

ELIXIR

Biodiversity, Food Security and Pathogens - Strategy





About this document

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Abbreviations

AgroServ	Integrated SERVICES supporting a sustainable AGROecological transition
AI	Artificial Intelligence
AnaEE	Analysis and Experimentation on Ecosystems ERIC
API	Application Programming Interface
BFSP	Biodiversity, Food Security, and Pathogens
BGE	Biodiversity Genomics Europe
BHL	Biodiversity Heritage Library
BiCIKL	Biodiversity Community Integrated Knowledge Library
BMD	Biodiversity Meets Data
CGIAR	Consortium of International Agricultural Research Centers
CMR	Cellular & Molecular Research
COL	Catalogue of Life
DiSSCo	Distributed System of Scientific Collections
EBP	Earth BioGenome Project
EMBRIC	European Marine Biological Research Infrastructure Cluster
EMPHASIS	European Infrastructure for Plant Phenotyping
ENVRIplus	Environmental and Earth System Research Infrastructures
ERIC	European Research Infrastructure Consortium
EVORA	European Viral Outbreak Research Alliance
ESFRI	European Strategy Forum on Research Infrastructures
FAANG	Functional Annotation of Animal Genomes
FAIR	Findability, Accessibility, Interoperability, and Reusability
FAIDARE	FAIR Data-finder for Agronomic REsearch
GBIF	Global Biodiversity Information Facility
GSC	Genomic Sequence Consortium
GTN	Galaxy Training Network
HDTR	Human Data & Translational Research
iBOL	International Barcode of Life
MIAPPE	Minimum Information About Plant Phenotyping Experiments
MIRRI	Microbial Resource Research Infrastructure
PHENET	PHENotyping and EnviroTyping services of European Research Infrastructures
RDM	Research Data Management
RI	Research Infrastructure
SDP	Service Delivery Plan
SWOT	Strengths, Weaknesses, Opportunities, Threats
TDWG	Taxonomic Databases Working Group (Biodiversity Information Standards)
TeSS	Training eSupport System



Summary

This document describes ELIXIR's Strategy for developing the Biodiversity, Food Security and Pathogens (BFSP) Priority Area within the Science Tier of the ELIXIR 2024-28 Programme. It has been developed by the BFSP Priority Area co-leads, with support from the ELIXIR Hub, and with input and feedback from ELIXIR members across Nodes, Communities, Focus Groups, and Platforms. The Strategy outlines relevant background information on the importance of BFSP-related research in overcoming societal challenges with a focus on life science data mobilisation and integration activities. Key challenges are summarised, including data brokering services, data interoperability solutions, and analysis tools and services for data exploitation. The Strategy also sets out the scope of BFSP-related activities considering ELIXIR's role as a Research Infrastructure (RI) for life sciences data and highlights existing and future opportunities in the context of complementary and interconnected national, regional, and global activities and other RIs. The overarching aims of the BFSP Priority Area are described by defining a vision and mission, addressing the key challenges and contributing to safeguarding planetary health and human wellbeing. The guiding goals are elaborated through objectives centred on federation, FAIR data, analysis, standards, and training, designed to build on ELIXIR's existing activities and expertise supporting a distributed infrastructure for biological data. Finally, the Strategy summarises the practical implementation of the work plan designed to deliver advances towards sustainable growth in the BFSP domain.

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Introduction

Background

The research areas of biodiversity, food security, and pathogens are critical for a One Health approach to humanity's wellbeing, and their management poses societal challenges that Europe must address over the next decade and beyond. Knowledge-based decisions are strongly enabled by the application, and integration, of high-throughput molecular biology and 'omics' sciences with phenotyping, environmental monitoring, and other data-intense disciplines. The importance of these scientific areas in contributing to overcoming societal challenges is also widely recognised by major transnational and national funding bodies and is reflected in their research strategies. One of the two newly established Priority Areas of the ELIXIR 2024-28 Programme¹ Science Tier aims at enabling scientists to access and analyse life science data through mobilisation and integration activities that support research programmes in biodiversity, food security, including agroecology and agrobiodiversity, and pathogens - applying ELIXIR's operational model that has successfully been used to coordinate human data. This Priority Area is referred to as "**Biodiversity, Food Security, and Pathogens (BFSP)**".

