Extended Abstract - NFDI4Agri

1. Formal details

Planned title of the consortium
NFDI for Agricultural Sciences

Acronym of the planned consortium
NFDI4Agri

Lead institution or facility
Leibniz Centre for Agricultural Landscape Research (ZALF)

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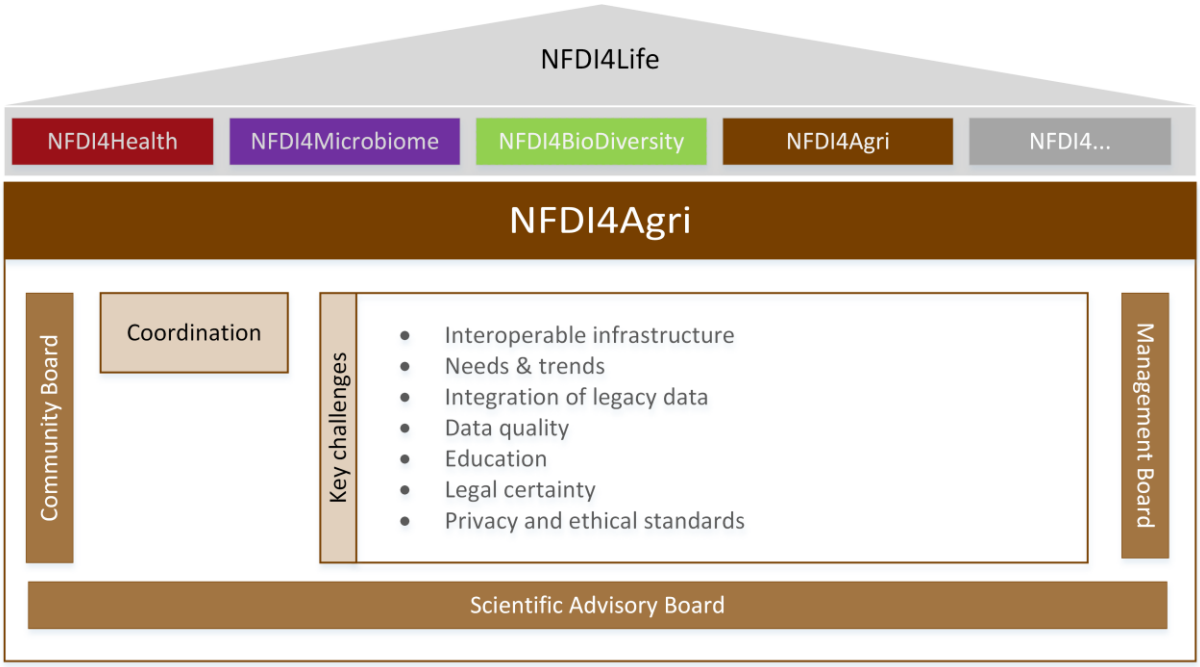
Research area of the planned consortium:
The proposed consortium is corresponding with the DFG Research Area 23: Agriculture, Forestry and Veterinary Medicine.

Participating research institutions (without address)
Leibniz Centre for Agricultural Landscape Research (ZALF)
Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
Leibniz Institute for Farm Animal Biology (FBN)
Federal Research Centre for Cultivated Plants (JKI)
Leibniz Institute for Information Infrastructure (FIZ Karlsruhe)
Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB)
Senckenberg Museum of Natural History Görlitz (SGN)
University of Bonn
Forschungszentrum Jülich (FZJ)
University of Düsseldorf
University of Potsdam
University of Rostock
Technische Universität Dresden

Participating infrastructure facilities and/or potential information service providers
Information Centre for Life Sciences (ZB MED)
Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL)

