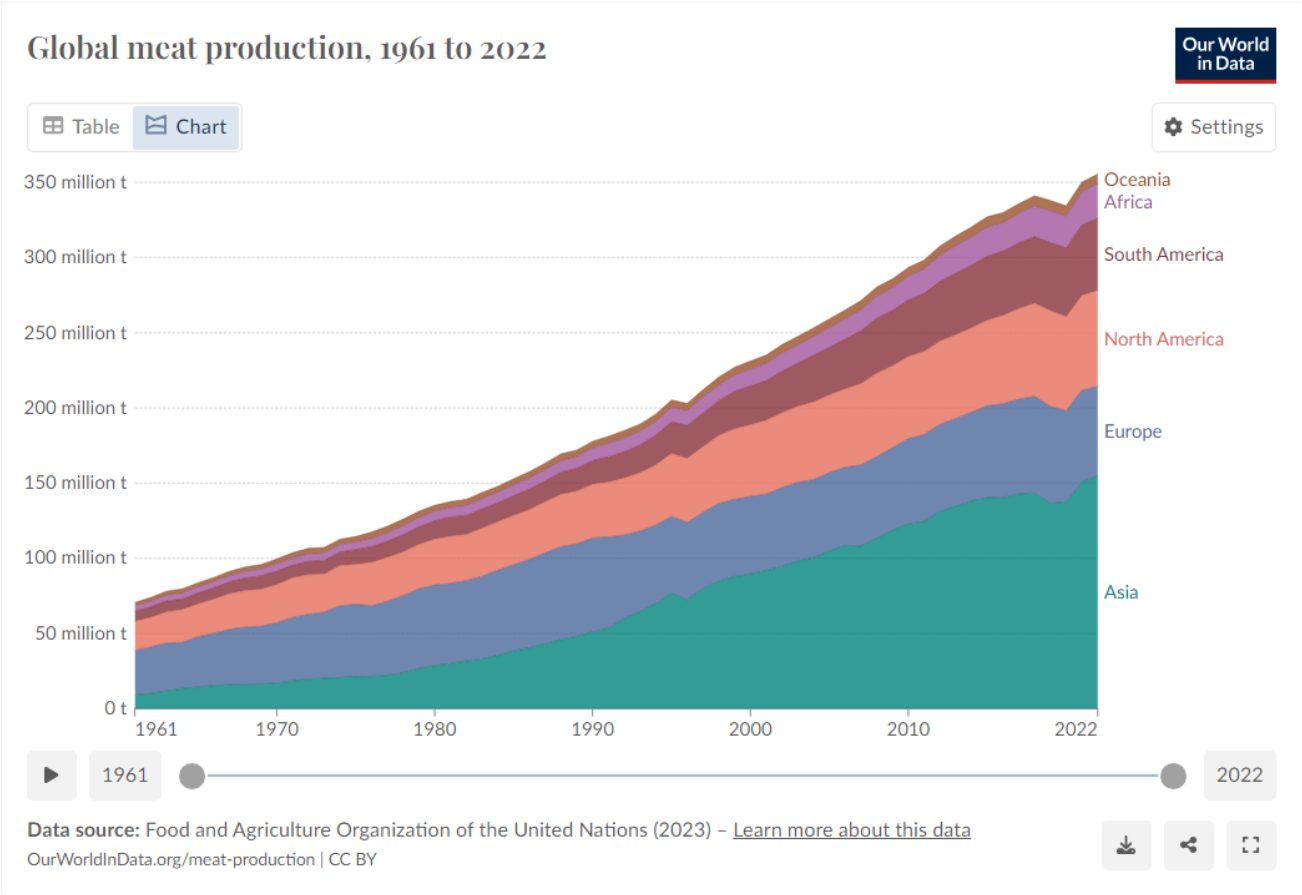


Fig. 14. Global meat production from 1961 – 2022, in million tonnes

	2022 (in Mio. t)	1961 (in Mio. t)
Oceania	6,54	2,3
Africa	22,74	3,68
South America	48,02	6,52
North America	63,98	19,58
Europe	59,08	29,45
Asia	155,08	9,03

Tab. 11 development of the global meat production within the different regions, showing an overall increase for all continents.

As we have seen in fig. 11, the number of living animals in **Europe** has been decreasing since 2002, with the reduction in cattle of 10 % and in pigs 14 %. The overall meat production in Europe in 2000 had a value of 51,39 Mio. t, still increasing until 2022 to 59,08 Mio t (Figure 14). This shows the enormous potential of precision breeding and selective breeding approaches, to increase animal performance. The data of the Food and Agriculture Organization of the United Nations in 2023 shows, that the increase was mainly reached due to rising output for Pigmeat, from 25.34 Mio t in 2000 to 29.65 Mio. t in 2022 and poultry, from 11.89 Mio t. in 2000 to 20.38 Mio t. in 2022. The production of beef and Buffalo meat is sinking and showed a decline from 11.78 Mio t. in 2000 to 9.47 Mio t. in 2022. The reduction of the sheep and goat population in Europe of 20 % from 2000 to 2022 resulted in a decreasing meat production (1.59 Mio t. in 2000; 1.20 Mio t. in 2022).

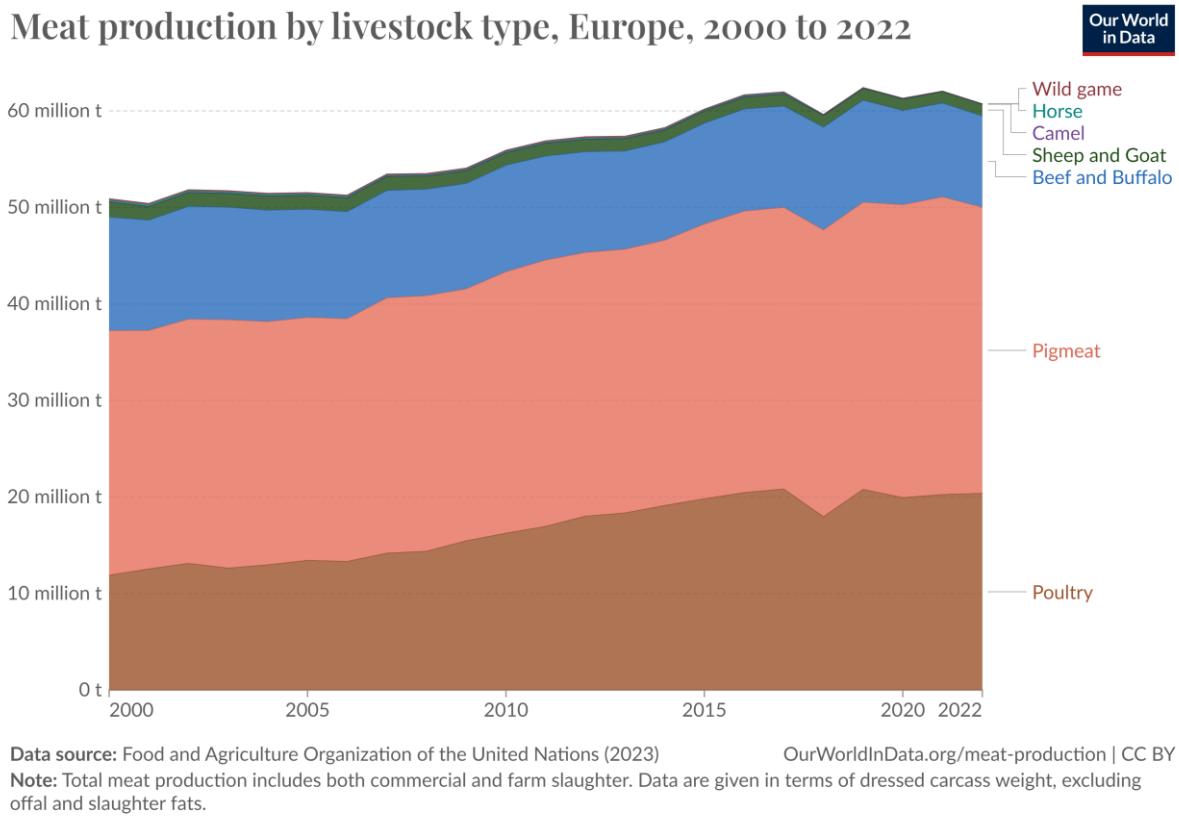


Fig. 15. Meat production by livestock type, European development 2000 – 2022, in million tonnes

Fig. 14 and 15, as well as table 11, show the development of beef, poultry meat and pig meat production from 1961 to 2022 and contrasts the development of the

European Union (27) with those of China, Brazil, Russia, India and the United States.

Milk production

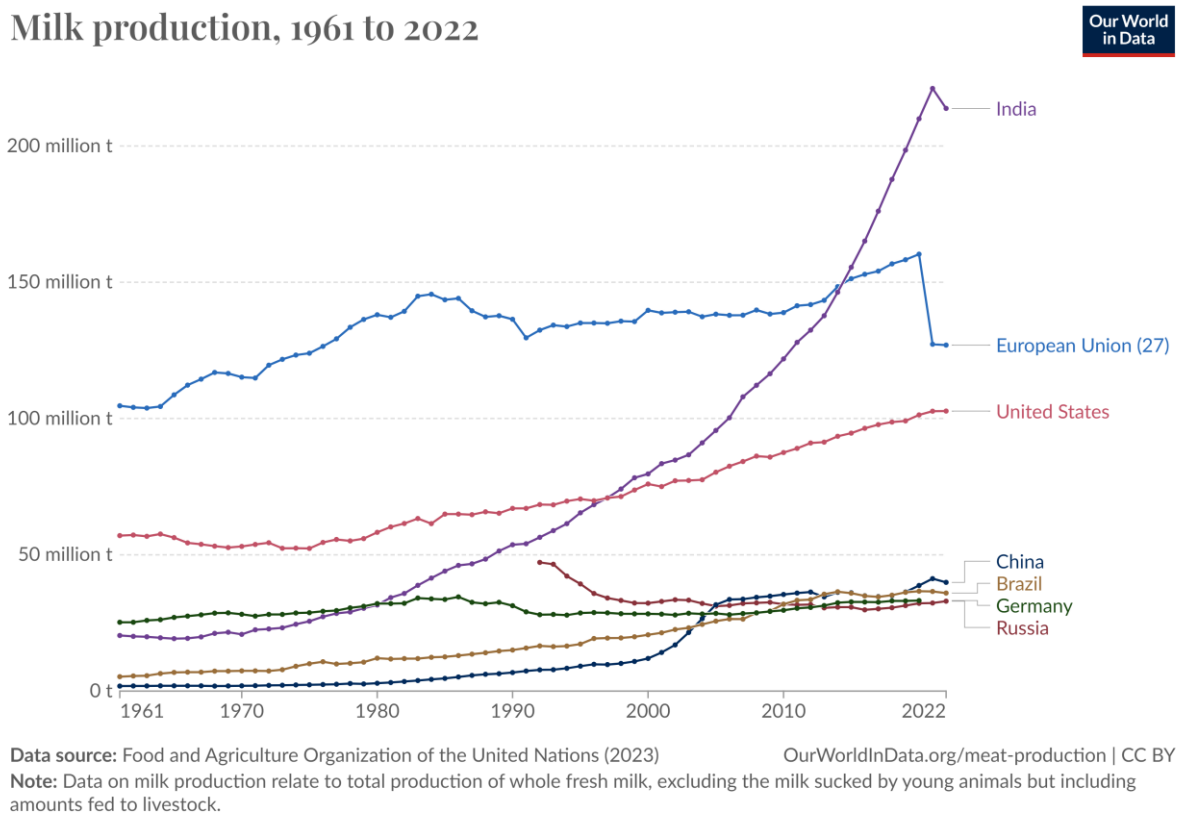


Fig. 16. Milk production in the EU (27) in contrast to China, India, Brazil, Russia and the United States from 1961 – 2022, in million tonnes

The decrease of bovine live animals of about 9% from 2002 to 2022, which also includes dairy cows, was accommodated by an increased performance. In terms of milk production the data show a strong increase for India and also the United States in that time frame.

In 2002 the EU produced 139,02 Mio t. of milk, thereby reaching higher values than India (84,77 Mio. t.) and the US (77,17 Mio t.). India was able to improve their performance until its peak in 2021 with a production volume of 221,10 Mio t. The US dairy sector increased their output to 102,75 Mio t. in the same timeframe.

The EU dairy farmers reached their peak performance by 2020 with a volume of 160,29 Mio t. of milk, but had strong break from 2020 to 2021 with then only producing 127,24 Mio t. This is presumably influenced by the Corona Pandemic

and worsened production conditions and difficulties on the trade and food retail side as a result of the pandemic restrictions.

4.1.3 Genetic material

The market for genetic material, including semen for artificial insemination and embryo transfer, cannot be decoupled from the development of livestock numbers and demand for primary products like meat, beef and milk in the respective regions. Nevertheless, its value is generally growing with the ability to breed animals with highly relevant traits through high prediction accuracy and therefore high economic relevance. Advantages to rely on artificial insemination and embryo transfer for breeding progress are the higher accuracy of breeding values for sires producing semen and for dams producing embryos, resulting in a higher genetic progress for desired breeding lines. This is supported by improved hygiene standards, which has to be accompanied by skilled personal to ensure the correctness of the application.

Type	2021	2022	2023	2024	2025	2026	2027	2028	CAGR (2023-2028)
Semen	630.2	695.2	760.7	825.4	886.5	945.0	998.9	1,046.8	6.6%
Embryos	28.7	32.8	37.2	41.8	46.6	51.5	56.4	61.3	10.5%
Total	**658.8**	**728.0**	**797.9**	**867.2**	**933.1**	**996.5**	**1,055.3**	**1,108.1**	**6.8%**

Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Tab 12 Market share of genetic materials, by type, 2021 – 2028, USD Million

The European Semen Market is showing a stable compound annual growth rate (6.6 %), which reflects on the dominating role of artificial insemination in this very competitive market, mainly for dairy cattle. The role of top quality genetics, especially in bovine, pigs and poultry worldwide to improve efficiency, quality and profitability will drive this development.

The growing importance of embryo transfer in cattle (CAGR 10.5 % 2023 – 2028) lies in the increase in breeding process with more offspring of breeding value estimated lines. It enables the integration of new genetics from completely different

genetic backgrounds without increasing the risk of bringing diseases into the herd or population.

The area of Semen sexing is growing in importance and application, but huge capital investments for their production systems, transfer technology and as well as handling storage and transport on a high level are challenges.