Research on BFSP-related topics is often linked with interrelated societal challenges for Europe and the rest of the world, with direct and indirect contributions to supporting the United Nations Sustainable Development Goals². Indeed, BFSP disciplines are linked and can impact each other. For instance, an intuitively relatable paradigm sees biodiversity disruption and decline impacting ecosystems including agroecosystems, hence affecting food production and quality and even provoking the emergence and spreading of new pathogens that impact human, crop, or livestock health. Any potential solutions to grand challenges in these interconnected domains will be complex, multidisciplinary, and long-term. Advances in all three areas are strongly enabled by genetics and omics technologies integrated with complementary observation data (e.g. environment, ecosystems, and phenotyping) and supported by associated bioinformatics services. By taking a coordinated and aligned approach across the bioinformatics needs of BSFP-related research activities, ELIXIR can drive the data-related component of the required solutions by establishing collections of tools, pipelines, services, and biodata resources, which are openly available, widely applicable, and that complement and enhance each other.

¹ <https://elixir-europe.org/sites/default/files/documents/elixir-programme-24-28-full.pdf>

² <https://sdgs.un.org/goals>

In this ambition, compared to the Human Data and Translational Research domain, ELIXIR is at a relatively early phase of work in the BFSP Priority Area. The Strategy nevertheless has been supported by managed growth over several years of a variety of activities through relevant ELIXIR Communities (*e.g.* Plant Sciences³, Biodiversity⁴, and Microbiome⁵) and Focus Groups (*e.g.* Domestic Animals Genome and Phenome⁶, and Pathogen Data⁷). This coincides with a rapid increase in the production of non-human data (genomics, phenomics, observations, *etc.*) worldwide, which is also reflected by the growing interest in these fields across the ELIXIR scientific community. In terms of coordination across these areas, much has already been achieved in the past few years both technically and organisationally, often driven by ELIXIR's involvement in multiple European Commission funded H2020 and Horizon Europe projects: *e.g.* the European Marine Biological Research Infrastructure Cluster (EMBRIC⁸), the Environmental and Earth System Research Infrastructures (ENVRIplus⁹), Integrated SERVICES supporting a sustainable AGROecological transition (AgroServ¹⁰), tools and methods for extended plant PHENotyping and EnviroTyping services of European Research Infrastructures (PHENET¹¹), the Biodiversity Community Integrated Knowledge Library (BiCIKL¹²), the Biodiversity Genomics Europe (BGE¹³) project, the European Viral Outbreak Research Alliance (EVORA¹⁴), the MICROBES-4-CLIMATE¹⁵ project, the upcoming Agriculture of Data partnership¹⁶ and Biodiversity Meets Data (BMD¹⁷) project, as well as ELIXIR projects such as ELIXIR-EXCELERATE¹⁸, ELIXIR-CONVERGE¹⁹, and ELIXIR-STEERS²⁰.

In these endeavours, ELIXIR is certainly not alone in the Research Infrastructure (RI) landscape, as reflected by the composition of project consortia and by the membership of European and global infrastructures. ELIXIR partners in such consortia primarily with data management and

³ <https://elixir-europe.org/communities/plant-sciences>

⁴ <https://elixir-europe.org/communities/biodiversity>

⁵ <https://elixir-europe.org/communities/microbiome>

⁶ <https://elixir-europe.org/focus-groups/domestic-animals-genome-phenome>

⁷ <https://elixir-europe.org/focus-groups/pathogen-data>

⁸ <https://www.embric.eu/collaborative-projects/embric-european-marine-biological-research-infrastructure-cluster>

⁹ <https://www.envriplus.eu/>

¹⁰ <https://agroserv.eu/>

¹¹ <https://www.phenet.eu/>

¹² <https://bicikl-project.eu/>

¹³ <https://biodiversitygenomics.eu/>

¹⁴ <https://evora-project.eu/>

¹⁵ <https://microbes4climate.eu/>

¹⁶ <https://errin.eu/calls/european-partnership-agriculture-data>

¹⁷ <https://www.bmd-project.eu/>

¹⁸ <https://elixir-europe.org/about-us/how-funded/eu-projects/excelerate>

¹⁹ <https://elixir-europe.org/about-us/how-funded/eu-projects/converge>

²⁰ <https://elixir-europe.org/about-us/how-funded/eu-projects/steers>



analysis roles, and through these projects and networking activities ELIXIR is building strong connections with many other infrastructures active in these domains e.g., the Distributed System of Scientific Collections (DiSSCo²¹), the Global Biodiversity Information Facility (GBIF²²), the e-Science European infrastructure for biodiversity and ecosystem research (LifeWatch ERIC²³), the Catalogue of Life (COL²⁴), the European Infrastructure for Plant Phenotyping (EMPHASIS²⁵), the Analysis and Experimentation on Ecosystems ERIC (AnaEE²⁶), and the Microbial Resource Research Infrastructure (MIRRI²⁷). In this landscape, ELIXIR stands as a hub for genetics and omics sciences, data integration and management, and bioinformatics tools and services at national and international levels across many scientific disciplines. Therefore, ELIXIR is well-placed to take part in leading organisational alignments and fostering collaborations between omics-focused partners across Europe, alongside a growing array of organisations involved in BFSP-related research and resources. Importantly, this extends beyond the production/collection of data, as research data management, FAIRification (Findability, Accessibility, Interoperability, and Reusability) of digital research objects, as well as interoperable analysis tools and services, championed by ELIXIR's Services²⁸ and Platforms²⁹, and recognised as Core Data Resources³⁰ or Recommended Interoperability Resources³¹, are increasingly recognised as essential components supporting effective life sciences research. These alignments and collaborations are essential to enhance the efficiency of investments, both for researchers and for funding instruments at national, regional, or global levels.