Planned proposal submission date (2019, 2020, 2021)
2019

Overview diagram or organisational chart for the planned consortium



2. Subject-specific and infrastructural focus of the planned consortium

2.1 Key questions/objectives of the consortium

Agricultural sciences comprise a broad and heterogeneous field of research disciplines such as soil science, plant production and livestock farming, applied genetics and physiology, agricultural economics and -sociology. The term **agricultural sciences** covers all disciplines as mentioned before, which will not be named separately later on. The planned NFDI4Agri consortium aims at a thorough implementation of the FAIR principles to make agricultural research data findable, accessible, interoperable, and reusable and, moreover, open. Our vision is to make it fully transparent who has measured what, where, when and how. Beyond that, we strive to take current agricultural research data management (RDM) to a higher level: connecting isolated infrastructures, organize RDM teaching, raise awareness, and pushing open data, achieve legal certainty and develop resp. improve data quality assurance procedures. Our mission is to meet the needs of the agricultural research community, connect disciplinary repositories and, hence, make publicly funded and yet isolated research data interdisciplinary available. In this context, key questions of NFDI4Agri are:

- How can discipline-specific infrastructures in agricultural sciences be made interoperable and allow data exchange in standardized ways to enhance their impact on the development of an efficient and sustainable agriculture?
- How to make ontologies in agricultural sciences (e.g. AGROVOC, Crop Ontology) interoperable in the technical application and how to connect them closely with NFDI4Life?
- How can data quality of highly diverse agricultural research data (content-related, textual and technical) be assured, quantified and provided as data products to the agricultural community?
- How to integrate the agriculture scientific community by involving disciplinary associations, and how to convince them of the benefits of open data publication?
- How to make open research data been recognised as a valuable output, additional to scientific publications (scientific reputation → NFDI4Life)?

In close collaboration with the agricultural scientific community main objectives of NFDI4Agri are to

- set-up a flexible, interoperable and scalable data **infrastructure** by connecting existing and supporting the creation of new disciplinary infrastructures for agricultural sciences,
- integrate **legacy** research data (e.g. agricultural long-term experiments). Concepts are being developed to identify data treasures and their provenance, to define responsibilities, to support them with licenses and to make data freely available,
- assure research data **quality** by domain specific measures of quality control and set-up a quality feedback and curation system. The evaluation of the data fitness-of-use is an important quality feature to ensure data reusability (e.g. long-term and high quality data series for analysis of breeding and farming improvement),
- assume **educational** responsibilities by transferring our knowledge to the next generation of scientists (agricultural informatics) and taking the specific needs of the community into account,
- respond properly to **future** developments by identifying needs and technological trends of the agricultural community in Europe and globally,
- develop **privacy** and ethical standards constituting a fair balance between the interests of authors of agricultural data (and respective institutions) and of those in the international research communities requesting data for reuse,
- improve concepts to deal with **sensitive** data (e.g. farm data with spatial reference), and
- develop a platform for **knowledge exchange and technology transfer** to get in dialogue with stakeholders (e.g. farmers, companies, decision makers in policy and public).

2.2 Known needs / current status of research data management in the relevant discipline/subject-specific relevance of the planned consortium:

From a research perspective

NFDI4Agri will follow a user-driven approach. It brings together most important actors from RDM in the field of agricultural sciences and actively integrates the community. This approach explores the needs and requirements of data infrastructure users and identifies knowledge gaps which then results in scientific research questions that need to be addressed.

Interoperability
Today, agricultural research data infrastructures are often not connected which hampers current trends of interdisciplinary data analysis. Harmonized and machine-readable access to research data is still lacking though RESTful services are commonly used but implement heterogeneous data structures, endpoint authentication and authorization schemes. Interoperability between different infrastructures (e.g. metadata exchange, standardized APIs) would increase reusability of data and benefit interdisciplinary analyses. The high diversity of agricultural data, different use conditions and applied standards represent a particular challenge for an interoperable and interlinked research data infrastructure in agricultural sciences.

Quality assurance
Quality assurance (QA) is a prerequisite to provide reusable research data. There is an increasing demand to develop QA methods and standards that can be implemented in infrastructures. Data quality review and curation is needed but still lacks of adequate criteria, resources and funding. There is a proper concept as a framework needed comprising (a) general methods that are applicable for every discipline, and (b) the integration of discipline-specific QA methods. The information about data quality should be provided in standardized form within the NFDI4Agri infrastructure. The QA concept has to consider the following aspects:

- minimum QA methods suitable for NFDI4Agri
- domain specific and transferable QA methods
- quality feedback system with neutral evaluation
- provide certificates indicating quality approved data
- data quality metrics, review and curation
- data compatibility and plausibility

The development and implementation of such concepts and methods will be part of the NFDI4Agri research activities.