Type	2021	2022	2023	2024	2025	2026	2027	2028	CAGR (2023-2028)
Bovine	385.4	427.0	469.2	511.3	551.5	590.3	626.5	659.2	7.0%
Porcine	122.0	133.5	144.8	155.7	165.8	175.1	183.5	190.5	5.7%
Canine	33.1	36.1	39.0	41.9	44.4	46.8	48.9	50.7	5.4%
Equine	39.2	43.1	47.0	50.8	54.4	57.8	60.9	63.6	6.3%
Other Animal Semen	50.5	55.6	60.7	65.7	70.5	75.0	79.1	82.7	6.4%
Total	**630.2**	**695.2**	**760.7**	**825.4**	**886.5**	**945.0**	**998.9**	**1,046.8**	**6.6%**

Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Tab 13. European semen market, by species, 2021 – 2028, USD Million

Table 13 shows the development of the value of the animal semen market from 2021 to 2028, with the respective compound annual growth rates. Interestingly, the market for bovine semen shows the strongest CAGR with 7.0 % in Europe, while the live animals market only shows a CAGR of 2.9 %. The worldwide growth rates mirror this development, where porcine and poultry market show strongest growth rates until 2028. The extent to which the European bovine semen market is influenced by growth rates in other regions cannot be conclusively clarified by this study.

The CAGR of Equine (6.3 %) reflects the growing value of high level stallions. If this is reached by a higher number or higher value of the semen cannot be concluded from this study. Since these data are not relevant for GenoPHEnix, taking into account the current stage of planning, this information shall just complete the overall picture.

Interestingly, the high competitive porcine semen market (CAGR 5.7%) and the market for canine semen (CAGR 5.4 %) show the same growth rates, on very different levels on market value. The market for selective breeding of canine is on

a much smaller level than those of farmed animals but taking into account higher animal numbers of certain dog breeds as well as to ensure their breeding process, genetic trait testing and mating of suitable males guarantees a stable growth rate.

Type	2021	2022	2023	2024	2025	2026	2027	2028	CAGR (2023-2028)
Bovine	18.5	21.3	24.3	27.5	30.8	34.3	37.8	41.3	11.2%
Equine	6.4	7.3	8.2	9.2	10.3	11.3	12.3	13.4	10.2%
Other Animal Embryos	3.8	4.2	4.7	5.1	5.5	5.9	6.3	6.6	7.2%
Total	**28.7**	**32.8**	**37.2**	**41.8**	**46.6**	**51.5**	**56.4**	**61.3**	**10.5%**

Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Tab 14. European Embryo market, by type 2021 – 2028, USD Million

4.2 Animal genetic testing services

Type	2021	2022	2023	2024	2025	2026	2027	2028	CAGR (2023-2028)
Genetic Disease Tests	40.0	45.9	52.3	59.0	66.0	73.2	80.5	87.8	10.9%
Genetic Trait Tests	16.6	19.3	22.3	25.5	28.9	32.5	36.3	40.2	12.5%
DNA Typing	10.1	11.7	13.4	15.3	17.2	19.3	21.4	23.6	12.0%
Other Services	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	9.5%
Total	**67.4**	**77.7**	**88.9**	**100.8**	**113.2**	**126.2**	**139.6**	**153.0**	**11.5%**

Source: Annual Reports, SEC Filings, Press Releases, International Society for Animal Genetics (ISAG), European Federation of Animal Science (EAAP), The Association for the Advancement of Animal Breeding and Genetics (AAABG), British Society of Animal Science (BSAS), American Genetic Association (AGA), Canadian Livestock Genetics Association (CLGA), Interviews with Experts, and MarketsandMarkets Analysis

Tab 15. Animal genetic testing services, by type, 2021- 2028, USD Million

The market for animal genetic testing services is driven by the need to reach the highest possible level of genetic improvement through improved prediction accuracy of animal genetic traits, e.g. performance traits when breeding for higher numbers of live born or higher milk yield. In addition, the breeding of disease resistant pigs is of major importance.

This market is expected to show the highest relative increase of all market analysis in the livestock sector by 2028.

Breed identification, performance and genetic traits tests are available for bovine (heifers, cow, etc.), porcine, and sheep.
DNA typing can also play a major role in biobanking for conservation of animal genetic resources and research purposes.

Summary

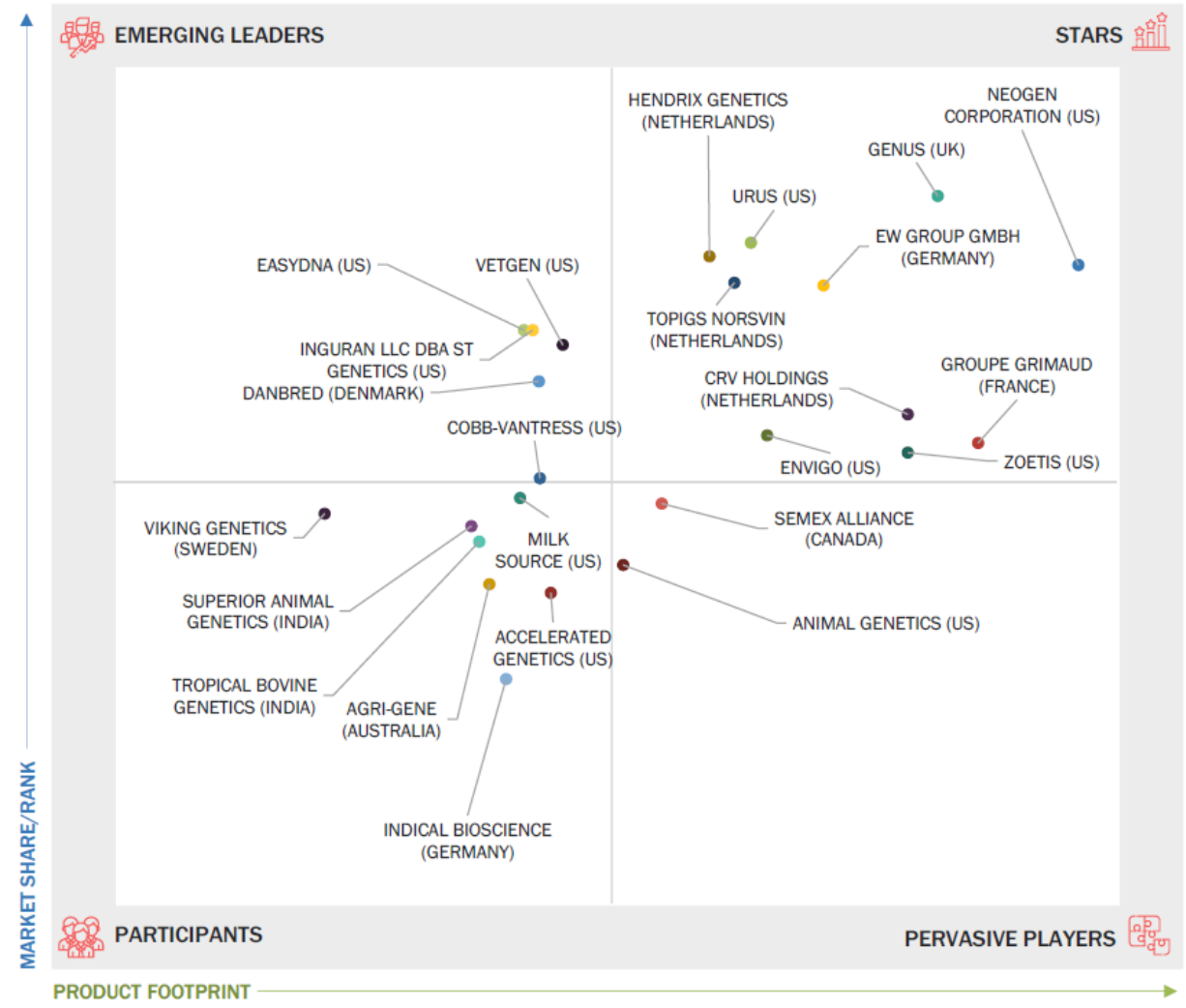
The analysis of the animal genetics market and its respective areas account for the economic growth potential of the European market for farm animal breeding in Europe. Despite sinking numbers of the different livestock in a total comparison of animal numbers there is growth potential in the direct market value, through:

- increasing consumption and prices in the areas of the primary products, like milk, meat and beef
- rising sales figures through higher use and value of artificial insemination and embryo transfer (cattle and horses)
- increasing demand and improved quality and value of genetic testing services (genetic trait testing, disease testing, biobanking services will increase the use of this sector in the future)

The report compares animal genetic products (live animals and genetic services) and animal genetic testing services as measures for the development of the animal genetics market as baseline for the GenoPHEnix research infrastructure.
This development is driven by the ever-increasing need to promote production efficiency in the context of necessary resource efficiency (with regard to circular resource cycles of the European bioeconomy strategy for long term planning), as can be seen by the increased amount of products marketed from a lower number of animals. Food security with regard to the increasing demand can only be guaranteed long term if we are able to direct the use of the resources required for animal husbandry and for the production of high-quality animal protein through the use of high-quality genetics, higher breeding accuracy and targeted control towards the development of desirable characteristics of increased efficiency, productivity, resilience and behavioral adaptability. In parallel the justification of

how high quality animal protein is integrated into sustainable food systems is one of the main challenges of the coming decade. GenoPHEnix research and the development of new tools and methodologies to increase precision, efficiency and implementation speed of farm animal breeding into relevant populations secures the role of farm animal products for human nutrition and enables a wider contextual design within the One Health context and possible disease challenges.

Figure 17 displays the high potential of GenoPHEnix to cooperate with the farm animal breeding industry within and beyond European boarders. Of the companies listed in the “Stars”-segment, indicating a strong and established product portfolio and market presence, GenoPHEnix already cooperates with 3 of them. One senior researcher in the field of genomics from Topigs Norsvin is also a consultant for the EuroFAANG concept development project in the scientific advisory board.



Source: MarketsandMarkets Analysis

Fig 17. Market share and rank in farm animal breeding companies, MarketsandMarkets analysis, 2023

5. SWOT – Analysis

This Analysis provides the opportunity of weighing up the advantages and disadvantages of Genophenix RI on an internal spectrum and possible opportunities the infrastructure can deliver to its outside environment as well as external threats towards the implementation of the infrastructure.

Internal describes the relations between the involved partner institutions both in terms of long term strategic approaches of the scientific work program and within the daily operations and service of the RI.
External defines influence of Member States (as members or observers of the RI) in terms of political developments that influence the RI or, the other way around, that are influenced by RI activities. Additionally, external institutions, stakeholders, companies of farm animal breeding, pharma or education, media and others fall in this category.

INTERNAL

Strength

- High level infrastructure with 16 partner institutions in farm animal G2P research
- 10 years of experience and strong community building through INFRAIA projects SmartCow, PigWeb, AquaExcel as well as AgroServe and AquaServe as INFRA Serv projects, to establish farm animal phenotyping research and deliver services to the respective farmed animal and aquaculture communities
- Strong foundation in FAANG and EMBL data community and cooperation with already implemented Infrastructures (EMPHASIS, MIRRI ERIC, AnaEE ERIC, IBISBA, LifeWatch ERIC, EMBRC ERIC, INFRAFRONTIER)
- Strong connection to farm animal breeding sector through project partner institution EFFAB & platform FABRE TP and high potential for inclusion
- Established connection with the European Regional Focal Point for animal genetic resources
- Specialized state-of-the-art services, defined by community needs
- Development of advanced technological methodologies, research approaches and applications based on Genophenix data and services
- Expansion and increase in capacities of project partners, training of scientists and staff

- Better coordination of research topics and possibility to avoid funding of similar topics, enabling a better and fairer use of funding

Weaknesses

- Inclusion of relevant number of Eastern European member states
- Relevant attraction of private companies with market-driven access to RI resources under payment of a fee
- Finding a suitable prioritization of institutional research and RI service offers
- Establish and maintain a suitable and functional governance structure. The status as the only “farm animal RI” and taking into account the large potential for expansion, different demands and expertise of partners and observers underlines the need for structural prioritization.

EXTERNAL

Opportunities

- Increase the visibility of partner institutions and possible partner institutions under the GenoPHEnix umbrella
- Added value through cooperation and development of new structures for data and TNA access (also industry cooperation)
- Possibility to incorporate industry data to a greater extent
- Increase of scientific impact, faster knowledge transfer between researchers
- Strong networking between high level experts enables policy advice
- Possibility of bundling of expertise with animal health sector, farm animal breeding industry, AI & Machine learning, data coordination and management & biobanking also in the context of One Health
- High level cooperation in the ESFRI Health and Food cluster
- High level innovation through accelerating fundamental research capacities and incorporate novel approaches of technological advancements
- Strengthening capacities through a single access Infrastructure in the areas of farm animal breeding, health and food security through increased

capacities for prediction accuracy, data coordination, European cooperation, harmonization of procedures and therefore coordinated but easier access to resources and capacities in biobanking, farm animal breeding, genome editing, AI and machine learning and overall G2P data coordination

Threats

- Social movements questioning current livestock production or procedures around animal testing for research. Though GenoPHEnix' goals are in line with the 3R principles to reduce animal testing, as well as promoting and finding new solutions to develop new knowledge for better conditions for animal welfare and suitable production, this may take some time and leave room for misunderstandings. A clear communication through appropriate channels with stakeholders and the broader public are key to shape the discussion and promote the effects GenoPHEnix can bring.
- Definition of services, that are suitable for engagement of industry partners and a suitable access structure with regard to legal implications (definition of public private partnerships)
- Engagement of best institutions, not all institution

6. Main challenges and opportunities for expansion

The analysis of the components show the extensive scope of GenoPHEnix referring to the large variety of species, methodologies and tools, services offered to the community, G2P analytics and tools, enabling research of genome, cell, herd or population - level and also regarding the geographic distribution and therefore pan-European relevance.
Based in the science and innovation concept of the RI, the implemented structures enable the consolidation of G2P research and streamline the development of European farm animal science as fundamental part of European agricultural- and food-policies through new standards, research methodologies and innovation beyond the field.

Main challenges:

- Anticipate and shape necessary evolution of animal science
- Inclusion of animal welfare and evaluation of environmental impacts of farm animal husbandry with prioritization of respective traits and phenotypes
- Driving implementation of 3R principles with development of methodologies and standardized procedures for a large variety of farm animal species and beyond
- Regarding multi-species phenotyping a lack of standardization and accessible, centralized information
- Inclusion of all mammalian species with a stronger focus on small ruminants and poultry
- Development of a roadmap to implement most advanced welfare standards
- Creation of a suitable data structure, incorporating also phenotype data and in vitro models as well as biobanked samples

The already established capacities from INFRAIA projects AQUAEXCEL, SmartCow and PigWeb as well as INFRASERV projects AgroServ and AQUASERV and their competences offer a more extensive service portfolio for researchers and make the infrastructure attractive as collaboration partner within the ESFRI “Health and Food” Cluster, to work on the shared goal of food security

and sustainability through developing tools and methodologies for improved farm animal breeding.