The BFSP Priority Area has the potential to encompass a wide range of activities where genomics and other omics sciences are connecting BFSP research. It will therefore support the study of biology at the organism, population, and community scales, in synergy with cellular and molecular aspects at finer resolutions, to help characterise and mitigate the impact of a changing climate on our environment, livelihoods, and ultimately health. In this context, ELIXIR's approach to open accessible research data and software plays a key role in making a difference in these domains, in partnership with other initiatives and RIs. In the ELIXIR 2024-28 Programme, the

²¹ <https://www.dissco.eu/>

²² <https://www.gbif.org/>

²³ <https://www.lifewatch.eu/>

²⁴ <https://www.catalogueoflife.org/>

²⁵ <https://emphasis.plant-phenotyping.eu/>

²⁶ <https://www.anaee.eu/>

²⁷ <https://www.mirri.org/>

²⁸ <https://elixir-europe.org/services>

²⁹ <https://elixir-europe.org/platforms>

³⁰ <https://elixir-europe.org/platforms/data/core-data-resources>

³¹ <https://elixir-europe.org/platforms/interoperability/rirs>



BFSP Priority Area therefore aims to support projects and technologies that are making a difference in overcoming the interconnected challenges in the domains of BFSP research.

Scope

The BFSP Priority Area aims to mobilise and integrate data from genetics, phenomics, observations, and other omics sciences to support research programmes integrated into the One Health approach to studying biodiversity, food security (including agriculture and aquaculture), and non-human pathogens (e.g. phyto- or zoopathogenic microbes). While acknowledging a continuum of potential domain-related activities, the scope of BFSP-focused actions remains distinct from the ELIXIR Priority Areas of *Cellular & Molecular Research (CMR)* and *Human Data & Translational Research (HDTR)*. BFSP therefore encompasses biology at the organism or population/community scale, including their genetic/genomic characterisation, the environmental context, and their observable characteristics/traits and phenotypes.

To maintain these distinctions, domains of activity considered beyond the scope of the BFSP Priority Area broadly include those that are deemed primarily as “fundamental research”, e.g. molecular and cellular laboratory research with well-studied model organisms. Similarly, activities deemed as “human research”, e.g. studies primarily involving human or human health-associated data, such as microbiome or virome data, are considered beyond the scope of the BFSP Priority Area. In this particular distinction, it is acknowledged that there is a spectrum of activities spanning from certainly human-related to clearly non-human-related data, with the potential for ambiguity in the middle. Here, the priorities of the BFSP Priority Area are focused on activities not already covered by existing programmes. An additional key distinction with respect to scope is the emphasis on food security, *i.e.* ensuring access to sustainable food resources, over food safety, *i.e.* ensuring contamination-free food to safeguard consumer health. Finally, activities dedicated to data production are also considered beyond the scope of the BFSP Priority Area, a distinction that takes into account ELIXIR’s mandate as an RI for life sciences data and ELIXIR’s expertise in data management, integration, and analysis.

Challenges

The BFSP Priority Area aims to support the development of data-centred solutions to overcome key challenges facing researchers and research infrastructures in their efforts to protect and restore biodiversity, ensure food security, and combat pathogens. This is set in the context of fundamental global challenges, additionally driven by climate change, that require integrated responses: (1) **Biodiversity Loss** - How to monitor, protect, and restore biodiversity and ecosystem services? (2) **Threats to Food Security** - How to protect and diversify the world's food sources? And (3) **Emerging Pathogens** - How to monitor and respond to new and re-emerging threats, with potentially devastating consequences for (agro)ecosystems that impact human wellbeing? Common overarching technical challenges include the three broad topic areas summarised here, where data science solutions are needed to advance BSFP-related research activities:

- ★ **Lack of brokering services inhibits data mobilisation.** While some producers of BFSP-related data have clear routes to publish their datasets in open repositories, in many cases the process of data mobilisation is hindered by a lack of support in the form of informatics tools, pipelines, and services that facilitate brokering of raw and processed data together with their rich metadata into accessible repositories. These include but are not limited to data outputs from ecosystem monitoring efforts to research characterising species and their interactions. A common challenge lies in working closely with data producers to co-develop mechanisms that facilitate the capturing of key information during data production. These then need auto-validating brokering solutions to accompany the raw or processed data into deposition databases with all relevant minimum information standards being fulfilled.
- ★ **Incomplete or missing connectivity limits data interoperability.** While data of similar types or origins may be linked across different research community repositories, resource interoperability is often limited by a lack of technical solutions and common standards required to fully connect more disparate data types amongst currently siloed reference repositories, which limits data findability and co-analysis. Relevant examples could include highly specialised - but therefore hard to connect/align - organismal trait or phenotype data repositories for different taxonomic groups, livestock and crops, or pathogens. A common challenge is the harmonisation of heterogeneous metadata standards to allow for better

data reuse, analysis, and integration across platforms. This requires a focus on interoperability solutions, following the FAIR data principles, working with deposition databases to enhance connectivity and further integrate genetics, phenomics, observations, and other omics data, as well as associated metadata.

- ★ ***Lack of co-analysis tools and services impedes data exploitation.*** While the power of connected data may be realised in specific research outputs, methodologies for high-throughput and near-real-time co-analyses of existing and new data are often laborious to develop and are implemented in an *ad hoc* manner. The challenges facing data mobilisation and interoperability mean that reaching the levels of integration required to fully exploit disparate data types in complex analyses is often onerous. An important consideration, highly relevant for BFSP-related research activities, is the role of reference databases/resources that are needed to facilitate larger-scale and reproducible analyses exploiting the available data. A focus on technological solutions to facilitate integrative analysis, data mining, and visualisation tasks is needed to realise the power of connected data and take advantage of opportunities offered by Artificial Intelligence (AI), machine learning, computer vision, and other data-intense approaches.

Opportunities

The BFSP Priority Area benefits from several key strengths developed over the years within the relevant ELIXIR Communities and Focus Groups, as well as the Platforms and Services. ELIXIR's growing interest in the BFSP area is evident from the expansion of established communities with a long history in the field (e.g. the Plant Sciences Community) and the establishment of new Communities and Focus Groups that deal with today's challenges such as the massive generation and integration of genomics data (e.g. the Biodiversity Community, the Domestic Animals Genome and Phenome Focus Group, and the Pathogen Data Focus Group). It has therefore gathered a critical mass of scientists across Europe that act as bridges to relevant existing networks such as scientific communities, projects, and infrastructures at Node, national, and European levels. At the same time, the participation of ELIXIR Members in different BFSP-related Communities, such as Biodiversity, Systems Biology, Microbiome, and Plants Sciences enhances the inter-community collaboration enabling synergies with horizontal benefits across the wider BFSP umbrella towards common, cross-cutting goals.

As well as capitalising on these strengths from the networks of networks, the development of the BFSP Priority Area will benefit from the experience ELIXIR gained over the years across all fields including human-related research, which will be leveraged to provide data services, bridging the gap between data producers, data handlers, and data consumers. Several key services, databases, and tools to process and access relevant data have already been developed, including data portals (e.g. Functional Annotation of Animal Genomes - EuroFAANG³², and FAIR Data-finder for Agronomic REsearch - FAIDARE³³) and data standards (e.g. FAANG, Minimum Information About Plant Phenotyping Experiments - MIAPPE³⁴, and Breeding API - BrAPI³⁵). These types of expertise will help to facilitate the improved linking of different data types that are disconnected in terms of data production constraints, raw data analysis principles, or data repositories. An example is harmonising observation and molecular-based approaches, such as phenomics, genomics and pangenomics, to link genotype and phenotype in farmed animals and crops, the main aim of EuroFAANG RI and the EMPHASIS-ELIXIR collaboration³⁶, respectively. Another example of relevance to the BFSP Priority Area, is the ongoing work supporting the connection of molecular biodiversity data with environmental data, in collaboration with other relevant projects, initiatives, and RIs (e.g. DiSSCo, the Biodiversity Genomics Europe project, LifeWatch ERIC, and others). This environment is fostering new opportunities for ELIXIR to grow the portfolio of data science tools and services in the BFSP domain, with the activities of the Priority Area aiming to support and guide these developments. The wider BFSP umbrella research theme extends beyond current ELIXIR activities and Communities, offering ample opportunities for growth within the ELIXIR framework.