In terms of available information providers and services

Current situation
Due to the wide range of research questions among the various agricultural disciplines, a high diversity of data is generated in terms of content and structure and, additionally, in sensitive information about landowners' areas. The national agricultural research disciplines face a heterogeneous landscape of data infrastructures. Examples are PUBLISSO - the open access publishing platform for life sciences (www.publisso.de), the open access repository OpenAgrar (www.openagrar.de) and the BonaRes repository managing and providing soil- and agricultural research data for free reuse, respecting the FAIR principles (datenzentrum.bonares.de). In the research field of plant genomics and phenomics, there exist a number of databases and information systems for national and international services, such as the German Genebank (GBIS: gbis.ipk-gatersleben.de), e!DAL-PGP (edal-pgp.ipk-gatersleben.de) and the European Search Catalogue for Plant Genetic Resources (EURISCO: eurisco.ipk-gatersleben.de). Soil-zoological information are collected in the Edaphobase (portal.edaphobase.org). Other relevant infrastructures are international central archives (EBI) and the joint management of phenotyping data together with data from agricultural robots (Cluster of Excellence: PhenoRob www.phenorob.de).
The already established infrastructures for spatial data. INSPIRE and GDI-DE, are of great importance for agricultural sciences. The BonaRes repository is already interoperable with these. Other sources for frequently used open spatial data are: DWD (climate), Copernicus (satellite imagery), and federal agencies as BGR (soil). Despite existing infrastructures operated and organised by the partners, only

a few are recognized in the community. There is no organized, interoperable and discipline overarching infrastructure available, which faces the challenges and demands of agricultural sciences. Isolated, disciplinary infrastructures must be interlinked and integrated into a superordinate infrastructure to be developed by NFDI4Agri, while new infrastructures must be supported to become interoperable with this concept. Thus, an interoperable RDM enables (inter-)disciplinary search and analyses and facilitate agricultural research data curation, time courses and quality control.

Data quality & standards
Although the importance of data quality is well known, only few data infrastructures have implemented structured quality assurance systems. Therefore, new objective quality criteria must be developed and implemented across infrastructures. The agricultural disciplines have their own individual requirements for standards, vocabularies and formats. Additionally, common standards in the field of research data provision (FAIR, Linked Open Data, etc.) need to be implemented. In existing infrastructures, the support of such standards varies resulting in the need for a common implementation of FAIR principles. Established standards for controlled agricultural vocabulary are AGROVOC, Provenance Ontology (PROV-O), the Biological Collections Ontology (BCO) and Global Agricultural Semantic Concept Scheme (GACS). Other relevant standards are MIAPPE, as minimal information standard for plant phenomics experiments and the FAO/IPGRI Multi-Crop Passport Descriptors (MCPD). The implementation of guidelines like INSPIRE, EOSC, EUDAT and OpenAIRE must be ensured. If no suitable standards or solutions exist, interfaces between existing infrastructures in the field of agricultural research have to be developed, provided to the community and implemented in disciplinary infrastructures.

Data providers and re-users
The awareness to provide reusable research data varies among researchers. Additional, there is a big uncertainty among researchers, concerning the process of publishing data (choice of suitable repositories, legal uncertainty, demand on resources). The knowledge of RDM in agricultural sciences (various formats, legal restrictions and aspects, standards) needs to be transferred to (young) scientists. Adequate methods have to be developed and implemented. In return, a permanent exchange of experiences towards RDM is needed in order to continuously evaluate existing methods and adapt them if necessary: Information management meets agricultural research (mutual learning). This poses a great challenge for infrastructure providers, data providers and reusers.

Respect legal regulations
Since agricultural data is often collected on private farms (e.g. soil-, yield data), data protection represents a particular task. The provision of data must not interfere with business. To this end, the development of useful methods to deal with sensitive data is a challenge. On the one hand, the needs of data protection have to be taken into account and, on the other hand, also those of the subsequent use of valuable research data. The ownership (data right) of agricultural research data is often unclear, posing a major challenge in making this data publicly available and reusable. A great requirement is to create legal certainty on the side of infrastructure providers (repositories), data providers (authors) and subsequent users (reusers). Policies have to be formulated for dealing with research data of agricultural sciences within the consortium and including the participating repositories. The creation of policies respecting the legal framework must be coordinated with other NFDI consortia in order to create synergies on the one hand and to avoid contradictions on the other. Policies and standards developed for NFDI4Agri may be applicable to other disciplines in which natural sciences data is subject to privacy concerns because it is collected on/about private lands and/or which feature significant collections of relevant data (including legacy data) with unclear ownership, e.g. the wider earth and environmental sciences (NFDI4Earth, NFDI4Biodiversity). This work within NFDI4Agri thus provides added value to the NFDI as a whole.