7. Data coordination and data management plan

GenoPHEnix RI builds strongly on the cooperation with the FAANG community (functional annotation of animal genomes) and the scientific work done by the EuroFAANG cluster projects under H2020 funding (see point 1). The goal of GenoPHEnix is to offer open access to a data portal for genomic data (FAANG), a biobanking directory and biosample sharing and phenotypic data for all relevant economic species, emerging farmed species, model animals, domestic animals and aquaculture.

Results and processed data will be made available through GenoPHEnix data portal and public repositories for five years after the end of a specific project. The inclusion into the International nucleotide sequence database (INSDC) secures the long term data management and preservation. It is issued upon submission into EMBL-EBI as data coordination center, BioSamples and European Nucleotide Archives to go beyond community specific portals. Access towards data shall be granted under open access criteria through the GenoPHEnix data portal or the public archives, in compliance with the outlined terms and conditions. With respect to possible industry cooperation and restricted access due to intellectual property rights the necessary structures will be established. The original data remains in the ownership of its institution.

Within the data management plan data descriptions and preferred formats for phenotypic data and genomic data are outlined:

“For phenotypic data, the preferred formats are:

- For tabular data: CSV, TXT
- For semi-structured data: JSON, XML
- For Textual data: TXT, unicode encoding.
- For images: mp4, jpg

For genomic data, the preferred formats are:

- For raw reads: Primarily submitted as FASTQ files, which store base calls and quality scores for each read.
- For aligned reads: Can be submitted as BAM (Binary Alignment Map) files, which represent aligned reads to a reference genome.
- For compressed formats: CRAM (CRAMmed Alignment Map) is a compressed version of BAM, often used for large datasets.
- For Metadata: Provided in a structured format like a spreadsheet or text file, detailing sample information, sequencing platform, and experimental conditions."

Metadata standards are secured through a brokered submission system, referring to the submission of samples, raw datasets, analysed datasets, detailed protocols and data workflows for the generation of data. The multi-use of data, inclusion into publications and citations is highly valued under the requirement that GenoPHEnix RI is acknowledged and the INSDC identifier is used. Data sharing of FAANG data has to be in line with the data sharing policy and FAANG data consumers need to adjust to Fort Lauterdale and Toronto principles. The FAIR criteria (findable, accessible, interoperable, reproducible) are ensured through the establishment of GenoPHENix data coordination center and data portal, building upon the expertise and provided by the FAANG data coordination center and data portal with the following specifics defined in the GenoPHEnix data management plan:

"· **Findable:** Data should be easy to find for both humans and machines. GenoPHEnix RI will use consistent naming conventions, providing clear and accurate metadata, and registering data in discoverable public repositories.
· **Accessible:** Data should be accessible to anyone in the research community (noting that it is expected that some generated data from industry may carry additional restrictions to protect Intellectual Property). GenoPHEnix RI will provide open access to data whenever possible and ensure that users provide standard formats and mandatory protocols for data access.
· **Interoperable:** Data should be interoperable with other data sets. GenoPHEnix RI will ensure the use of a common data model and ontologies and providing documentation that describes the data in a way that others can easily understand.

· **Reusable:** Data should be reusable for other purposes than the original study. This means ensuring clear information about the provenance of the data, extensive rich metadata, and open licenses that allow others to reuse the data whenever possible. “

The data coordination center also offers links to open access analysis software and clear provenance and licensing requirements.

GenoPHEnix may collaborate with other infrastructures and data repositories and user training and resources will be made available.

8. Impact assessment and societal challenges

There are several publications on how to measure and summarize the socio-economic impact of research and innovation infrastructures, with different regard to financial analysis scenarios and inclusion of economic macro-indicators and their relation and influence on economic effects on regional sites or general research-related activities. For the GenoPHEnix impact assessment the publications of Massimo Florio [4] “Exploring cost-benefit analysis of research, development and innovation infrastructures: an evaluation framework” from 2016 were evaluated, especially for reference to the socio-economic benefits.

For the socio-economic impact assessment as systematic analysis we refer to the socio-economic guide on socio-economic impact assessment for research infrastructures, provided by RI Path as reference document. [5]

A socio-economic impact evaluation is a systematic approach to evaluate social, economic and cultural impacts of a proposed structure. The socio-economic impact realms can also include a biophysical spectrum, where impacts on water, land & air wildlife and health are considered. Since the context of research infrastructure is set up on life cycle approach as specific roadmap process, the stages of concept development and design influence the level of stage and RI

[4] (PDF) EXPLORING COST-BENEFIT ANALYSIS OF RESEARCH, DEVELOPMENT AND INNOVATION INFRASTRUCTURES: AN EVALUATION FRAMEWORK

[5] Griniece, E., et.al., RI-PATHS, https://doi.org/10.5281/zenodo.3950043, RI-PATHS_Guidebook.pdf

impact assessment this evaluation can provide. GenoPHEnix is setting up their strategy and policy formulation to create a business case and provide information to the roadmap process.

Nevertheless, socio-economic impact studies are highly context driven and oftentimes outside of the control (and therefore the responsibility) of a research infrastructure. We therefore outline the strategic approach through impact pathways, the resources and activities which cause short and longterm outcomes, with the impact we intent. The included possible changes can influence economic growth and societal and cultural impacts and show the potential impact of GenoPHEnix on strengthening regional growth and optimizing the quality of research resources and beyond.

We are moving along the guidelines of RI-path, where 13 key evaluation criteria are outlined. These enable also a monitoring on implementation and impact on each lifecycle stage.

P1

Publication-citation-recognition

- Takes into account a greater effort and better resources for scientific research and therefore a stronger output (quantitative and qualitative) of research papers (which is of course also a central KPI for GenoPHEnix)
- The knowledge push will also enable the member institutions of GenoPHEnix to strengthen their research, which in consequence can strengthen the visibility and reputation of the institutions (can also result in higher attractiveness for other researchers to work in that institution -> Region gain -> free circulation of researchers as ERA goal)
- Florio refers to this as “knowledge output and their impact”, where an analysis scenario includes marginal production costs of published articles within the GenoPHEnix planning
    - 2.38 articles per researcher
    - 6.9 research FTEs -> 16.45 articles published in impact factor journals
    - 1.8 as multiplier factor
    - Value of publications 379 k in 2027 to 985k in 2033 onwards

Formula: RI & researcher -> knowledge and information -> scientific recognition & RI visibility

P2

Employment, operations and standardized procurement

- RI as an economic actor
    - GenoPHEnix plans 33.8 FTEs (April 1st 2025) for 16 member institutions from preparatory, operation and implementation phase
    - Therefor the RI generate a large variety of high quality jobs, which result in retention of employees and prevents “brain drain” for the member institutions, since RI employment needs special qualifications
    - Also the RI generates stability for the member institutions, secures and strengthens quality of research and therefore the position and jobs of staff -> secures regional spending
    - Provision of service for users evolve from 6.5m (2029) to 5.3m (2049)

Formula: RI & researcher & private sector -> scientific recognition and RI visibility -> economic value, innovation, efficiency gain

P3

Technology transfer and licensing

- The RI plans to engage industry stakeholders, (e.g. farm animal breeding companies) as users with a planned share of 14 % of access requests for GenoPHEnix services
- GenoPHEnix delivers on TRLs, biobanking, breeding applications, big data analytic tools as potential technology innovative areas

Formula: RI & researcher -> knowledge, information -> economic value, innovation, efficiency gain

P4

Learning and training through joint development and tools

- Follows on innovation pathway and synergetic approaches on joint solutions or methodologies
- Strong development activities through Think Tanks and ELIXIR focus group
- GenoPHEnix does not plan to establish technical innovations at the moment
- Data coordination, RDM and development of suitable data repositories
- Inclusion of data from private sector possible and thinkable

Formula: RI & private sector & public sector –> data, tools and instruments -> economic value, innovation, efficiency gain

P5

Learning and training by using RI facilities and services

- GenoPHEnix puts great effort into training and education activities
- Training and education is organized via a dedicated hub for these tasks, providing knowledge transfer and skill training for researchers of all career stages and all relevant topics of GenoPHEnix expertise
- Offers for other user groups from industry users with specific requirements, policymakers or education providers are thinkable - > flexibility is ensured through large expertise of the consortium
- Training for laboratory staff in the establishment of quality management and ISO-standardized procedures is foreseen, e.g. for biobanking
- Different formats from hands-on training within a laboratory or an experimental facility, webinars and online courses, hybrid events and hybrid training on data applications and online data repositories will be made available
- Through integration into the service structure, we offer dedicated access procedures and ensure the traceability of training activities, since it is also one of the key performance indicators to measure RI success
- Through integration of EFFAB (forum of farm animal breeders in Europe), GenoPHEnix also integrated a specific organization for communicative activities, to provide necessary online tools and enlarge the network beyond the research space

Formula: RI & private sector and public sector -> knowledge, information –> economic value, innovation, efficiency gain

P6

Training and higher education cooperation

- Development of human capital, with specific value through high level qualifications
- Cooperation with different universities and higher education providers secures training of talents and access to resources, available through GenoPHEnix

Formula: RI & researcher -> knowledge and information -> network & qualifications

P7

Interactive problem-solving for the private sector (industry)

- This is mainly delivered through P3, which involves also that industry users actively seek cooperation with GenoPHEnix as partner for certain challenges
- A dedicated evaluation panel monitores proposals before giving access to GenoPHEnix expertise and resources
- Industry coorperation and dedicated cooperative approaches, e.g. on data sharing and analytics, was evaluated during EuroFAANG concept development phase
- EFFAB and the Fabre TP ensure connection to industry stakeholders of the farm animal breeding sector

Formula: RI & private sector -> knowledge, information -> economic value, innovation, efficiency gain

P8

Addressing societal and public sector challenges

- Governments, ministries, agencies as user with special demands, which put up challenges outlined by national, regional or European bodies
- GenoPHEnix positions itself to solve challenges for sustainable food production and new dimensions of animal farming in different contexts, from environmental challenges (climate change), to demographic (human

population), new resources (European bioeconomy), economic (farm animal breeding as driver of traits for production efficiency, health, sustainability, resilience to meet the rising demand of human and animal nutrition and define the role of farmed animal breeding within the larger economic value chains under changing circumstances), or referring to health-related topics.

- GenoPHEnix is a driver of scientific innovation for biobanking, G2P breeding applications, in vitro and in vivo challenges, big data approaches on genomics data for better prediction accuracy, new methods on animal phenotyping, inclusion of image and sensor technologies, non-invasive methods to deliver also on the challenges of animal welfare and ethical challenges of 3R , demanded by governments and society all the same
- Through its large network and centralized organization with an annual workprogram and defined development procedures with technologies, methodologies and overall scientific innovation, GenoPHEnix is well equipped to answer to those challenges and also provide evidence-based advice, for example for policy procedures

Formula: RI & public sector -> knowledge and information -> societal solutions

P9

Provision of specifically edited/curated data

- GenoPHEnix is strongly committed to data architecture and providing open access research data to strengthens its communities, delivering into EOSC and strengthening the position of the European Union as leading in open access data repositories
- GenoPHEnix is building an own data portal which contains a threefold of data access, thereby building 1) on the foundations of the FAANG data portal (functional annotation of animal genomes) and the expertise of intergovernmental organization EMBL-EBI and of the collaboration with the life-science infrastructure ELIXIR. GenoPHEnix is fully committed to FAIR principles and generating data and making it available in an open data repository. The data collected as part of the functional annotation of

genomic data is made available and published in the FAANG data portal or directly via INSDC public archives. 2) Phenotypic data, e.g. quantitative measurements and images will be stored at the BioStudys database and the BioImage Archive. 3) As third component, a Biobanking directory delivers access on biosamples and biosample data in an open access repository. Research data management includes regulations on data sharing, the obligation to comply with the FAIR principles, long-term data management, data standards and metadata standards, as well as regulations on publication under Fort-Lauderdale & Toronto principles, data use and clarification of the role of the EMBL Data Coordination Center. GenoPHEnix RI thereby explicitly supports the multiple use of data, provided that they are correctly cited and referenced, GenoPHEnix is referenced and, in the case of the INSDC, the project identifier is included in the publication. Further details are visible in the GenoPHEnix access policy principles and the data management plan. As an example for conceptualizing the access to biosamples within the infrastructure, a request procedure prototype has been conceptualized in the context of EuroFAANG, to give a centralized access option for European multi-species biosamples. This will be further developed during the preparatory phase of GenoPHEnix.

Formula: RI & researcher & public sector & private sector -> data, tools and instruments -> economic value, innovation, efficiency gain + societal solutions

P10

Changing fundamentals of research practices

- As distributed RI, GenoPHEnix isn especially adapted and equipped to deliver on the refinement and further development of research procedures, especially since we have a large variety of possible innovation to drive forward farm animal breeding
- GenoPHEnix connects 11 member states within one centralized work program for a scientific and innovation concept

- The science and innovation framework shows significant gaps within the current research framework of G2P research, for example in the creation of harmonized procedures for farm animal biobanking and sample and data sharing in open access repositories or in the establishment of gold standard methods for consolidation of phenotyping procedures within the realm of multi-species approaches (so to use multidisciplinary and synergetic approaches)
- The development of in vitro cell models and organoids for testing farm animal meds
    - Fit for purpose in vitro models for farmed animals, including organoids and cell lines, including those derived from highly phenotyped animals.
    - Use of in vitro models for pre-validation of in vivo experiments or instead of in vivo experiments, e.g. for disease challenges, environmental perturbations, contributing to the 3Rs.
    - High-throughput cellular screens using CRISPR technology, for example, to screen 100's of a 1000's of potentially causal variants in appropriate in vitro systems (see above).
    - These would provide additional targets for genome editing, including multi-plexed edits for polygenic traits such as disease resistance.
    - Improvements in genomic selection based on better knowledge of the genome particularly for difficult to measure/improve traits such disease resistance.
    - Artificial intelligence using high resolution phenotypes for model training e.g. for animal behaviour/welfare traits.
    - Innovative for genomic and phenomic data visualisation tools including for pangenomes and for comparative genomics.
    - Novel means of sharing proprietary data with breeding companies and other stakeholders e.g. via data encryption.

