Memorandum of Understanding

Integrated European long-term ecosystem, critical zone and socio-ecological system research infrastructure (eLTER RI)

AMONG

The core partner research institutions leading the national LTER developments and operating or using LTER facilities (the Parties)

Preamble

The challenges of global change, including changing climate, decreasing water resources, increasing frequency of extreme events, changes in land use and societal developments, require new strategies and infrastructures for environmental research. It is widely accepted that multidisciplinary, integrated approaches to environmental observation and experimentation at the continental and global level will be necessary to provide a more holistic understanding of the state and evolution of our environment. Such knowledge is indispensable for projections of future changes and for informing decision making targeted at achieving Sustainable Development Goals.

Long-Term Ecosystem Research (LTER) is an essential component of worldwide efforts to better understand ecosystems. Through research and comprehensive observation, LTER seeks to improve our knowledge of the structure and functions of ecosystems and their long-term response to environmental, societal and economic drivers. Since the founding of LTER-Europe one decade ago, LTER research communities in Europe have sought to better integrate traditional natural sciences and holistic ecosystem research that include studies of human-environment interactions and the critical zone in a multi- transdisciplinary approach.

Nevertheless, Europe still lacks an integrated environmental research infrastructure capable of operating at multiple scales to address dynamic changes across broad extents of space and time (a 'geo-eco-socio-system').

The eLTER Research Infrastructure (eLTER RI) aims to close this critical gap in collaboration with related environmental RIs. The RI will enable cutting edge European environmental research to develop a sound mechanistic understanding of system change or adaptation in response to global change pressures and the impacts of multiple stressors on natural resources, ecosystems and biodiversity.

The Parties of this MoU are institutions leading national eLTER RI developments and/or operating registered LTER facilities and/or using these eLTER facilities. Through working together for many years in numerous projects they have established a sustainable community and consortium committed to advancing the eLTER RI through this multilateral collaboration in the context of ESFRI.

These institutions have made substantial efforts to design and formalise an **integrated backbone infrastructure for long-term ecosystem, critical zone and socio-ecological research** (eLTER RI) **in European benchmark systems** (major geo-eco-sociological systems across the continent´s ecoclimatological zones). **The crucial next steps** are to specify in detail and to implement the **eLTER Research Infrastructure** under the framework of the European Strategy Forum on Research Infrastructures (ESFRI). Following the 2015 eLTER ESFRI application, eLTER was acknowledged as an

"emerging ESFRI RI" in the ESFRI Roadmap 2016. Owing to the successful 2017 eLTER ESFRI application **eLTER has entered the ESFRI Roadmap 2018** as a fully recognised Roadmap project in the environmental domain.

This endeavour specifically considers:

- the importance of **coordinated efforts to address the major societal challenges of global change** and its impacts on the environment
- the **key importance of defining new multi- and transdisciplinary strategies and infrastructures** for environmental research supporting sustainable societies
- the **improvement in efficiency brought about by the eLTER RI**, accomplished by (1) maximizing the return on previous investments through multiple RI and legacy data usage, (2) comprehensively covering Europe's diverse range of ecosystems, (3) integrating the generic backbone RI on the basis of key contemporary scientific questions, common concepts, and shared services, (4) consolidating long-term strategies among European, and global, LTER networks for harmonised geo-eco-socio-system and biodiversity observations, and thereby (5) reducing redundancies and total Continental RI costs, *inter alia* through complementarities with related RIs (e.g. Memorandum of Cooperation between LifeWatch and LTER).
- the **positive effects for the signatories** of this MoU, including the enhancement of the value of their pre-investments by adding an international dimension to previously local/national/regional engagements; privileged access to a distributed European RI and to its services; technical and methodological guidance for site upgrades.

ARTICLE 1: Purpose

(1) By this MoU, the Parties express their agreement on the science case, basic design and high strategic importance of the eLTER RI as described in more detail in the Annex, as well as on the high relevance of the project for their scientific agendas. The signatories (Parties) are institutions leading the national LTER development and/or operating sites (as major contributions to the National Research Infrastructures) and/or scientific key users of European LTER infrastructure.

(2) By this legally non-binding MoU, the Parties also commit to collaborate in implementing the eLTER RI alongside the scientific needs outlined above.

(3) The design, business plan, legal and governance structure of the eLTER RI will be explored in detail, negotiated and approved among the shareholders (funding agencies, participating countries and Research Performing Organisations (RPO)) during the Preparatory Phase Project (PPP) which has started in February 2020.

(4) The signatures on this MoU are collected and archived at the Helmholtz Centre for Environmental Research - UFZ in Germany, which leads the eLTER ESFRI process and co-ordinates the eLTER PPP.

ARTICLE 2: Duration

(1) This MoU has entered into force with the eLTER ESFRI 2017 submission, that is September 2017. This MoU shall remain in full force and effect until the creation of the eLTER RI or until the Parties agree to replace this MoU with another kind of agreement.