Legacy data
Publicly funded research data is partly not publicly accessible and runs the risk of permanently getting lost. Reasons are manifold, e.g., research projects are finalised but research data was not published or responsibilities of scientists change. Research data from agricultural long-term experiments (LTE), some of which have been carried out for more than 100 years, are of particular importance and must be preserved and made available. The BonaRes project started an initiative to make LTE data freely available, but lots of other publicly funded research data remains inaccessible. Other examples are historical evaluation data of gene banks, like documents of the Federal Ex situ collection of crop plants. Concepts have to be developed to identify such data treasures and responsibilities have to be clarified to make them reusable.

2.3 Summary of the planned research data infrastructure that is specifically intended to address the needs of research users in their respective work processes

The existing infrastructures in agricultural sciences are decentralized, specialized to individual requirements of disciplines and less connected, thus data availability is scarce. The NFDI4Agri approach reacts on this without completely changing this system by setting up a superordinate, scalable infrastructure connecting individual, discipline specific systems and making research data available. This infrastructure will be flexible with respect to the integration of newly developed infrastructures of NFDI4Agri relevant disciplines. General demands towards the infrastructure are user-friendliness, secure and legally sound data storage and accessibility to data from other disciplines. The development of the superordinate infrastructure will include the following aspects:

- Inventory and assessment of existing infrastructures e.g. Publisso, OpenAgrar, BonaRes or the planned BioBank
- Set-up of a higher-level search infrastructure by connecting existing RDIs via Linked Open Data principles
- Development and implementation of APIs to provide homogeneous access to scattered RDIs
- Support disciplinary infrastructures to set-up data publication systems
- Services for alignment and mapping of ontologies - to be identified and assessed before - to make disciplinary ontologies interoperable within NFDI4Agri
- Integration of semantic methods for the special use of data - a task that is approached in collaboration with NFDI4Life
- Platform for the dissemination of NFDI4Agri relevant information into the community

2.4 Description of data types and underlying data processing / data analysis methodologies

Types of data

Agricultural sciences have to deal with diverse data sources, typically with spatial and temporal components, originating from laboratory analysis, landscape monitoring, sequencing, phenotyping, spectrophotometer measurements, remote sensing (e.g. airborne sensors, satellite data), economic market data, breeding or modelling results and environmental sensor data (IoT: new monitoring purposes with a high spatial resolution by the application of cost-efficient, autonomous sensors). In agricultural field measurements, data is collected to describe the physical condition and development of plants as a function of soil, management and climate. Increasingly, agricultural data will be automatically generated by (semi-) autonomous systems e.g. robotics (big data), with the need for direct data processing. Research data of agricultural sciences is created in various formats and types: Geodata (shp, gdb, FeatureClass, GeoTIFF), databases (SQL, SQLite), structured data (tabular, xml, json), pictures, audio/video, sequence data (FASTA, VCF Files), qualitative and descriptive data.

Data type examples grouped by disciplines:
Plant: cultivation data (yield, root, management, fertilization), phenotyping data, sequence data, gene expression, genbank material, parameters for biological effects, products and physiology (e.g. spectroscopic data of quality and content), chemical data (like plant protection products);
Animal: collection (death and life collections of insects, viruses, bacteria), livestock (physiological, production-related, pollutant emission, descriptive), phenotyping/ sequence data;
Soil: profiles, physical and chemical analysis, microbiological data of environmental samples (optical and molecular data), soil biodiversity (taxonomic) occurrence data, metabolic networks;
Environment: land use, weather, climate, biomes, topography, relief, hydrology;
Socio-economy: agricultural statistics, impact assessment, risk assessment, farm data (management, economics);
Other: laboratory information management system data (LIMS), biochar (chemical data), metadata (formats/ standards);
Sensitive data: The above-mentioned data may fall under the heading “sensitive data” if they fulfil certain requirements (e.g. personal data, farm data, data from private land).