Formula: RI & researcher & policy makers and funds -> knowledge and information -> networking and qualifications

P11

creating and shaping scientific networks and communities

- these might develop along the lines of scientific development for innovative challenges
- GenoPHEnix in itself is a large scientific network for farm animal breeding, including species with growing interests, e.g. small rodents, black soldier fly and other emerging farmed animal species
- The speed within the AI space, development of new solutions for big data analytics and research tools to shape farm animal breeding strengthens the expertise available within the RI
- Creating interfaces for the connection of academic research data and company data might strengthen the community efforts on synergetic approaches
- The work program highlights research high resolution topics as well as frequent developments within the RI over the years, so for real scientific networks it needs common Think Tanks and working groups to deliver solutions in a shared challenge
- High level experts cooperate on these tasks, shaping scientific communities

Formula: RI & researcher -> network and qualifications -> scientific recognition, RI visibility + networking and qualifications

P12

Promoting engagement between science, society and policy

- RIs open up the space around the scientific topics and show cooperative and communicative pathways to engage a larger group of society with different focus areas and abilities than those of scientists
- Especially in context to social and cultural impacts of scientific research, possibilities to highlight to meaning of facts and proof on complex topics is especially useful and impactful for policy advise
- Science can therefore also act as a kind of moderator between conflicting parties, for example NGOs, companies and policy, since scientists are among the most trusted groups

- On the other hand, the broader view of societal perspectives and impact pathways for scientific results sharpens the profile of the RI and widens the scope on recent developments
- Designing pathways towards dialogue forums, especially interesting for ethically relevant topics, like genome editing and 3R principles on animal testing
- GenoPHEnix will establish 4 boards: scientific and innovation/technical advice, ethical advise, user and stakeholder forum and an open innovation forum, where we plan to actively engage independent experts in their field for specific questions and challenges, that presumably will arise during the duration of the RI

Formula: RI & public sector & private sector & policy -> knowledge and information -> societal solutions

P13

Communication and outreach

- This point addresses the pathway from RI results and activities to public and private sectors and a larger public without them having an interest to contribute to RI
- Inclusion of media relations to conclude on RI visibility, description of scientific results and the context for society
- Identification of suitable communication channels and social media to engage a broader public scope during and after defined activities
- Within GenoPHEnix EFFAB is in charge of the communication strategy and brand design for the RI

Formula: RI & mass media -> knowledge and information -> scientific recognition, RI visibility

Summary

HR

GenoPhenix plans on establishing 33.8 FTEs in personnel in 16 member institutions, highlighting the need for scientific personal, data specialists and

coordinative personnel, to stear financial and administrative tasks and requirements within the different phases and developmental procedures of infrastructure development. This enables local or regional employment and possibly redgional spending, but also free circulation of scientists, especially since GenoPHEnix, as all RIs, is in need of the best expertise and scientists in the fields. Based on the extensive and most flexible training and education offers of the RI, which also is reflected in the governance structure, GenoPHEnix creates active opportunities for career development within different scientific areas, and sharpens the skills of its entire staff. Through large-scale cooperation and multi-national networks, the access to resources and the impact-opportunities are scaled up efficiently. Through multi-actor collaboration with public and private entities, users of different backgrounds are trained, which establishes the RI as central point of expertise for farm animal breeding and G2P laboratory and experimental capacities, as well as related research data management topics.

All this increases the scientific quality of outputs and therefore the credibility of GenoPHEnix. Innovative solutions and private sector collaboration enable the possibility of generating economic value through innovative breeding tools and data sharing between sectors.

Economy and innovation

Through several planned investments in INRAE and FBN buildings and equipment for facilities, GenoPHEnix strengthens regions in France and Germany with 19.22 million Euros. With the help of optimized animal housing conditions, better data collection and analysis tools GenoPHEnix strengthens the research base for members and users and enables high quality publications and service for the scientific community, knowledge transfer and industry collaboration towards a more market-oriented approach for technological and methodological developments of the RI.

Employment opportunities and training activities ensure the investment in human capital, as another strengthening opportunity within the regional context and to provide an adequate sustainable income.

Through the operation of the facilities and their involvement within the infrastructure, their impact and visibility is highlighted, which account for stronger networks and higher attractiveness as an employer.

Taking into account the local economy benefit, referring to travel costs share of 25%, 80% accommodation share and 70% food expenditures share to value will rise from 116 k in 2029 to 306 k in the following years.

Societal impact

Social and cultural impacts in the context of scientific and research-political results, enabled through the large scale frame of GenoPHEnix, are numerous. The systematical core of activities evolves around the development of farm animal breeding and animal husbandry under changing geopolitical, climatic and demographic conditions as well as through the high level developments of big data approaches, mathematical models and sensor based technologies.

Only from this short description the impact chain of optimized scientific resources with clear focustopics, multilateral cooperation, stronger scientific output (through quantitative and qualitative improvement), better visibility and transfer towards industry cooperations with technological readiness evaluation up to the evaluation of market readiness and patents becomes visible. Through strong networking activities and knowledge transfer, scientific data and fact based results will be actively presented towards related communities and the broader public.

For the scientific communities, GenoPHEnix enables new solutions for farm animal biobanking, in vitro research of cell models and organoids, multi-species phenotyping and imaging techniques, big data analytics and optimized G2P breeding applications through European cooperation and establishment of new open access data repositories for data and sample sharing.

The broader public can benefit through knowledge gain on new breeding technologies, like genome editing, where GenoPHEnix can take on the task of explaining facts and impacts on different breeds and possible implications for human nutrition or animal health and One Health.

European Infrastructures applying for the ESFRI roadmap have to elaborate on the sustainability aspects of their endeavor, with specific issues on environmental impact with regard to the European Sustainability Reporting Standards (ESRS). The environmental impact is defined by 5 criteria; climate change, pollution, water and marine resources, biodiversity and ecosystem and resource use and circular

economy. A summary on planned measurement to reduce the environmental food print and emissions is visible in section 9.

Impact on policy

Impact on political strategies is visible in section 3. GenoPHEnix delivers into the following strategic frameworks: European Green Deal, Farm2Fork, Research and Innovation, Green and Digital Transition, One Health, Conservation of Animal Genetic Resources, Livestock Farming Systems as part of European Bioeconomy, Food 2030, Agricultural Vision 2040, European Partnership on Animal Health and Welfare.

The RI also drives the discussion on the implementation of the 3R principles to reduce animal testing and can inform the public on current developments. Since GenoPHEnix streamlines those topics, it gains visibility and credibility and thus can take on the task of educating on complex topics for engaged stakeholder groups and the broader public to drive public awareness and engagement.

GenoPHEnix delivers on the following UN sustainability goals:

- Unlocking the power of data for sustainable development
- Zero hunger
- Decent work and economic growth
- Industry, innovation and infrastructure
- Partnership for the goals

Unlocking the power of data for sustainable development

The strong data structure of the FAANG data portal integrated into EuroFAANG, the global cooperation with the FAANG community, the great expertise in the field of e-data and AI of the project partner EMBL-EBI as well as the cooperation with the already established life science infrastructure ELIXIR via the establishment of a focus group ensures that GenoPHEnix has all the necessary resources in the long term to work at the forefront in this area and to develop and establish new data portals. The infrastructure is committed to European open data access according to FAIR principles and also to future inclusion into EOSC. The possibility of integrating data from industry partners opens up new research potential and

synergetic collaborations. This strengthens key partnerships in Europe in terms of accelerated data and knowledge transfer.

Zero Hunger

The context of Zero Hunger is, of course, maximally broad. Transformation processes within the value chains for human and animal nutrition are largely determined by other factors. However, the consolidation of G2P research for livestock and the pooling of the partner institutions involved can significantly influence the knowledge advantage for the application of advanced breeding science. However, accelerated breeding progress through better basic research and more accurate prediction probabilities for preferred traits will safeguard legal measures that have already been introduced and conversion processes for modified housing systems (e.g. group housing or free farrowing for pigs by 2036). There is certainly enormous potential in further research into disease resistance and the reduction of antibiotic use, as well as in further approaches to investigating how environmental influences, animal health and human activities determine disease dynamics. Through increased understanding of disease mechanisms, immunological pathways & host-pathogen interactions, integrated health management systems can be developed. Animal husbandry must justify its value, as refined animal products and the organization of their production cycle are placed in competition with alternative protein sources. The “life cycle assessment” of production and the design of rural areas (land-based livestock farming, issues of crop production efficiency, fertilization) will be just as decisive as the criterion of resource efficiency. The markets, food retailers, processors and consumers will continue to play a decisive role in determining market structures.

Decent work and economic growth

GenoPHEnix can create regional jobs by establishing new structures, e.g. the national central hub or new experimental facilities, possibly with suitable IT infrastructure and server capacities. The participation of the partner institutions under the RI umbrella ensures national support from the ministries and thus the safeguarding and further development of the infrastructure. At the same time, the collaboration forces the institutions to develop core competencies and expertise in order to differentiate themselves with a certain unique selling point, and the

interlocking of processes can lead to the setting of priorities. This also provides the basis for acquiring projects with industrial cooperation or economic interests. The impact of the research driven by GenoPHEnix and possible transfer into practical results can only develop economic relevance over the course of years and possible progressive cooperation and integration into economically relevant products or patents.

Industry, Innovation, Infrastructure

The innovation potential through the development of in vitro technologies and in the field of genome editing can be classified as high to very high. In addition, 7 areas were identified that will underpin future priorities. Institutions with expertise in this area can be integrated into the consortium for the next funding phase. These include: Robotics - high throughput phenotyping; Focused AI, machine learning & digital twin technology; Large scale automated phenotyping from sensors and other devices; Testing genetic combinations & screening of chemical compounds for pharmaceutical effects; Big data and analytics; Advanced tools for understanding animal breeding & production in a social science context; Immunogenetics / genomics.

Partnership for the goals

The cooperative approach of research infrastructures in the sense of the open data policy and synergistically reinforcing expertise should correspond to this goal.

Impact assessment: Conclusion on innovation, transfer and cooperation with industry, science and society

The EU “Science, Research and Innovation” report states “Investing in research and development means investing in the challenges of the 21st century”. The EU supports projects in research and development with 2.2% of GDP, with the aim of reaching the 3% mark, and is thus still below the contributions of the USA, Japan, South Korea and China. The European Union is second in scientific output and leads the field of “data open access” with a high number of international collaborations. A lead in the area of innovation can at least be initiated through the

creation of research infrastructures as a large-scale community project with the strengthening of the capacities and excellence of an entire research community and, in the best case, contribute to a fast and highly active community whose results and technological advances are published for scientific progress and, where possible, transferred into market-relevant products and applications. As distributed European RI, GenoPHEnix impacts not only the partner institutions through measurable funding streams and an optimized output performance, but streamlines the career options for scientists, innovation potential through technological and methodological developments within the RI and the economic potential around the main goals of farm animal breeding, food security and included topics.

9. Environmental considerations

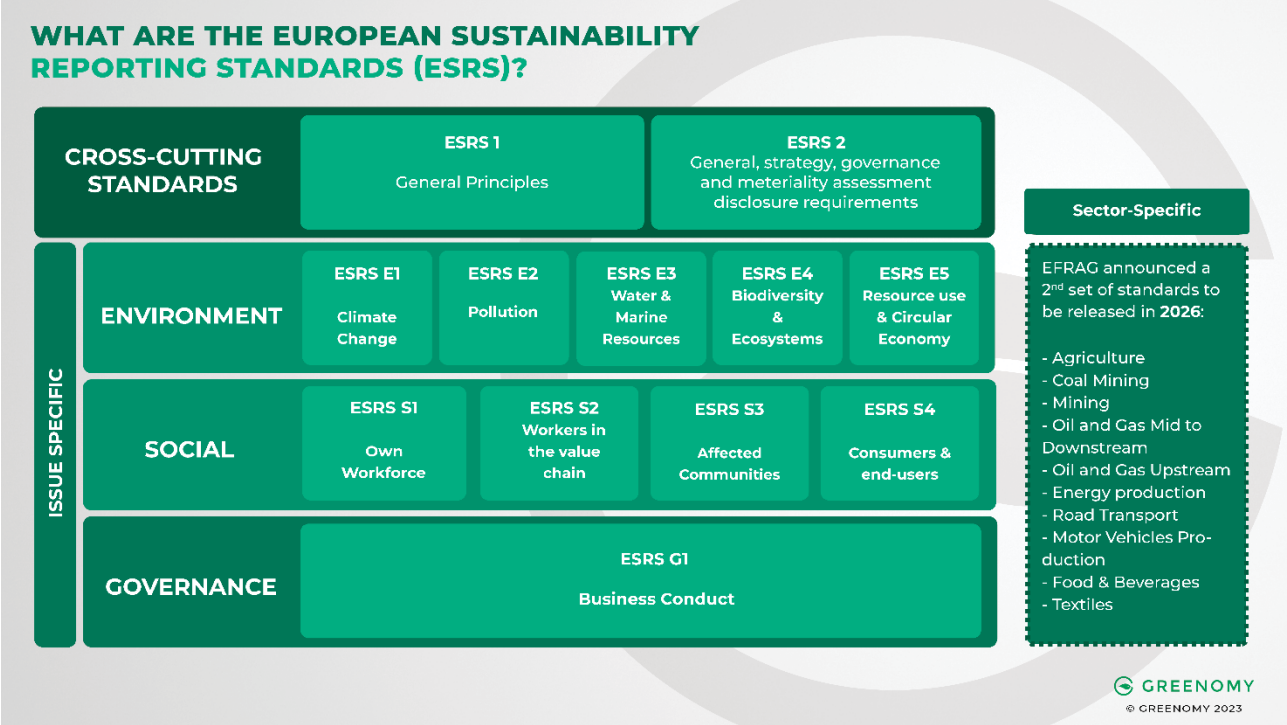


Fig. 18 European sustainability reporting standards (ESRS)

Taking into account the pan-European orientation of the research infrastructure in the context of the European Strategy Forum (ESFRI) and the underlying minimum criteria, which also include a checklist for evaluating the environmentally relevant aspects, the evaluation of sustainability is carried out under the “European sustainability reporting standards”. This comprises five categories and is shown in Figure 1 in the context of the general and topic-related standards. It should be emphasized that these criteria are primarily intended to be applied to large companies with a strong public interest, e.g. banks or insurance companies, categorized according to the number of employees or turnover figures. In the EU, small and medium-sized companies, for example, will also be assessed over time using this standard.

Within the framework of the ESRS, it seems sensible to establish a process that must be carried out within each partner institution of the infrastructure with laboratory or IT capacities as well as the national nodes and the central hub and with which the evaluation of the existing sustainability processes and future necessary processes can then be carried out. As part of the general requirements ESRS 1, key figures are classified and calculated in order to meet the criteria of

completeness, comparability and verifiability. ESRS 2 defines the sustainability expertise of the administrative, management and supervisory bodies, maps risk management and ensures disclosure through the so-called “materiality analysis”. Following these definitions, an inventory can then be carried out within each individual institution in the topic-related standards on corporate policy, the environment and social issues. Internal representatives and specialists and managers of the institutions as well as external stakeholders must be involved.