The strengths and opportunities outlined above are based on the ongoing activities and future ambitions of ELIXIR members across the network. These are necessarily embedded within a much larger and more complex landscape of BFSP-related initiatives, which are driven largely by complementary and interconnected national, regional, and global activities and RIs. Like ELIXIR, some of these RIs are part of the European Strategy Forum on Research Infrastructures (ESFRI³⁷), particularly in the Environment and Health & Food domains. In the ESFRI Landscape Analysis, ELIXIR is defined as an umbrella RI in the Health & Food domain that enables researchers to

³² <https://eurofaang.eu/>

³³ <https://urgi.versailles.inrae.fr/faidare/>

³⁴ <https://www.miappe.org/>

³⁵ <https://brapi.org/>

³⁶ <https://emphasis.plant-phenotyping.eu/european-infrastructure/collaboration-with-elixir>

³⁷ <https://www.esfri.eu/>

access and analyse life science data to improve their value and impact on public health, the environment, and the economy³⁸. While acknowledged for the cross-cutting contributions of bioinformatics services for the life sciences, ELIXIR is placed within the Health sub-domain of biological sciences and resources, despite ELIXIR activities already encompassing aspects of the Food sub-domain such as Food and Nutrition, Industrial Biotechnology, and Plant Phenotyping. The development of the BFSP Priority Area envisages enhanced interactions with other RIs on BFSP-related topics, where ELIXIR brings strengths in data science tools and services for research data management and analysis. In the Environment domain³⁹, ELIXIR is positioned within the Biosphere sub-domain, together with the Distributed System of Scientific Collections (DiSSCo⁴⁰), the Microbial Resource Research Infrastructure (MIRRI⁴¹), the European Marine Biological Resource Centre (EMBR⁴²), the e-Science European infrastructure for biodiversity and ecosystem research (LifeWatch ERIC⁴³), the European Infrastructure for Plant Phenotyping (EMPHASIS⁴⁴), the Analysis and Experimentation on Ecosystems ERIC (AnaEE⁴⁵), the European Long-Term Ecosystem Research Infrastructure (eLTER⁴⁶) and others. Further strengthening and expanding these existing collaborations and working towards strategic alignment amongst Life Science RIs is foreseen in the near future. In the Biosphere sub-domain, ELIXIR's contributions with respect to genetic and genomic data are highlighted, in particular regarding applications in biodiversity discovery, phylogenetics, and taxonomy, as well as integrated bioinformatics resources connected across domains. Here the development of the BFSP Priority Area envisages an extended portfolio of activities towards addressing challenges in research data management at organismal and ecosystem levels, in collaboration with other RIs operating in the Environment domain.

Beyond the ESFRI framework, the BFSP Priority Area seeks to build and strengthen partnerships with relevant organisations and infrastructures by identifying and developing synergies leveraging ELIXIR's strengths in genetics and omics sciences, data integration and management, and bioinformatics tools and services across scientific disciplines. These include cross-cutting

³⁸ <https://landscape2024.esfri.eu/landscape-analysis/thematic-areas/health-food/current-status-in-the-domain/>

³⁹ <https://landscape2024.esfri.eu/landscape-analysis/thematic-areas/environment/current-status-in-the-domain/>

⁴⁰ <https://www.dissco.eu/>

⁴¹ <https://www.mirri.org/>

⁴² <https://www.embrc.eu/>

⁴³ <https://www.lifewatch.eu/>

⁴⁴ <https://emphasis.plant-phenotyping.eu/>

⁴⁵ <https://www.anaee.eu/>

⁴⁶ <https://elter-ri.eu/>

data and standards initiatives relevant to the BFSP goals and mission such as the work of the Genomic Sequence Consortium (GSC⁴⁷) and the BioFAIR⁴⁸ data commons infrastructure for biological and biomedical sciences, as well as initiatives with more specifically BFSP-related objectives. Recognising the complexity of the biodiversity informatics landscape⁴⁹, this includes collaborating on key joint initiatives with major contributors such as the Global Biodiversity Information Facility (GBIF⁵⁰), the Catalogue of Life (COL⁵¹), the Biodiversity Heritage Library (BHL⁵²), the Biodiversity Information Standards organisation (TDWG⁵³), the International Barcode of Life (iBOL⁵⁴), the Earth BioGenome Project (EBP⁵⁵), and others, where ELIXIR can support efforts to connect genomics data with knowledge and information from collections, observations, literature, and taxonomy. This similarly applies to the agricultural-related food security landscape, with opportunities to develop collaborations with key initiatives such as the AgBioData⁵⁶ consortium of agricultural biological databases, the Consortium of International Agricultural Research Centers (CGIAR⁵⁷), the Breeding API (BrAPI⁵⁸) community enabling interoperability among plant breeding databases, and the Food and Agriculture Organization's Agro-informatics Platform⁵⁹. Informatics solutions and interoperability standards also play an important role in the non-human pathogens data landscape, which often involves close links with food security initiatives, such as in the work of the intergovernmental World Organisation for Animal Health (WOAH⁶⁰) and its information system for reporting terrestrial and aquatic animal diseases, or the standard setting body for plant health the International Plant Protection Convention (IPPC⁶¹), as well as increasingly with biodiversity initiatives such as wildlife-surveillance focused organisations like ENETWILD⁶² and One Health approaches of the European Centre for Disease Prevention and Control (ECDC⁶³).