Data processing / data analysis methodologies

In agricultural sciences, data processing and analysis methodologies comprises different aspects, i.e.

- Data preparation: creation of RDM plans, restructuring of data, teaching/training courses for communities with focus on data handling, harmonization;
- Data provision: annotation and submission of sequence data to EMBL ENA, MIAPPE compliant annotation and publication of plant phenotyping data using ISATAB, anonymization of data, metadata schema, semantic lookup platform, and terminology services;
- Data analysis & -evaluation: GIS, machine-learning and artificial intelligence, data analysis pipelines, modelling, formal tests, plausibility checks, statistical tests, automatic data annotation based on text mining to standardize data descriptors;
- Data compression and long-term preservation;
- Data QA: conformity key for soil data, expert knowledge, review, curation, documentation.

2.5 Planned implementation of the FAIR principles and information about any existing policies or guidelines in the relevant discipline

NFDI4Agri intends to create a superordinate infrastructure for agricultural research data that comprehensively implements the FAIR principles. The existing national infrastructures such as PUBLISSO, OpenAgrar, BonaRes, GBIS, e!DAL-PGP, EURISCO, Edaphobase, and BGR must be connected to setup an interlinked network following the requirements of the community, e.g. for interdisciplinary data queries. NFDI4Agri disciplines with poor or missing data infrastructures must be supported to become compatible to the NFDI-network.

Following the approach of a minimum information policy, we will specify a metadata core that must be supported by all disciplinary infrastructures. Standardized QA-tools will be provided to assure quality of research- and metadata. Different existing ontologies (e.g. AGROVOC, PROV-O, BCO, MIAPPE, FAO/IPGRI Multi Crop Passport Descriptor) will be evaluated and made interoperable by developing mapping and alignment methods. In order to ensure a high degree of reusability of research data, both, a DOI infrastructure and an infrastructure for long-term preservation (archiving) will be provided.

We will support data policy creation and establish a policy hub for agricultural sciences. Legal information will be consolidated to develop methods for dealing with sensitive data like farm data which are then transferred into the community. It is planned to implement a federated API broker for integrated data retrieval operations and/or a central infrastructure providing metadata for and links to all data acquired in the context of the consortium.

Most of the consortium members have already implemented some of the FAIR principles by developing suitable data policies. e.g. ZALF/BonaRes (dx.doi.org/10.20387/BonaRes-E1AZ-ETD7), JKI (julius-kuehn.de/media/IB/PDF/IB-JKI-Leitlinien_Forschungsdaten.pdf), SGN/Edaphobase (senckenberg.de/files/content/forschung/projekte/edaphobase/Rechtliches/edaphobase_data_policy_2018_09_15.pdf), ATB (atb-potsdam.de/institut/ueber-uns/forschungsdaten.html), and FBN. So far, the general realization has not been described uniformly and is usually difficult for the user to recognize. Within NFDI4Agri, a structured procedure and documentation for the implementation of the principles including FAIR metrics will be established. It is planned to intensively cooperate with the GO FAIR initiative, the Research Data Alliance and other relevant (inter-)national actors.

2.6 Planned measures for user participation and involvement

While our mission is to meet the needs of the participating agricultural research community, associations will be involved in a comprehensive user participation concept. This concept follows the rules of a user-driven approach and is pioneered by the development of a platform for the dissemination of NFDI4Agri relevant information into the community and vice versa. This will be complemented by a feedback/support system to improve the planned infrastructure. Our chosen approach strives to bring together the most important actors from RDM in the field of agricultural sciences. We will actively integrate the community by regular surveys to identify needs and wants, by workshops, conferences, and summer schools to train involved parties, and by webinars for educational purposes. Information exchange will be offered by social media and discussion forums, while a more unidirectional dissemination of information into the community will be provided by a specialized “NFDI4Agri information platform”. A platform for knowledge exchange and technology transfer will be developed to get in dialogue with stakeholders (e.g. farmers, companies, decision makers in policy and public). An important precursor for our concept is to find research partners for infrastructures that have pressing needs and want to contribute to specifications of new services and be pilot users – while making sure at the same time, that their needs are actually exemplary of the wider community needs.