This is important for carrying out the materiality analysis, in which topics and data points along the laboratory workflow process must be specified both inside-out and outside-in in terms of scope and extent. The evaluated status of the analysis can then be used to define a strategy based on the circumstances of the respective institution. A kind of internal roadmap process is then used to prioritize goals and define measures over a short, medium and long-term period, with suitable key figures for further monitoring and controlling the processes. Continuous data collection in this way ensures the long-term reduction of the resources used.
In terms of the proposed criteria that are open for evaluation - climate change, environmental pollution, water and marine resources, biodiversity and ecosystems as well as resource use and recycling systems - the ecological footprint can be reduced primarily through improved resource use, including reduced water consumption, waste management and recycling.

Laboratories

In the planning of the research infrastructure, the local and stationary laboratories are currently being evaluated in terms of resource use, i.e. energy and water consumption, use of chemicals and materials as well as disposable plastics under sustainable conditions.
The seven partner institutions do not yet have an overall strategic approach to reducing their ecological footprint in the long term. Therefore, the creation of the research infrastructure offers a very good opportunity to establish this for the participating institutions in the areas of laboratory & experimental facilities as well as with regard to the IT structure in a common approach.

In order to do justice to the specific facilities of the laboratories, the assessment of the Royal Society of Chemistry was used, which already presented a report on "Sustainable laboratories - A community-wide movement towards sustainable laboratory practices" in 2022. [6]

Resource	**area of use**
Energy	- light, Air conditioning, cooling, freezer - Equipment in the form of fume hoods, freezers, heaters, lamps, microscopes, NMR, sequencers throughout the entire institution - IT equipment in the form of personal computers, server facilities, high-performance computing, data storage, cloud-based applications, systems for modeling
Water	- Cooling and cleaning - Laboratory procedures
Chemicals and material	- Reagents - Helium, F-Gases (Freezers) - Xenon (lamps)
Plastic	- Often consumables for single use, but which can be recycled and returned to the material cycle - For example: pipettes, bottles, plates, filters, cuvettes, racks

Tab. 16 summary of resources and their area of use in the context of potential of sustainable laboratories

Particularly with regard to the use of fluorinated greenhouse gases, e.g. in the area of refrigeration technology used, action should be taken in accordance with REGULATION (EU) 2024/573 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of February 7, 2024, on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014.

If these resources, as well as the existing equipment and consumables, are included in the "materiality analysis" of the evaluation process presented above,

[6] Royal Society of Chemistry, Sustainable laboratories – A community wide movement toward sustainable laboratory practices, 2022, RSC Sustainable laboratories report

the status quo of each institution involved is obtained. In this way, key figures can be created and their progress can be monitored in order to reduce the consumption of water and energy as well as the use of chemicals and plastic in line with an action plan. Targets for reduction and savings can also be agreed. For new purchases and new buildings, clear criteria are agreed with regard to energy efficiency and resource conservation, e.g. also via structural heat utilization concepts and reheating.

In the assessment of energy demand and greenhouse gas emissions, the RSC report showed, among other things, that possible target figures can make a significant contribution to achieving climate neutrality by 2050:

evaluation	**To Do**	**targeted effect**
EXTRACTOR HOODS AND -80 ° C FREEZERS ARE THE MOST ENERGY-INTENSIVE EQUIPMENT	Setting the freezer from -80 °C to -70 °C Closing the hoods on the extractor hoods	Reduces energy consumption by 30 - 40 % Reduces energy consumption by 40 %
essential air conditioning and refrigeration systems contribute significantly to the emission of fluorinated greenhouse gases 5.5 MILLION TONS OF PLASTIC WASTE COMES FROM CONSUMPTION IN BIOLOGICAL, MEDICAL AND AGRICULTURAL LABORATORIES	Sealing controls, recording obligations, recovery obligations Feeding into the recycling loop	Reduction in the use of F-gases to 0% by 2050 Reduce plastic waste by 15%

Tab. 17 assesment of energy demand and potential improvements for sustainable laboratories

All of these measures ensure reduced resource consumption and an increased awareness of the relevance, quantity, quality and origin of the resources used. The

cooling technologies used on a large scale in laboratories require adequate handling with regard to fluorinated greenhouse gases (F-gases), which, depending on the substance, can have a 23,500 times greater effect on the climate (depending on the substance) than carbon dioxide in comparison. In terms of infrastructure, the greatest leverage is certainly the conscious use of energy resources, reduced consumption and targeted waste management in order to recycle laboratory consumables made of plastic

10. Governance and management

10.1 Organisation and governance for preparatory phase

Preparatory phase is an intermediate phase, which allows for the necessary scientific, methodological, personnel, financial and administrative groundwork before the actual implementation and service-offering of the RI in relation to its science and innovation work program with regard to its development. The establishment defines the level of maturity as well as visible expertise in the frame European Research Area (ERA). It relates to the ESFRI minimal criteria, which can function as implementation performance indicator (IPI) and later on as part of the key performance indicators (KPIs) for full implementation and scientific-technological as well as socio-economic maturation of the RI.

France is the lead-country with the coordinating institution INRAE. The Co-Coordinator will be the German institution Research Institute for farm animal biology (FBN).

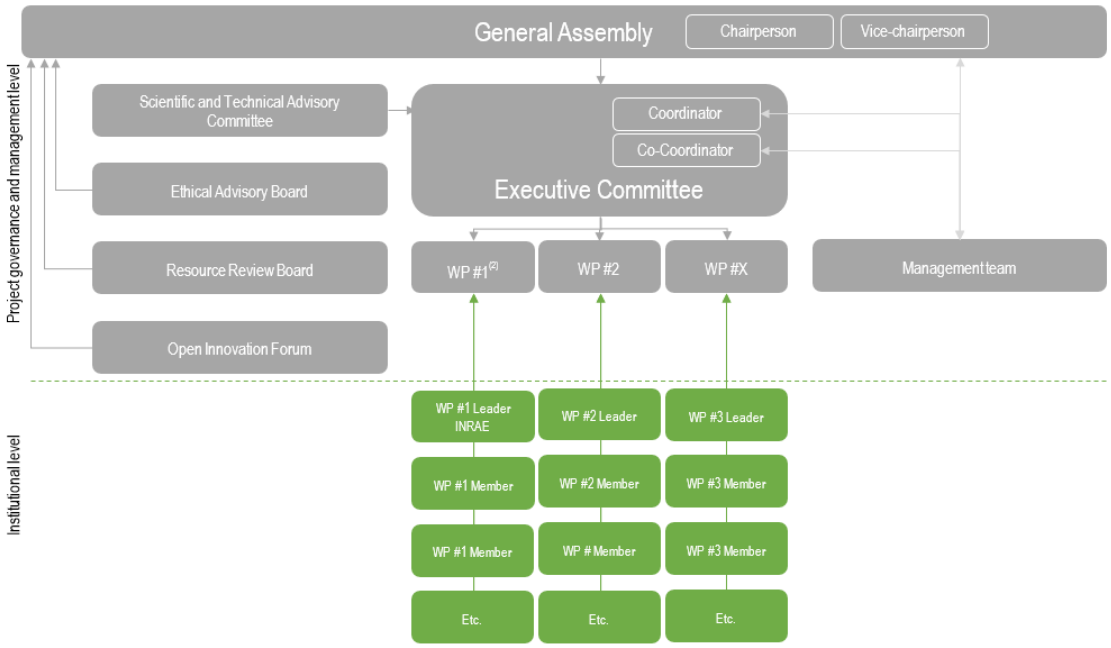


Fig. 19 Governance structure and management as planned during preparatory phase

Fig. 19 illustrates the governance structure for preparatory phase with established bodies, responsibilities, links and reporting structures. The general assembly is the highest decision making body of the RI, where every member has one vote. It establishes a chair and a co-chair. The executive committee is responsible for the correct project management with regard to timely, administrative or scientific planning structures, while integrating the decisions of the GA under realization of the specifications of the Consortium Agreement. It is led by the project coordinator and co-coordinator.

In parallel, necessary structures for scientific and technical advisory committee, ethical advisory board, user and stakeholder forum as well as open innovation forum will be established.

Board	function	members
Scientific and Technical advisory committee	Tests in independent function the scientific, technical and methodological	3 – 5 independent members, not participating in GenoPHEnix

	decisions of the Executive committee, advises on matters of project management, dissemination and other relevant decisions & evaluates the impact of those matters and measures.	
Ethical advisory board	Advise on all ethical questions, full access to documents, establishes guidelines on ethical challenges related to farm animal welfare and health, to solve these issues in the frame of GenoPHEnix	3 external experts, implemented by the GA
User and stakeholder forum		tba
Open innovation forum	Advises the GA on cooperation with innovation partners and industrial stakeholders	Members of partners or associations, working in the field of farm animal breeding or similar fields

Tab 18. Advisory boards as planned for GenoPHEnix RI

During preparatory phase one essential focus point is the detailed design of project governance. Access will be granted via the central coordination hub. To guarantee an optimal execution of the work program, four organizational units will be established, which are based in the main aims of the RI as well as research political focus points:

- Data management, integration and modelling (EMBL-EBI)

- Biobanking and genetic resources (INRAE)
- Science and technology innovation (FBN)
- Training and Education (USB)

10.2 Organisation and governance in full operation

GenoPHEnix governance for implementation and operation will be established with these bodies and advisory boards:

Level	Body	Member
Decision	General Assembly	Representation of 1 or 2 delegates (officially appointed) 1 or 2 representatives of observer countries
Decision	Financial Committee	
Executive	General Director	Within the coordinating entity, supported by scientific and administrative staff
Advisory	Scientific advisory board	3 – 5 independent members, not active within GenoPHEnix
Advisory	User forum	
Advisory	Ethical Committee	3 external experts

The possibility of establishing the respective bodies of scientific and ethical advisory committee, user and stakeholder forum, open innovation forum is evaluated as high, given a successful implementation in preparatory phase.

Governance level	Body and responsibilities
Decision	General Assembly: - Centralized planning of infrastructure, its direction and supervision - Is responsible for coordination of all procedures, implementation and advancement of structures and agreements - Responsible for budget of legal entity GenoPHEnix - All members are part of the general assembly - Representation by 1 or 2 delegates who must be officially appointed by the competent authority - 1 or 2 representatives of the observer countries with official authorization (but participating only as observers) - Yearly adoption of workprogram and budget + workprogram and budget for the upcoming 2 years - Adoption of rules of procedure and financial regulations - Elects and dismisses the chairman + deputy chairman - Chairman of the Finance Committee? - Appoints Director General of the central control unit - Establishes SAB, defines tasks and regulations - Accession of members and observers - Approves annual report and financial statements
	Audit – Committee - Finance, risk assessment and quality

	Financial committee • Advises General assembly and General director on budget and financial regulations • Proposals of appointment for external autitors • Report to General director and financial committee • Work is based in rules of procedure and financial regulations of the RI
Executive	chief executive officer of central hub • Is appointed for at least 3 years • Employed at the RI itself, which indicated the choice of a suitable legal form for the RI • Responsible for administration of the RI, coordinates the central hub, finances, administration of personnel, implementation of the decisions of the General assembly • Implementation of the work program, annual draft of the same + budget and personnel planning • Preparatory work for work program + budget planning 2 years in advance • Prepares necessary documents for the EC • Coordinates flow of information between the national nodes
Operative	national nodes - Experimental facilities and equipment - Provide training for scientists - Are self-organizing and economically independent

Advise	Advisory boards: - Scientific and technical advisory board - User forum (if deemed necessary and useful) - Ethical advisory board - Open innovation forum

Tab 19. GenoPHEnix governance bodies and boards

10.2.1 Establishment of a legal entity

The choice of a legal entity for a distributed research infrastructure has implications for "management, funding, human resources, access policy", according to OECD, 2017[7]. Usually the legal entity is determined during the preparation phase, before the project enters into its implementation, where the construction of the infrastructure services is finished and all the necessary resources and implications for the scientific case and the organizational structures for governance, financing and legal structures are established.

Projects with pan-European relevance are funded via European funding streams (like INFRA-DEV in Horizon Europe), the legal form of an ERIC (European Research Infrastructure Consortium) is the most popular. There are other available forms, which are based in the countries of the central hub, for example AISBL (Association Internationale Sans but lucrative) under Belgian law, or the GmbH (company with limited liability) in Germany. A lighter form of legally binding document is a Memorandum of Understanding between partners (usually between the central hub and the national nodes), which cannot replace a legal entity as foundation for the RI.

ERIC (European Research Infrastructure Consortium) closes the gap identified in the implementation of large pan-European infrastructure consortia, where government negotiations and the implications of national law hindered the process of implementing an infrastructure. Through establishment of the ERIC as an international legal entity, these negotiations are reduced to a minimum. The partners agree on building and operating a research infrastructure, with maximum

[7] OECD (2017), "Strengthening the effectiveness and sustainability of international research infrastructures", *OECD Science, Technology and Industry Policy Papers*, No. 48, OECD Publishing, Paris, https://doi.org/10.1787/fa11a0e0-en.

flexibility regarding its structures and governmental bodies that are necessary for implementing.

In accordance with the third report of the EC on the application of the regulation (EG) No.723/2009 of the European Council from June 25th 2009 on the community legal framework for a consortium of a European research infrastructure (August 14th, 2023) currently 26 ERICs are established and seven requested. The statistics show that ERICs that were founded 5 years ago have now 70% more members, which the commission sees as positive affirmation for the appeal of this legal form for research institutions and member states all the same. On average, 14 MS are members of an ERIC and some even include members of all MS of the European Union.

With the establishment of these structures and the associated support for capital-intensive infrastructures, the EU also has a tool at its disposal to establish social and societal developments within the consortia. At the same time, solutions for the integration of measures for the green and digital transition as well as the implementation of new technologies and sustainable use are developed and integrated within the projects and landmarks.

Economic measures in the frame of an ERIC can only take place in a limited framework. Since the term “limited” is not defined within this scope, there is no final commitment on how much income an infrastructure can create, to support its own sustainability.

Within GenoPHEnix it is planned to establish services for different scientific communities, to manage data in respective data portals under open access criteria and FAIR principles. Since there is a strong connection to the farm animal breeding community with active participation from large stakeholders in GenoPHEnix Think Tanks, we explore the possibility of integrating their data in anonymous form into the relevant data portals. In turn, the breeding industry can access research data by a centralized and standardized process through GenoPHEnix management, with charging of a user fee.

Implementation of the ERIC in the context of ESFRI Lifecycle

In the course of the ESFRI Lifecycle the consortium needs to determine the legal form as a minimal key requirement for the implementation case. With entry from being an ESFRI Project (Preparatory phase) to being an implemented ESFRI Landmark (Implementation & Operation Phase) the financial foundation of the infrastructure needs to be determined and the funding is carried by MS, funding agencies or other funding opportunities.
The procedure of ERIC application is to involve national authorities when designing the ERIC with a relatively short timeframe of 3 month after application.
The advantage clearly lies in the “recognition of the European identity on a non-economic basis” as stated by the OECD report on distributed research infrastructures, 2014. Another argument pro ERIC is the VAT exemption as key feature.