⁴⁷ <http://www.gensc.org/>

⁴⁸ <https://biofair.uk/>

⁴⁹ <https://bdj.pensoft.net/article/82953/>

⁵⁰ <https://www.gbif.org/>

⁵¹ <https://www.catalogueoflife.org/>

⁵² <https://www.biodiversitylibrary.org/>

⁵³ <https://www.tdwg.org/>

⁵⁴ <https://ibol.org/>

⁵⁵ <https://www.earthbiogenome.org/>

⁵⁶ <https://www.agbiodata.org/> , <https://doi.org/10.1093/database/bay088>

⁵⁷ <https://www.cgiar.org/>

⁵⁸ <https://brapi.org/>

⁵⁹ <https://www.fao.org/agroinformatics/en>

⁶⁰ <https://www.woah.org/en/home/>

⁶¹ <https://www.ippc.int/en/>

⁶² <https://enetwild.com/>

⁶³ <https://www.ecdc.europa.eu/en/one-health>



Strategy Aims

Vision

The vision of the BFSP Priority Area is focused on three main requirements to achieve a future where connected FAIR data are routinely informing regional and transnational programmes and RIs in BFSP research. This encompasses ambitions to foster the development of informatics systems that support the transformation of research data into knowledge, and to enhance the applications of research results in driving data-informed decision-making and policy.

- ★ **Data brokering:** tools and services supporting data producers that facilitate standardised data mobilisation together with comprehensive metadata into open reference collections for the research community. ***A vision for unencumbered data sharing that self-catalyses participation as opportunities for data reuse multiply.***
- ★ **Resource interoperability:** technical solutions and common standards and best practices supporting diverse data repositories that facilitate reference resource connectivity with enhanced accessibility. ***A vision for seamless connections that motivate integration and harmonisation efforts demonstrating tangible benefits.***
- ★ **Data discovery, integration, and analysis:** software, data science tools, workflows, and high-quality curated reference datasets that facilitate exploitation of integrated repositories and data reuse leveraging powerful technologies such as artificial intelligence. ***A vision for intuitive interfaces that support researchers delivering answers to increasingly complex questions.***

Mission

The BFSP Priority Area's operational mission is to extend and connect the services and activities of the BFSP-related ELIXIR Communities and Focus Groups, and other relevant RIs and initiatives, to overcome key interdisciplinary challenges. These are both technical, in terms of data analysis and data integration, and at the level of the scientific user communities, which face a complex landscape of tools and data sources, making it difficult to navigate and decide which are the most appropriate. Recognition by multiple stakeholders across BFSP-related research activities



of the need for data science solutions that leverage increasingly connected infrastructures and integrated services is a testament to the importance of this operational mission. Through supporting efforts to address interconnected challenges in the domains of BFSP-related research, the broader mission is to contribute to overcoming societal challenges threatening planetary health and human wellbeing.

Principles

The Strategy of the BFSP Priority Area and its delivery are aligned with ELIXIR's commitment to Open Science principles and FAIR scientific data and tools⁶⁴. ELIXIR is guided by the principle that well-managed and open data, tools, and standards are the lifeblood of future scientific progress, enabling collaborative and equitable research to address societal challenges. As the European RI for life science data, ELIXIR works with the European Strategy Forum on Research Infrastructures (ESFRI⁶⁵), and coordinates and develops life science resources so that researchers can more easily find, analyse, and share data, exchange expertise, and implement best practices. ELIXIR brings together a virtual Research Infrastructure which enables and supports scientists in curiosity-driven and investigator-led research and helps translate these advancements into sustainable solutions for food security, the bioeconomy, our health, the environment and beyond. The ambition is for Europe to have a robust, connected network of established national services, internationally recognised resources, and federated enabling technologies for data-centric life science research. This involves building a European network of biological data resources and scientific software using common technical standards and best practices, promoting sustainability, standards compliance, reusability, and quality service provision. ELIXIR is key in this endeavour.

⁶⁴ <https://academic.oup.com/bioinformatics/article/37/16/2506/6310171>

⁶⁵ <https://www.esfri.eu/>



Strategy Goals

Objectives

The BFSP Priority Area Strategy is guided by five broad objectives.