2.7 Existing and intended degree of networking of the planned consortium

The consortium is already highly networked by the partners involved:

Nationally
The NFDI4Agri partners work closely with the following institutions, infrastructures and networks with a high degree of RDM expertise. These are either more generic, such as DataCite, Open Researcher and Contributor ID (ORCID-DE), FDMentor/FDNext, DINI/nestor, and GO FAIR or with a more specific agricultural orientation at national level such as BonaRes, German Network for Bioinformatics Infrastructure (de.NBI), German Federation for Biological data (GFBio), The German Plant Phenotyping Network (DPPN), Network of competence of agricultural and nutritional research (PHÄNOMICS), Vereinigte Informationssysteme Tierhaltung (vit), Beratungs- und Koordinierungsausschusses für genetische Ressourcen landwirtschaftlicher und gartenbaulicher Kulturpflanzen (BEKO), and Cluster of Excellence: Robotics and Phenotyping for Sustainable Crop Production (PhenoRob). Due to the strategic nature of NFDI and the envisaged convergence, NFDI4Agri is closely associated with the NFDI working group of Mecklenburg-Vorpommern and other NFDI consortia right from the start: NFDI4Life, NFDI4Health, NFDI4BioDiversity, NFDI4Microbiome and NFDI4Earth.

As representatives of the scientific **community** in NFDI4Agri, relevant associations are closely linked to the consortium. So far, the following national and international associations have agreed to participate actively (www.nfdi4agri.de/index.php/partners): German Soil Science Society (**DBG**), German Agricultural Research Alliance (**DAFA**), Gesellschaft für Pflanzenbauwissenschaften e. V. (**GPW**), Society for Plant Breeding e.V. (**GPZ**), German Botanical Society - Section Applied Botany (**DBG**), German Phytomedicine Society (**DPG**), and International Organisation for Biological Control West Palaearctic Regional Section (**IOBC-WPRS**).

Internationally
NFDI4Agri's partners are already well connected internationally in terms of RDM such as Research Data Alliance (RDA), AgroPortal, Modelling European Agriculture with Climate Change for Food Security (MACSUR), Agricultural Model Intercomparison and Improvement Project (AgMIP), International Organic Nitrogen Long-term Fertilisation Experiment (IOSDV), the International Union of Soil Sciences (IUSS), International Soil Reference and Information Centre (ISRIC), Global Open Data for Agriculture and Nutrition (GODAN), European Cooperative Programme for Plant Genetic Resources (ECPGR), European Plant Phenotyping Network (EPPN), International Plant Phenotyping Network (IPPN), Functional Annotation of ANimal Genomes Project (FAANG), Functional Annotation of All Salmonid Genomes (FAASG), ELIXIR, EMPHASIS, Distributed System of Scientific Collections (DiSSCo), the community driven effort to unlock the potential of crop diversity (DivSeek), Gene Expression Omnibus (GEO), and Genetic Sequence Database (GenBank). We plan to deliver characterization and evaluation data (C&E) to European and international repositories of plant genetic resources (e.g. EURISCO, GENESYS, GLIS).

Between the infrastructure facilities and the research community
Some of the partners maintain or participate in infrastructures that are well received and utilized by the community, such as: BonaRes, de.NBI, GFBio, DPPN, DivSeek, Breeding API, MIAPPE Steering committee, and Geo.X network.

With respect to major networking topics
The consortium partners participate in different agricultural networks, such as the editorial board of AGROVOC, RDA Interest Group Agricultural Data (IGAD), implementation of the European Open Science Cloud (EOSC) as part of a global Internet of FAIR Data & Services (GO FAIR), agricultural Global Long Term Experimental Network (GLTEN), and linking repositories with C&E-Data with national and international search catalogues (e.g. WheatIS, GrapeIS by INRA/URGI).

2.8 Additional information

As part of the NFDI4Life umbrella consortium, higher-level tasks of NFDI4Agri, such as educational offers, consultation of political actors, and the provision of interfaces, policies and standards, will be coordinated by the broader life-science community of NFDI4Life.