10.2.2 Necessary staff and job descriptions

The structures that are created for the RI are both the entire coordination hub in the country where the RI meets and the necessary personnel capacities required to manage the four hubs. Since scientific staff and technicians contribute to the success of the institutions both in terms of the services they offer to other scientists and in terms of transnational access to the institutions, they are also taken into account as service leaders.

Human resources coordination hub	
function	*responsibility*
Executive Director Degree in biology, veterinary sciences, bioinformatics, agriculture, or an	- Is appointed for at least 3 years - Employed at the RI itself, which indicated the choice of a suitable legal form for the RI - Responsible for administration of the RI, coordinates the central hub, finances,

equally qualifying position PhD necessary Research background, research management experience, International experience	administration of personnel, implementation of the decisions of the General assembly - Implementation of the work program, annual draft of the same + budget and personnel planning
Administration officer Finance and controlling background, legal or industry experience?	- Human Resources - Legal implications - Accounting and Reporting
Scientific officer Degree in biology, veterinary sciences, bioinformatics, agriculture	- Centralized evaluation of scientific access or projects requests, access to research data, publications, data portals, samples - Communication, Negotiation, Engagement of orientation committee and institutions towards new projects and TNA requests - Access management to biobanking resources, like samples, IT, equipment… - Public relations and communication with national nodes / scientific hubs as well as external partners, stakeholders and the general public -

IT officer Senior IT or research data management specialist	- Organization, maintenance and development of established structures - Providing access to tools and services - Development of data portals

Tab. 20 necessary human resources and responsibilities

Within the different member organizations several qualifications will be necessary, which are essential for the rolls as data stewart, access officer and service leader.

11. Financial plan and funding framework

The financial plan was summarized and calculated by project leader INRAE for the ESFRI application and will be summarized in this section. The original document will not be changed and was part of the GenoPHEnix ESFRI application, submitted on April 8th 2025.

GenoPHEnix connects 154 facilities of 16 partner institutions, which offer 503 services. European relevance is mirrored through the involvement of 11 member states.
The preparatory phase is scheduled between 2027 and 2030, Implementation will be reached until 2032 and the operational phase shall start in 2033.
For preparatory phase the following costs have been calculated: 93% of them are personnel costs (4.3 millions), followed by travel and other costs, visible per partner institution in figure 20.

1.4. Preparatory Phase cost breakdown overview					
Partners	2027	2028	2029	2030	TOTAL
Aarhus Universitet	18 675	71 100	71 100	71 100	**231 975**
Consejo Superior de Investigaciones Científicas	15 300	57 600	57 600	57 600	**188 100**
European Bioinformatics Institute	44 925	175 100	175 100	175 100	**570 224**
European Forum of Farm Animal Breeders	9 900	44 000	37 000	37 000	**127 900**
Forschungsinstitut für Nutztierbiologie	20 578	84 288	84 288	84 288	**273 443**
Institut de Recerca i Tecnologia Agroalimentàries	10 800	39 600	39 600	39 600	**129 600**
Institut national de recherche pour l'agriculture, l'alimentatic	110 263	445 521	445 521	445 521	**1 446 825**
Jihoceska Univerzita v Ceskych Budejovicich	9 850	46 533	46 533	46 533	**149 450**
Luonnonvarakeskus	18 675	71 100	71 100	71 100	**231 975**
Norges miljø- og biovitenskapelige universitet	26 550	102 600	102 600	102 600	**334 350**
Scotland's Rural College	14 175	53 100	53 100	53 100	**173 475**
Sveriges lantbruksuniversitet	15 550	58 600	58 600	58 600	**191 350**
University of Edinburgh	7 550	26 600	26 600	41 933	**102 683**
Wageningen Research	19 275	72 100	99 100	72 100	**262 575**
Wageningen University	18 675	71 100	71 100	71 100	**231 975**
Ελληνικό Κέντρο Θαλάσσιων Ερευνών	14 175	53 100	53 100	53 100	**173 475**
TOTAL	**374 916**	**1 472 042**	**1 492 042**	**1 480 375**	**4 819 375**

Fig 20. Breakdown of costs during preparatory phase

This reflects on the work package structure to develop the further necessary scientific and implementation steps towards a sustainable governance and service offer of the RI.

If services are offered within the preparatory phase, costs will be presented within the operational phase, since the cost category belongs to the OP budget.

The implementation phase is best characterized by cost categories and budgets for buildings, equipment, personnel and travel per part institution. It totals 37.47 m of investment costs (building and equipment make up for 33m), personnel and travel between 2028 and 2034 (Figure 21).

2.2. Implementation Phase budget by cost category											
Implementation Phase	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Buildings											
Aarhus Universitet	0	0	0	0	0	0	0	0	0	0	0
Consejo Superior de Investigaciones Científicas	0	0	425 000	625 000	450 000	250 000	0	0	0	0	0
European Bioinformatics Institute	0	0	0	0	0	0	0	0	0	0	0
European Forum of Farm Animal Breeders	0	0	0	0	0	0	0	0	0	0	0
Forschungsinstitut für Nutztierbiologie	0	0	0	4 058 180	4 058 180	4 058 180	0	0	0	0	0
Institut de Recerca i Tecnologia Agroalimentàries	0	0	0	0	0	0	0	0	0	0	0
Institut national de recherche pour l'agriculture, l'alimenta	0	0	0	1 826 784	1 826 784	0	1 015 000	1 015 000	0	0	0
Jhoceska Univerzita v Ceskych Budejovicich	0	0	0	0	0	0	0	0	0	0	0
Luonnonvarakeskus	0	0	0	0	0	0	0	0	0	0	0
Norges miljø- og biovitenskapelige universitet	0	0	0	0	0	0	0	0	0	0	0
Scotland's Rural College	0	0	0	0	0	0	0	0	0	0	0
Sveriges lantbruksuniversitet	0	0	0	1 818 182	1 818 182	0	0	0	0	0	0
University of Edinburgh	0	0	0	0	0	0	0	0	0	0	0
Wageningen Research	0	0	0	0	0	0	0	0	0	0	0
Wageningen University	0	0	0	0	0	0	84 910	0	0	0	0
Ελληνικό Κέντρο Θαλάσσιων Ερευνών	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	425 000	8 328 145	8 153 145	4 308 180	1 099 910	1 015 000	0	0	0

Fig. 21 planned investments for buildings during preparatory and implementation phase

The GenoPHEnix legal entity will be established presumably in 2031 or early in 2032, as part of the implementation phase.
The operation of GenoPHEnix and full cost estimation is visible in figure 22.

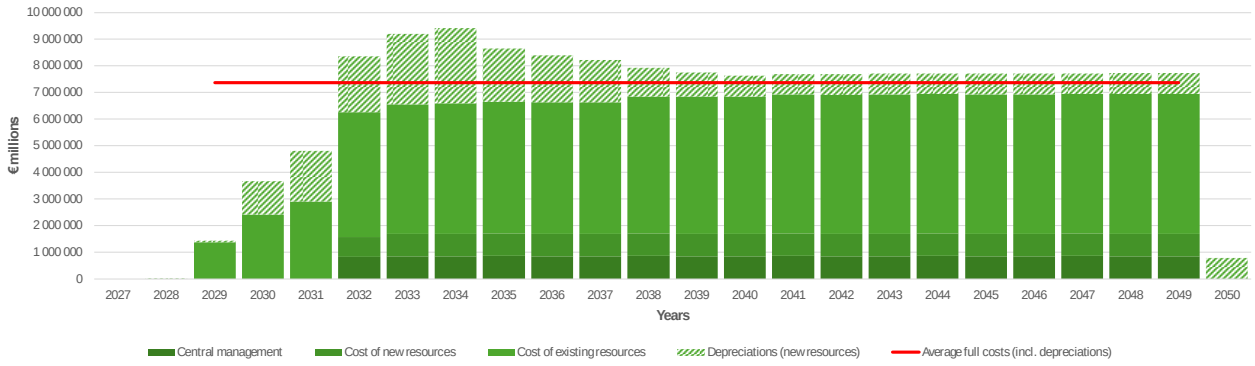


Fig. 22 full cost estimation for GenoPHEnix RI over the full RI lifetime

In 2029 the TNA project shall start, which is estimated 5.3 m € in total. The actual value depends on whether funding is available. This would also serve as kind of a

running test, for availability of full service provision before reaching the operational phase. Marginal mistakes or structural incongruencies could be corrected.

Costs for the GenoPHEnix legal entity are planned with 850.000 € on average over the whole operational period from 2032 – 2049. It 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.

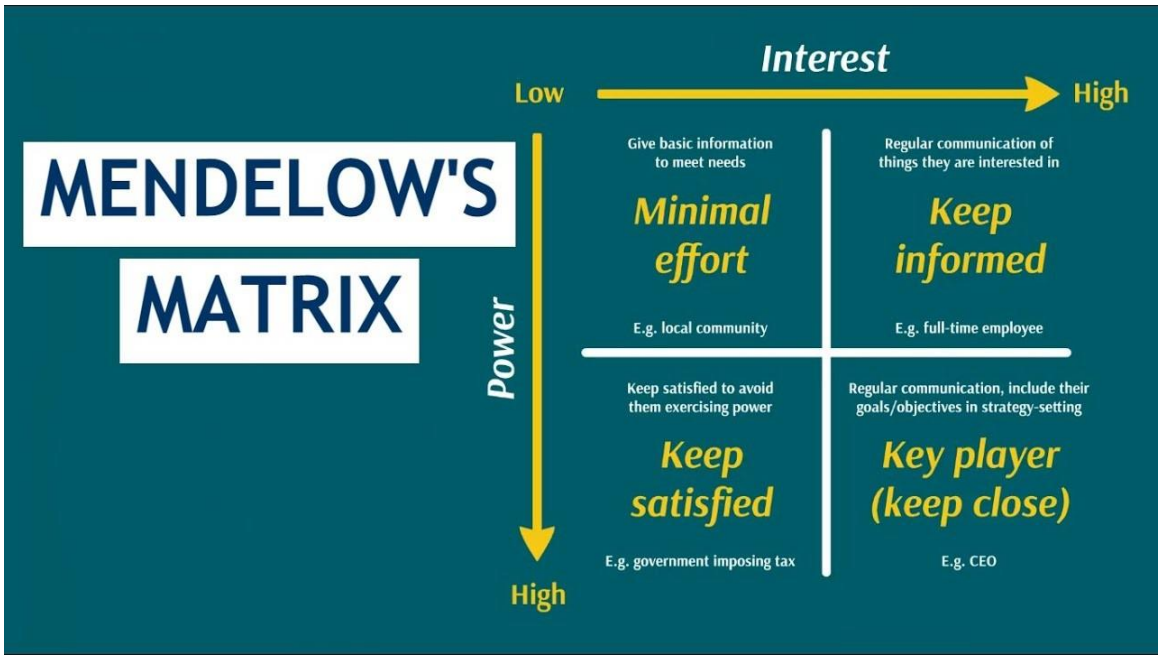
For access provision, costs amount from 5.4m € (2032) to 6.1m € (2049) in total for all member institutes, price base year 2025. Costs for new resources and depreciation of new resources were calculated for the whole operational phase.

Figure 23 lists revenues and costs for the different project phases as well as resources and how they should be funded throughout the lifetime of the RI. Preparatory phase is financed through a mix of Framework Programme grant (FP 10), in-kind contributions and national funds. This is widened throughout the Implementation phase through inclusion (wherever possible) of foundation grants and regional programmes (co-funded by ERDF). 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 shall be mostly positive over the years.

Financial sustainability	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Revenues													
Revenues from e-services (data)	-	-	-	-	2 000	2 300	2 645	3 042	3 498	4 023	4 425	4 867	5 354
Revenues from physical and remote access													
Market-driven access fees (GenoPHEnix legal entity + margin	-	-	-	-	26 202	108 575	140 703	169 533	199 647	226 712	255 051	291 216	318 628
Costs													
Preparatory Phase costs													
Personnel & travels	(374 916)	(1 464 042)	(1 491 042)	(1 479 375)	-	-	-	-	-	-	-	-	-
Others	-	(8 000)	(1 000)	(1 000)	-	-	-	-	-	-	-	-	-
Implementation Phase costs													
Buildings	(425 000)	(8 328 145)	(8 153 145)	(4 308 180)	(1 099 910)	(1 015 000)	-	-	-	-	-	-	-
Equipment	(262 000)	(1 876 703)	(3 214 703)	(1 150 000)	(2 301 935)	(1 381 935)	(130 000)	(631 702)	-	-	-	-	-
Personnel & travel costs, others	-	(300 000)	(300 000)	(26 000)	(1 681 037)	(1 661 037)	-	-	-	-	-	-	-
Operational Phase costs													
Costs of resources	-	-	(1 376 228)	(2 423 360)	(2 911 297)	(4 703 684)	(4 866 698)	(4 905 004)	(4 932 850)	(4 932 850)	(4 932 850)	(5 133 054)	(5 141 902)
Other access costs	-	-	-	-	-	(730 067)	(851 694)	(851 694)	(851 694)	(851 694)	(851 694)	(851 694)	(851 694)
Reinvestments and upgrade	-	-	-	-	-	-	-	-	-	-	(8 569 589)	-	-
Termination Phase costs													
Decommissioning costs	-	-	-	-	-	-	-	-	-	-	-	-	-
GenoPHEnix legal entity costs													
Legal entity costs	-	-	-	-	-	(834 029)	(845 029)	(845 029)	(859 029)	(845 029)	(845 029)	(859 029)	(845 029)
Remains to be funded	**(1 061 916)**	**(11 976 890)**	**(14 536 118)**	**(9 387 915)**	**(7 965 978)**	**(10 214 878)**	**(6 550 073)**	**(7 060 854)**	**(6 440 428)**	**(6 398 838)**	**(14 939 686)**	**(6 547 694)**	**(6 514 643)**
Resources													
Preparatory Phase resources													
European competitive grant	187 119	731 240	744 766	736 876	-	-	-	-	-	-	-	-	-
In-kind contribution	102 125	408 500	408 500	408 500	-	-	-	-	-	-	-	-	-
In-kind contribution ORnational funds	82 484	317 238	323 713	319 936	-	-	-	-	-	-	-	-	-
Non-competitive national grant	3 189	15 064	15 064	15 064	-	-	-	-	-	-	-	-	-
Foundation grant	-	-	-	-	-	-	-	-	-	-	-	-	-
Implementation Phase resources													
Foundation grant	-	-	-	-	656 250	656 250	-	-	-	-	-	-	-
Combination of ERDF and national funds	262 000	9 779 848	10 217 848	4 964 180	3 061 778	2 056 868	130 000	381 702	-	-	-	-	-
Non-competitive national grant	-	-	1 150 000	520 000	269 177	249 177	-	250 000	-	-	-	-	-
In-kind contribution ORnational funds	-	300 000	300 000	-	71 100	71 100	-	-	-	-	-	-	-
In-kind contribution	425 000	425 000	-	-	1 024 577	1 024 577	-	-	-	-	-	-	-
Operational Phase resources													
In-kind contribution	-	-	-	-	-	-	-	-	-	-	-	-	-
European competitive grant	-	-	1 376 228	2 423 360	2 823 958	-	-	-	-	-	-	-	-
Non-competitive national grant	-	-	-	-	-	4 515 537	4 623 363	4 610 703	4 587 550	4 538 222	4 963 893	4 619 749	4 576 293
Revenues reinvested	-	-	-	-	87 339	217 350	285 920	345 402	404 918	462 764	520 609	598 475	659 296
In-kind contribution ORnational funds	-	-	-	-	-	700 865	809 109	800 593	792 076	783 559	775 042	766 525	758 008
Combination of ERDF and national funds	-	-	-	-	-	-	-	-	-	-	8 094 589	-	-
Termination Phase resources													
Non-competitive national grant	-	-	-	-	-	-	-	-	-	-	-	-	-
GenoPHEnix legal entity resources													
Member/shareholder contribution	-	-	-	-	-	770 307	698 634	666 161	650 934	606 364	578 774	564 033	513 425
In-kind contribution	-	-	-	-	-	35 520	35 520	35 520	35 520	35 520	35 520	35 520	35 520
Balance	**(0)**	**0**	**0**	**0**	**28 202**	**82 673**	**32 473**	**29 227**	**30 570**	**27 590**	**28 741**	**36 608**	**27 898**
Cash position (at start of the period)	-	(0)	0	0	0	28 202	110 875	143 348	172 575	203 145	230 735	259 476	296 084
Deposit/ Drawdown	(0)	0	0	0	28 202	82 673	32 473	29 227	30 570	27 590	28 741	36 608	27 898
Cash position (at end of the period)	(0)	0	0	0	28 202	110 875	143 348	172 575	203 145	230 735	259 476	296 084	323 982