- ★ **Federation:** to strengthen interactions on BFSP-related research and resource activities by supporting existing community networks working on data-related challenges (e.g. in plant and animal sciences, biodiversity genomics and monitoring, environmental metabolomics and microbiome multi-omics, as well as in genetic resources for crops, farm animals, microbes, etc.), building new ones through Focus Groups, and identifying connections to encourage and enhance joint actions. To support projects within ELIXIR Nodes and joint projects at European and global levels where ELIXIR is identified as a key actor for data management expertise. ***This will pave the way for and demonstrate the benefits of collaborations amongst the BFSP domains.***
- ★ **FAIR Data:** to support and develop connected biodata resources that aim to ensure visibility, findability, usability, and sustainable access to community/domain research data using trusted repositories and data discovery portals registered in dedicated collections, e.g. within FAIRSharing⁶⁶. To encourage intra- and inter-community interoperability of data resources at technical levels (e.g. APIs, dataflows) and data levels (e.g. interoperability of key resources with permanent identifiers and synonyms). ***This will improve connectivity amongst heterogeneous data infrastructures and resources across the BFSP domains.***
- ★ **Analysis:** to promote tools and workflows that facilitate reliable and reproducible data analyses, including not only the adoption of services from ELIXIR Platforms and Communities (e.g. Galaxy⁶⁷) but also the development of approaches, e.g. through use cases, that enable the adoption of machine learning and AI. To encourage the maintenance of FAIR catalogues of BFSP-related tools and workflows, e.g. in Bio.tools⁶⁸ and WorkflowHub⁶⁹, and the development of benchmarking datasets that facilitate objective performance assessments. ***This will help connect developers of tools/workflows/databases with user communities and expose analysis tools and services to the wider communities of users.***

⁶⁶ <https://fairsharing.org/>

⁶⁷ <https://elixir-europe.org/communities/galaxy>

⁶⁸ <https://bio.tools/>

⁶⁹ <https://workflowhub.eu/>

- ★ **Standards:** to support the development and adoption of community standards and research data management (RDM) best practices within and beyond BFSP-related researcher communities, including the use of and contribution to global data standards and promoting their adoption by researchers and repositories. To encourage domain-specific RDM development by researcher communities working with the RDM Community⁷⁰ to contribute to ELIXIR's resources and enable their broad adoption. ***This will enhance data quality, integrity, integration, and long-term usability through improved data lifecycle management.***

- ★ **Training:** to support training and knowledge exchange for data management, analysis tools and workflows, and biodata resources, in connection with BFSP-related projects and the ELIXIR Training Platform⁷¹. To integrate efforts, e.g. connecting developers with users through training activities, and expose collections of training materials, for example through the Training eSupport System (TeSS⁷²), the Galaxy Training Network (GTN⁷³), and the RDM toolkit for Life Sciences (RDMkit⁷⁴), as well as best practices in training (The FAIR Training Handbook⁷⁵). ***This will encourage the adoption of available standards and best practices through community-driven skills sharing that responds to changing technologies and associated services.***

The outcomes and impacts of the prioritised activities undertaken within the scope of the BFSP Priority Area during the ELIXIR 2024-28 Programme will be expected to contribute to the advancement of these five broad objectives. They are also expected to enhance interactions amongst researchers from across the ELIXIR Nodes, through coordination and cooperation efforts on the development and delivery of BFSP-related tools and services as part of Node Service Delivery Plans, as well as fostering alignments of practices across the relevant ELIXIR Communities and Focus Groups.

⁷⁰ <https://elixir-europe.org/communities/research-data-management>

⁷¹ <https://elixir-europe.org/platforms/training>

⁷² <https://tess.elixir-europe.org/>

⁷³ <https://training.galaxyproject.org/>

⁷⁴ <https://rdmkit.elixir-europe.org/>

⁷⁵ <https://elixir-europe-training.github.io/ELIXIR-TrP-FAIR-training-handbook/>

Implementation

The implementation of the BFSP Priority Area work is based on the BFSP work plan (2024-2026). It focuses on establishing a Strategy document, as presented here, and explores how to achieve the identified goals. A number of different instruments are being and will be used to support activities that advance the BFSP mission and vision. This section outlines the mechanisms and approaches adopted for effective delivery of the Strategy itself, and the associated activities.

Instruments

A number of instruments have been and will be used to support the development of ELIXIR's BFSP Strategy guided by relevant stakeholders, as well as to begin to augment and extend BFSP-related activities across ELIXIR Nodes.