Fig. 23 planning and estimation on financial sustainability of GenoPHEnix

12. Stakeholder engagement strategy



[8]Fig 24 Mendelow's matrix on stakeholder engagement

High interest and high influence

- GenoPHEnix member institutions
- GenoPHEnix observer
- Member states and possible member states
- Researchers involved, as representatives of their instituts and possible service leader

Looking at the Mendelow's Matrix it becomes obvious, that GenoPHEnix will be shaped through the member states as founders of the RI and the institutions coordinating and designing research, service and access towards the resources. Within the governance structures and voting rights of members, the design of the workprogram and scientific innovation, inclusion of relevant experts and private

[8] https://media.licdn.com/dms/image/v2/D5612AQEWixL18MTyyQ/article-cover_image-shrink_720_1280/article-cover_image-shrink_720_1280/0/1698714122311?e=2147483647&v=beta&t=MUIRXiX-EfBMIB2Oh21Cx17nEzkVfU3pnNKS8XYnqFU

companies for technological development and possible collaboration towards research data integration responsibilities, influence and opportunities are large. Through a dedicated communication structure, information and a fluent workflow through all levels of research, coordination and service secures the governance and structures of the RI. Through clear feedback-mechanism towards the relevant political decision makers as funders of the RI, political relevance and support is ensured.

High interest and low influence

- ESFRI
- EC
- Contributors
- Private sector companies (depending on the status of their involvement within the innovation board)
- Farm animal health space

ESFRI as strategic European forum for research infrastructures needs to be informed of ongoing developments. Through their landscape analysis and other feedback mechanism, the positioning within the ESFRI RI landscape and within the European research space is secured and well developed along the ESFRI criteria. Users and contributors within the advisory boards need to be informed about latest developments and given the opportunities to participate and connect through relevant service- and TNA offers as well as stakeholder- and networking events. Their activities and relevant developments will contribute to RI developments and decisions.

Low interest and high influence

- Politicians
- Researcher
- Supporting scientific societies

Need be informed and engaged via relevant communication and networking events.

Low interest and low influence

- Farmers
- The general public
- NGOs

This point holds the lowest relevance at first glance and does not go beyond increasing visibility and brand implementation of the RI. But as a form of informed risk management and anticipated inclusion of different stakeholder opinions, especially with emphasis on ethically relevant topics around animal health, the 3R principles on reducing animal testing and refinement of methods and genome editing within farm animals, the involvement of those groups and a structured interview process (Q methodology [9]) may improve stakeholder management, support risk anticipation and create informed legal and political advice, that includes both – scientific facts and informed stakeholder perspectives.

Stakeholder groups of GenoPHEnix

Researcher

- take on different positions within the consortium (working in a member or observer institution), e.g. within the GonepHEnix governance, as RI user or as advisor in the advisory boards
- as members they participate actively trough boards, voting rights, workprogram design and as researcher within their area of expertise
- To deliberately engage them and secure the imimplementation of research and decision procedures, respective meetings will be held weekly or monthly

[9] *Stakeholder engagement in large-scale energy infrastructure projects: Revealing perspectives using Q methodology

Funder

- Under given circumstances political decision makers are founders of the RIs legal entity and the RI as such (the Member States have an interest to build the RI, given their own strategic priorities)
- Inclusion of national or regional programs to diversify funding frameworks

Government

- Within preparatory phase strategic implications are more developed along the lines of scientific excellence, data coordination, socioeconomic impact, environmental impact, implementation, governance, human resources, finance, risk analysis in more detail and therefore the establishment and execution of implemented structures, services and access can be driven forward
- With this, financial planning and strategy and the necessary funding investments and funding structures can be targeted
- Moving towards implementation, member states will be incorporated into planning and political and financial commitment will be strengthened through suitable and transparent information
- Funders and relevant political ministries will be informed about latest and relevant developments through the coordination structures (coordination hub, executive director, scientific advisory boards with dedicated members)

Contributors

- Institutions with observer status, observing member states, scientific societies or interested collaborative projects will be participating in the RIs activities in the context of agreements of the consortium agreement
- Events, networks and training and education offers and services secure relevant participation and flow of information

Society

- The larger society will be informed about ongoing developments through relevant channels, information will be prepared and shared to be understandable and secure the possibility of transparent information of relevant results
- Relevant results and insights about research methodologies, reduction of animal testing, big data and high scale solutions to transfer methods for breeding success into relevant populations, will be visible over the next 1 - 2 decades
- The duty of information lies within GenoPHEnix

Private companies

- Integration into innovation board, to secure relevant knowledge transfer and suitable input from experts in their field -> technological developments within infrastructure innovations
- Participation as RI-user through market-driven access -> integration of industry data under relevance of data security and IPR, develop suitable options through data encryption
- longterm public-private partnerships
- RI member EFFAB and technology platform FABRE TP integrate a significant share of farm animal breeding companies, active in Europe and worldwide
- Events secure visibility and share of information

13. Implementation, monitoring and risk assessment

13.1 IPI – Implementation performance indicators

The implementation criteria evolve along the lines of the ESFRI minimal key criteria for the different stages of the roadmap process, which is designed with a specific view point of the policy cycle. It goes from setting the agenda for the concept development phase, to strategic outline in the design phase, priority setting in the preparatory phase and then implementing the policy mix and monitoring and evaluating the process during implementation and operational phase. Implementation might be streamlined with the use of defined impact pathways, referring to the different types of priorities and which areas are touched and influenced through the respective actions. For monitoring and management the effective use of key performance indicators can support the on-going management activities and shape the design activities that evolve during the implementation and operational phases.

ESFRI implementation performance indicators move along the lines of securing stakeholder commitment, building suitable structures within the long term sustainability planning, governance, management and human resources, finances and risks.

Stakeholder commitments needs to be secured through a strong member and user base of the RI, which takes into account the respective demand of its communities, grants access to the most suitable and excellent resources and connects multiple pan-European and global consortia. Through proof of scientific excellence, demand and relevance a strong political and in consequence also financial commitment can be secured.

Phase	IPI
Preparatory	- Number of Members and observers, bound by Consortium Agreement, - Letter of intent and support - Strategy for consortium extension
Implementation	- Inclusion in national roadmaps - Commitment of MS or AC through legally binding documents, depending on the legal form of the RI
Operation	- Budget plan for organisational units

Tab. 21 IPIs for stakeholder commitment over the GenoPHEnix lifecycle

Within **preparatory and planning parameters**, there are certain overlaps to all other defined criteria for infrastructure implementation and development within the roadmap process. Most of it evolves around strategic planning towards building and construction and a suitable financial plan to update and maintain equipment and resources.

Phase	IPI
Preparatory	- feasibility study finished - business case in place and updated - investment plan adapted
Implementation and operation	- annual workplan + planning for next 2 years - financial plan and funding framework update on annual

	basis, in accordance with the workprogram - investment plan for building and equipment with annual update - financial strategy to update remaining resources and equipment - services updated

Tab. 22 IPIs for preparatory and planning parameters over the GenoPHEnix lifecycle

Governance, management and human resources outlines the importance of adequate administrative, financial, legal and managerial staff and structures, necessary for providing the operation of the RI. Within the governance structure, the necessary expertise for the advisory boards needs to be included here.

Phase	IPI
Preparatory	- staffing plans installed - KPIs for implementation consolidated - Governance structure established - Staffing plans with clear responsibilities per institution established - Experts secured for advisory boards - Strategic outline for a HR policy - Gender balance and equality plan - (does education and training secure own staffing)
Implementation and operation	- legal entity established

	- KPIs for administration, finances, facilities and management - Staff recruited - Staffing plans along the lines of the workprogram - service leadership established per institution -

Tab. 23 IPIs on governance, management and human resources over the GenoPHEnix lifecycle

Regarding the respective **finances and funding structure**s the RI established already for the ESFRI application a cost-book with visible long term planning on investment and operational costs, access unit and respective costs (referring to resources and implemented services within the institutions), in-kind funding and funding through national and European grants for the different stages.

When the RI is implemented, the access revenues of market-driven access will create an income for the RI. Investment plans and upgrades on building and equipment are included within the long-term financial planning and therefore also in the annual work program and financial planning. The net cash flow and return on national capital will be monitored. Within the governance structure, a financial advisory committee secures the maturity of the financial concept and structured updates in congruency with the work program.

Phase	IPI
Preparatory	- Cost-book established and updated - Annual update on financial support of MS and AC - Funding opportunities identified for the whole RI life cycle - In-kind contributions visible

Implementation and operation	- Financial reporting structures fully established - Central budget on all access units, central hub and organisational units, in-kind contributions and operational costs - Projections on operational costs for five years - Annual update on long-term planning for budget and funding structures - Implementation for environmental strategy actions

Tab. 24 IPIs on finances and funding structures over the whole GenoPHEnix lifecycle

13.2 KPI – Key performance indicators

Enabling scientific excellence	
1. Number of user requests for access	**Relevance 4/5** An important KPI to set up internally to control for the demand intensity of services and the competitiveness of GenoPHEnix resources
2. Number of users served	**Relevance 5/5** This is the most important KPI, the one that testifies of the GenoPHEnix-RI success or failure.
3. Number of publications	**Relevance 4/5** The number of publications is important, however quality is at least as equally important.

4. Percentage of top (10%) cited publications	**Relevance 5/5** A critical KPI for GEnoPHEnix, an indicator of the quality of research carried out at GenoPHEnix.
Delivery of education and training	
5. Number of master and PhD students using the RI	**Relevance 3/5** GenoPHEnix has serious ambitions for training and education, so much so it has made training and education one of the four Service Centres. PhD students are central in this respect, even more so than Master-level students.
6. Training of people who are not RI staff	**Relevance 4/5** GenoPHEnix has serious ambitions for the training of personnel from the private sector.
Enhancing collaboration in Europe	
7. Number of members of the RI from ESFRI countries	**Relevance 2/5** With its access quota policy, this indicator may be less relevant than for other ESFRI landmarks or projects. The geographical origin of users is influenced heavily by the access quota policy.
8. Share of users and publications per ESFRI member country	**Relevance 2/5** The remark that applies to KPI #7 above applies also to KPI #8: the geographical origin of users is influenced by the access quota policy.
Facilitating economic activities	
9. Share of users associated with industry and publications with industry	**Relevance 5/5**

	GenoPHEnix has high ambitions with market-driven access (up to 14% of total access value)
10. Income from commercial activities and the number of entities paying for service	**Relevance 4/5** Same remark as KPI #10, but revenues are not the top priority when it comes to contractual research. What is important is the scientific interest and the respect of ethics.
Outreach to the public	
11. Engagement achieved by direct contact	**Relevance 2/5** GenoPHEnix communication will be directed mostly towards stakeholders such as potential users from the public and private sector. Communication towards the public at large will be focused on ethical concerns.
12. Outreach through media	**Relevance 3/5** As a future major actor of research in agriculture, food and indirectly health, GenoPHEnix may have to develop an expertise in communication on ethical concerns.
13. Outreach via the RI's own web and social media	**Relevance 2/5** Same remark as for KPI #11
Optimising data use	
14. Number of publicly available data sets used externally	**Relevance 5/5** GenoPHEnix ambitions to create the data portal of reference for farm and aquafarm animal genomics and phenotyping, for the benefit of relevant scientific and industrial communities.

Provision of scientific advice	
15. Participation by RIs in policy related activities	**Relevance 3/5** GenoPHEnix aims at becoming a central actor in the domains of farming and aquaculture, and this should translate by GenoPHEnix presence in major fora where agricultural and research policy issues are debated, and policymaking is done.
16. Citations in policy related publications	**Relevance 2/5** GenoPHEnix contemplates the possibility to extend its scientific scope to agricultural policymaking, legal and economic dimensions of farming and aquaculture, but has chosen so far to keep those aspects out of the RI.
Facilitating international cooperation	
17. Share of users and publications per non-ESFRI member country	**Relevance 2/5** The remark that applies to KPI #7 and #8 above applies also to KPI #17: the geographical origin of users is influenced by the access quota policy and plays against non-GenoPHEnix legal entity Member or shareholders.
18. International trainees	**Relevance 2/5** GenoPHEnix-RI does not plan to discriminate PhD students or Master students based on their origin, in compliance with the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers

19. Number of members of the RI from non-ESFRI countries	**Relevance 1/5** In the scientific communities involved, the European or extra-European origin of partner institutions is of little relevance.
Optimising management	
20. Extent of resources made available	**Relevance 5/5** This is a strong point for GenoPHEnix: the commitment of GenoPHEnix partners to provide resources to GenoPHEnix users is very high. Constant fine-tuning will be required to tradeoff between resources that partners wish to make available and the anticipated demand met by the RI.
21. Revenues	**Relevance 3/5** Although GenoPHEnix has high ambitions for contractual research with the private sector (market-driven access up to 14% of access value), laws on state aid for research, development and innovation require that GenoPHEnix does not exceed a threshold of 20% annual revenues/total annual cost of operations. Achieving the maximum allowed would be considered a noticeable achievement.