- ★ **Workshops and Collaborative Events:** Allowing ELIXIR-wide engagement and input to develop BFSP as a Priority Area, its Strategy, and positioning within a broader landscape.
 - An in-person workshop was held as part of the BFSP mini-symposium during the 2024 ELIXIR All Hands⁷⁶ meeting in Uppsala. Representatives from a subset of ELIXIR Nodes (France, Switzerland, Greece, Sweden, Norway) presented ongoing BFSP-related activities and ELIXIR-wide BFSP-related activities were collated during an interactive session.
 - An online cross-community workshop⁷⁷ was held in September 2024 gathering input from ELIXIR Members for the development of this Strategy document. A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis conducted online prior to the workshop gathered members' perspectives to guide the workshop discussions and to feed into the development of the BFSP Strategy.
 - Future All Hands Meetings will host additional BFSP workshops, showcasing the projects selected from the first Open Call, learning about perspectives from additional Nodes, and fostering strategic discussions on updates to the Strategy and future directions for ELIXIR in the BFSP domain. These will be complemented by further online cross-community workshops.

⁷⁶ <https://elixir-europe.org/events/elixir-all-hands-2024>

⁷⁷ <https://elixir-europe.org/events/elixir-biodiversity-food-security-pathogens-cross-community-workshop>

- Another in-person workshop is under consideration, to bring together key contributors to the BFSP Priority Area, as well as to connect with relevant external stakeholders. This activity aims towards coherent alignment and positioning for the benefit of all interested parties.
- ★ **Open Calls for Projects:** Encouraging bottom-up contributions, supported by a minimum of one ELIXIR Community. This promotes bottom-up collaborative initiatives and purpose-driven projects in the BFSP domain.
 - A first call ran during 2024 (opened March 25th, closed May 10th) with four selected projects⁷⁸ that started in January 2025.
 - A second call is planned for 2025. This will likely have more defined application areas targeting the objectives/goals defined in this Strategy document.
- ★ **Strategic Funding for Emerging Communities:** the programme design allows for the BSFP co-leads and Hub support to reserve a targeted allocation for strategic funding based on assessed needs and feedback on the Strategy and its implementation.
- ★ **BioHackathon Europe:** the 2024 event⁷⁹ provided a valuable framework for ELIXIR Members to work on and advance concrete projects relevant to the BSFP domain, while building collaborations through cross-Node and cross-Community interactions.
- ★ **Community and Focus Group Meetings:** These regular online events provide a forum for relevant interest groups within ELIXIR to discuss the ongoing development of the BFSP Strategy and collate feedback and perspectives to share with the BFSP co-leads. They also crucially serve as an interface between ELIXIR and many relevant externally funded projects, initiatives, and infrastructures in the wider BFSP-related research landscape, ensuring good alignment with ongoing activities and fostering opportunities for ELIXIR Members to engage.
- ★ **Partnership with the European Commission, seeking participation in Horizon Europe Projects:** ELIXIR can also develop these themes through partnership with the European Commission by seeking participation in Horizon Europe Projects. There are currently three

⁷⁸ <https://elixir-europe.org/internal-projects/commissioned-services/science/biodiversity-security-pathogens>

⁷⁹ <https://biohackathon-europe.org/>



different models of doing so: 1) ELIXIR Hub Coordinated projects; the Hub can coordinate 2-3 pan-European proposals each year, typically in the area of Research Infrastructure Consolidation (e.g. ELIXIR-CONVERGE⁸⁰ and ELIXIR-STEERS⁸¹) or the development of the European Open Science Cloud (e.g. EOSC ENTRUST⁸²); 2) ELIXIR Node Coordinated projects; in cases where funding is available for specific scientific or technology themes within the domain expertise of individual ELIXIR Nodes, a Node can coordinate on behalf of the organisation (e.g. EVERSE⁸³); 3) ELIXIR Member/s participation in Horizon Europe projects (PHENET⁸⁴).

Strategy Ownership

As defined in the work plan, the BFSP Priority Area work is led by three co-leads, all of which are ELIXIR Members namely: Tereza Manousaki (ELIXIR Greece), Cyril Pommier (ELIXIR France) and Robert Waterhouse (ELIXIR Switzerland). Together with Hub staff support they lead the development and execution of the Priority Area work. The development of this Strategy document received invaluable input through the in-person and online meetings/workshops, and through the open review of the contents with contributions from many ELIXIR Members (see Contributor List below). The selection and management of the open call projects are overseen by this leadership team and administrative support is given by the ELIXIR Hub. For scientific alignment the team also relies on ELIXIR Community co-leads as well as the project leads themselves. Alignment beyond ELIXIR is also overseen by the ELIXIR Director, Tim Hubbard.

⁸⁰ <https://elixir-europe.org/about-us/how-funded/eu-projects/converge>

⁸¹ <https://elixir-europe.org/about-us/how-funded/eu-projects/steers>

⁸² <https://eosc-entrust.eu/>

⁸³ <https://everse.software/>

⁸⁴ <https://www.phenet.eu/en>

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