Tab. 25 Key performance indicators for GenoPHEnix RI

Risk management

Risk management and risk mitigation strategies are an inherently important step towards a secure and structured RI implementation and monitoring throughout its operation.

Within the concept development 37 risks were identified and scored, based on a method adapted from PMI – the guide to the project management body of knowledge[10]. It scores the interplay of impact (measured in cost/time/scope/output) and probability (% of occurance) within a scale of very low (1) up to very high (5). The risk management plan involved all stages of the ESFRI lifecycle planning for the categories organisation, legal, financial, HR, schedule, performance, technical and general.

Organisation

Risks might arise in the context partner collaboration, insufficient planning of service provision and scientific performance, withdrawal of a partner institution that would impact the scientific expertise and service provision towards the different scientific communities and stakeholders. Risk mitigation needs a structured form of collaboration and political support, that secures within a contractual form the engagement and scope of partners and clear strategies and legal advice, if problems arise. The GenoPHEnix consortium collaboration of members and observers is based in the consortium agreement, entering into force October 8th, 2024 until the transition into a legal entity or the termination of the RI. A well structured governance with organisational and scientific hubs and a clear scientific program secures the commitment and performance of member institutions and is a suitable foundation for consortium extension and integration of scientific expertise within the development of the science and innovation program.

Legal

Legal implications and potential risks evolve around the suitable and timely implementation of contractual agreements. With the current consortium agreement the role of members and observer institutions as well as a suitable governance structure is established, so the risk can be defined as low in probability. The risk of failure in transferring this form of cooperation into a legal entity while establishing

[10]PMBOK-guide . The guide to the project management body of knowledge, Project management institute inc., Pennsylvania, 2013, a-guide.pdf

the RI as fully implemented infrastructure on the ESFRI roadmap would be high in impact. Timely regulation need to be taken into account. To abide local regulations, especially with respect to farm animal testing and other regulations on animal housing the ethical advisory board will be installed.

Financial

For infrastructure planning the ESFRI lifecycle approach provides a clear guideline on funding schemes and necessary resources. Regarding possible investments for building and construction medium to high risks arise if costs were underestimated or, due to the long term planning, costs increase significantly. Within the context of RI establishment a clear science and innovation program, a strong network and well established coordination and partner institutions can attract funding and long-term funding commitments and guarantees. GenoPHEnix partner institutions are experienced and well equipped to attract international grants, national grants and institutional funds. Failure to attract these would be high in impact. Another risk might arise if GenoPHEnix fails to attract revenues from industry partners.

HR

RI activities require oftentimes a specific set of skills for scientific and implementation activities. Through structured planning necessary staff for central hub and partner institutions is included and financially secured. Necessary staff descriptions and responsibilities are established. Should GenoPHEnix fail to attract necessary personnel the risk would be high in impact. Since GenopHEnix institutions are providing extensive training and education opportunities, scientific expertise can also be secured through own activities. This is the foundation for scientific expertise within the GenoPHEnix scope and beyond. Since the ERA goals foresee a free circulation of scientists as a necessary advantage for scientific excellence, GenoPHEnix provides valuable resources to the whole ESFRI health and food cluster.

Schedule

Failure in schedule might impact necessary cooperation or timely provision of services, if necessary resources could not be installed, upgraded or adapted. Since most of the GenoPHEnix services and necessary structures towards high quality research are already implemented within the institutions, the probability of this risk occurring seems low. If, however, incongruencies in scheduled planning might hinder the necessary research, service or training activities GenoPHEnix output as measured and monitored through the key performance indicators might be impacted negatively.

Performance

GenoPHenix performance is measured through a large variety of key performance indicators, referring to scientific excellence and output, data and data repositories, training and education and service provisions.
Failure in the attraction of doctoral students and scientists of different career stages, user of the scientific communities and users of industry partners.

13.3 Risk assessment

DP = Design phase, PP = Preparatory phase, IP = Implementation phase, OP = Operation phase, DP = Decommissioning phase

No.	Risk	Type	Project phase	Description	Mitigation strategy	Probability	Impact	Risk rating
1	Failure, bankruptcy or withdrawal of a partner hosting a facility	Exogenous	General	e.g. due to political circumstances	Development of a strong consortium agreement defining clearly the responsibilities for partners with exit possible only when tasks are taken over by other partners; Early discussions	Medium	Low If it's only one partner, the impact is low as we have 15 letters of intent from other organisations that	1.0

					and negotiations with institution higher managements and national ministries; vast coalition of partners with facilities able to assume responsibilities from a defaulting partner		apply to join GenoPHEnix	
2	Failure, bankruptcy or withdrawal of a partner	Exogenous	General	e.g. due to political circumstances	Development of a strong consortium agreement defining clearly the benefits for partners; Early discussions and negotiations with institution higher managements and national ministries	Medium	Low If it's only one partner, the impact is low as we have 15 letters of intent from other organisations that apply to join GenoPHEnix	1.0
3	Delays, difficulties in agreeing on distribution of the RI	Organisation	DP		Responsibilities of each partner towards the future RI are defined within the Matrix of Interests	Low	Medium	1.2
4	Delays, difficulties in agreeing with partners on integrated services	Organisation	DP		Responsibilities of each partner towards the future RI are defined within the Matrix of Interests	Low	Medium	1.2
5	Delays, difficulties in agreeing with partners on the breakdown of	Organisation	DP	Including for integrated services	Responsibilities of each partner towards the future RI are defined within the Matrix of Interests in the	Low	High	2.4

	responsibilities				Consortium Agreement			
6	Delays in establishing a legal body or Consortium Agreement	Legal	DP		A consortium agreement is in place until a legal entity is established, including decision procedures, dispute-solving mechanisms and intellectual property rights	Low	High	2.4
7	Failure to obtain funding for the implementation of the RI	Financial	IP		We have already 5 EoC. Partners have contacted the Managing Authorities responsible for ERDF Ops in their region to obtain financial commitments; GenoPHEnix on the national roadmap (2 countries) and candidate in 4 countries	Medium	High	4.0
8	Failure to obtain funding or sufficient guarantees for funding of the operational phase	Financial	OP		Setting up of a Resource Review Board (made of representatives from ministries/funding agencies) to deal with funding questions and firm up the financial model and plan during the Preparatory Phase; Partner responsibilities include the maintenance of their own facilities from national sources	Medium	High	4.0

9	Failure to acquire sufficient and qualified human resources	HR	PP/IP/ OP		As per the partnership evaluation, about XX% of all personnel needed is already on the job among partner staff; Recruitment of current GenoPHEnix partner staff within the future legal entity is possible; New positions will be advertised widely using also the close connections of GenoPHEnix partners and associated labs to university PhD programs	Low	High	2.4
10	Difficulties, planning & building documentation	Organisational / external	IP		Few new facilities foreseen hitherto; Existing facilities enable the RI to provide most services to users already	Low	Medium	1.2
11	Lack of coordination in the construction	Organisational	IP	Consequences are likely re-work or necessary scope / cost / schedule changes	No challenging construction planned hitherto; Existing facilities enable the RI to provide most services to users already	Low	Medium	1.2
12	Failure to timely complete constructions	Schedule	IP	Possibly due to inaccurate estimation of the schedule / communication or coordination issues	No challenging construction planned hitherto; Existing facilities enable the RI to provide most services to users already;	Low	Medium	1.2

				between partners	Inclusion of contingencies in costs and schedule, as authorised by ERDF programmes			
13	Increase in the cost of construction (or underestimation of costs)	Financial	IP		Inclusion of contingencies in costs, as authorised by the ERDF programmes	Medium	Medium	2.0
14	Failure to timely procure equipment	Schedule	IP	Possibly due to delays from external suppliers, due to underestimation of time requirements for procurement (e.g. through publicly funded procurement processes), due to failure of supply chain due to economic conditions / limited suppliers, due to flaws in procured equipment and need for re-procurement	Long expertise of the many partners in handling procurement; Existing facilities and equipment enable the RI to provide most services to users already	Low	Medium	1.2
15	Failure to timely install equipment	Schedule	IP		Existing facilities and equipment enable the RI to provide most services to users already;	Medium	Medium	2.0

					Inclusion of time contingencies in the project schedule			
16	Increase in the cost of equipment (or underestimation of costs)	Financial	IP		Existing facilities and equipment enable the RI to provide most services to users already Inclusion of contingencies in costs, as authorised by the ERDF programmes	High	Medium	4.0
17	Failure to apply funding programme rules	Legal	IP		Most partners are experienced with EU, national and regional funding programmes, with many institutions having dedicated funding offices to support projects in complying with funding programme responsibilities and requirements	Low	Medium	1.2
18	Need for changes / rework of RI responsibilities	Organisational	PP/IP/OP	Possibly due to political changes	The Scientific and Innovation Agenda provides the common vision for the scientific direction of the RI; The Matrix of Interests that is part of the signed Consortium Agreement provides for the conditions under which partners may transfer responsibilities	Medium	Medium	2.0

19	Failure to deliver services during RI operation	Performanc e	OP		The partnership already provides most of the services through 3 projects with a TNA component (SmartCow, PigWeb, AquaExcel) and the FAANG data portal	Very low	Very high	1.6
20	Failure/Delay in establishing a legal entity to manage the RI	Legal	OP	e.g. political changes	Firming up the choice of a legal entity, and drafting the statutes of the legal entity will be a priority task of the Preparatory Phase	Low	Very high	4.8
21	Failure to abide by local regulations	Legal	OP		Partners are advised by their respective experienced legal departments in order to comply to local regulations. An Ethical Advisory Board will be set up in the framework of the Consortium Agreement to supervise and advise the General Assembly of the GenoPHEnix Consortium on ethical issues;	Low	Medium	1.2
22	Failure to attract students	Performanc e	OP		Partners currently do not meet with difficulties in recruiting students or junior researchers; Positions will be advertised	Low	Medium	1.2

					widely, using also the close connections of GenoPHEnix partners and associated labs to university PhD programs			
23	Insufficient user base or failure to attract users (Researchers)	Performanc e	OP		The partners that today set up the GenoPHEnix Consortium have provided services to users for more than 10 years; Track record shows that demand is on the rise (see Demand Analysis)	Low	High	2.4
24	Insufficient user base or failure to attract users (Industry)	Performanc e	OP		As a scientific community, the farm and aquafarm genomics and phenomics scientific community is not earmarked by the same divide with the industry sector that other scientific communities may experience; The partners that today set up the GenoPHEnix Consortium have provided services to users, including users from the private sector, for more than 10 years; The Open Innovation Forum, a body within the GenoPHEnix Consortium	Low	High	2.4

					governance, is tasked to communicate to businesses on opportunities offered by GenoPHEnix; The GenoPHEnix Consortium includes businesses and some of their interprofessional representatives			
25	Failure to attract revenues	Financial	OP		Partners finance the maintenance and operation of their facilities; Users will be requested to pay for access; Data services are a strong component of the GenoPHEnix service range, those services will be offered against a fee to business users; Transnational access funds will be applied for by GenoPHEnix; GenoPHEnix will engage more intensively in collaborative and contractual research with the private sector; GenoPHEnix will provide training to professionals against the payment of fees	Medium	High	4.0
26	Failure to attract European or international grants	Financial	OP	During operation phase	Setup of a funding office at the GenoPHEnix central hub with close connections	Medium	Medium	2.0

					to the funding offices of GenoPHEnix partner and host institutions			
27	Failure to attract national grants	Financial	OP	During operation phase	As facilities will remain the property of national institutes/universities, ministries and funding agencies will keep on financing the operation and maintenance of facilities used by GenoPHEnix	Low	Medium	1.2
28	Failure to attract institutional funds	Financial	OP	During operation phase	As facilities will remain the property of national institutes/universities, ministries and funding agencies will keep on financing the operation and maintenance of facilities used by GenoPHEnix	Low	High	2.4
29	Failure in the provision of expected in-kind contributions from partner institutions / members of the consortium	Organisational / financial	OP	e.g. political changes	Cash and in-kind provisions will be defined in the funding model and 5-year plan; The complete funding model and plan for the next 5 years of the GenoPHEnix-RI (including legal entity) will be firmed up and agreed on by the Resource Review Board in the Preparatory Phase; The modalities under which the	Low	High	2.4

					next 5-year plan will be developed will be defined in the Preparatory Phase			
30	Failure to deliver socio-economic impact at local / national level	Performance	OP		The socio-economic impact of the RI is highly dependent on (1) savings from the more intensive use of existing resources; and (2) outcomes of research carried out at GenoPHEnix; The Access Policy principles adopted by the GenoPHEnix Consortium are designed to guarantee the maximum impact of research carried out at GenoPHEnix; Early and continuous engagement with private users through the Open Innovation Forum	Medium	Medium	2.0
31	Increase of operational costs (or underestimation of operational costs)	Financial	OP		Long experience of operating facilities accessible through GenoPHEnix; Estimates based on precise financial data series	Medium	Medium	2.0
32	Increase in the cost of decommissioning the RI	Financial	DP		No planned facility to be owned by GenoPHEnix; Decommissioning of facilities	Very Low	Very Low	0.1

					remain the responsibility of each partner (not GenoPHEnix's);			
33	Difficulties, delays to treat hazardous materials	Technical	DP		Decommissioning of facilities remain the responsibility of each partner (not GenoPHEnix's);	Very Low	Very Low	0.1
Other risks (relevant to GenoPHEnix)								
34	Reinforcement of legal restrictions or even interdiction of in vivo animal experimentation in several EU countries	Legal	OP	e.g. Political changes	Early and intensive implementation of 3Rs principles; development of alternatives to in vivo animal experimentation, trough in vitro techniques, mathematical modelling, AI	High	Medium	4.0
35	Increased societal concern on environmental impact of livestock and pressure to decrease livestock production	Ethical	OP	e.g. Political changes	Enable research that provides solutions to decrease environmental impact of livestock production (decreased GHG emissions; increased feed efficiency) and promote sustainable production	High	Medium	4.0
36	Increased societal pressure against genome editing even under severe laboratory-controlled conditions	Ethical	OP	e.g. Political changes	Coordinated identification and biobanking of naturally variable genetic lines, that will be available as alternatives	Medium	Medium	2.0
37	Epidemic and diseases leading to	Technical	OP		Coordinated identification and biobanking of	Medium	High	4.0

	temporary shutdown of experimental facilities				genetic lines to enable prompt restart. Network of local coordinators to offer an alternative combination of services thanks to the wide possibilities offered in GenoPHEnix			

Tab. 26 list of risks, evaluation and mitigation strategies