(2) For a party which accedes to this MoU after this date, it enters into force from the date of the accession.

(3) Any Party has a right to terminate participation by giving 90 days written notice to the coordinator (Helmholtz Centre for Environmental Research - UFZ, Germany).

ANNEX: Advancing towards the eLTER Research Infrastructure (eLTER RI)

Science case

The eLTER RI will adopt a fundamentally systemic approach to monitor, observe, explore and analyse the environmental system, encompassing biological, geological, hydrological and socio-ecological perspectives. While several existing thematic environmental RIs focus on impacts of climate change and/or other elements of environmental change, the eLTER RI will be the only research infrastructure embracing holistically the integrated impacts of such stressors on a wide variety of European ecosystems. It will therefore occupy a vital and as yet unfilled niche in the European RI landscape. The eLTER RI will foster observation of ecosystems in their entirety, with a focus on relevant *in-situ* terrestrial, freshwater and transitional waters sites dedicated to long-term research. It will allow *in-situ*, co-located acquisition and gathering of Essential Variables ranging from bio-physico-chemical, to biodiversity and socio-ecological data. These will be interpreted in the context of long-term pressures and short-term pulses in a nested design across all the scales covered by the eLTER RI site network.

Core to the eLTER RI science case is the concept of "Macrosystems Ecology". This extends and connects traditional approaches that focus predominantly on either (1) processes at a plot or site scale or (2) patterns at larger spatial scales. Macrosystems Ecology explicitly recognises the interactions between processes within and across scales and systems. By combining ecosystems ecology with macroecology, it unifies analyses of patterns, processes, fluxes and biodiversity. This then provides the potential to model within-scale feedbacks among drivers, cross-scale interactions among drivers and cross-scale interactions with feedback loops.

With Macrosystems Ecology at its foundation while striving to support knowledge-based decision making at various levels, the eLTER RI would lead the way toward a comprehensive, integrated view of interactions necessary to address overarching core questions such as:

- How do ecosystems and biodiversity respond to global-change pressures, with special focus on natural resources?
- How do multiple stressors, e.g. of global change, interact?
- What are the determinants of ecosystem resilience, how can these be strengthened, and thus how can ecosystems be managed to achieve the UN Sustainable Development Goals?

These complex fundamental questions can only be tackled by concerted cross-disciplinary research focussing on derived and more specific topics. A unique feature of the envisaged eLTER RI is the distributed site network that provides the long-term platform for such targeted contributions to findings, which individual disciplines and single research projects cannot deliver. This design enables considerable flexibility in the selection of sites, habitats and datasets most applicable to specific research questions. Depending on the research question, site habitat type and site category, not all sites will necessarily host research of all disciplines and not all signatories of this MoU will or can cover all research topics.

The eLTER RI will therefore enable the integration of different research approaches and joint usage of research sites: For example, abiotic components studied in critical zones research can be linked to corresponding processes of biological diversity, thus enabling a better understanding of ecosystem functions and biodiversity relationships and how these correspond to ecosystem services. Hence the single and combined effects of long-term changes in, for example, reactive nitrogen, temperature, soil water or hydrological flows, on the number of species in a system or their functional composition in

terms of e.g. pollination provision or pest regulation, can be jointly analysed, experimentally tested and linked to societal demands.

The European eLTER RI is dedicated to streamlining the operation of long-term facilities providing holistic and detailed system information which, together with scientific forums and training initiatives developed by the LTER community, will make it possible to answer both present day socio-environmental challenges and to tackle unforeseen environmental challenges. The systematic gathering of data by an infrastructure designed to address the most pressing environmental questions of day, also provides opportunities to detect and quantify previously unanticipated behaviour – thus serendipitous discovery is likely to provide considerable added value to the eLTER RI over time.

Accordingly, and as science advances, the eLTER RI science case, overarching research questions, work programme and infrastructure implications will be periodically reviewed and adapted.

eLTER RI: a RI dedicated to a holistic appraisal of environmental change

Scientists and research stakeholders in 25 European countries have made substantial efforts to design and formalise an **integrated backbone infrastructure for long-term ecosystem, critical zone and socio-ecological research** (eLTER RI) **in European benchmark systems** (major geo-eco-sociological systems in main ecoclimatological zones).

The key purpose of the eLTER RI is to gain sound mechanistic understanding of system change or adaptation in response to global change pressures and the impacts of multiple stressors on natural resources, ecosystems and biodiversity from global to regional and local scales. Such knowledge is indispensable for predictions and informing decision making targeted at achieving Sustainable Development Goals at various levels notably by mitigation of the impact of climate change. The science case of the eLTER RI addresses the structures and functions of ecosystems and their services in an integrated approach and at various scales. Structure refers to the elements of the internal organisation of ecosystems (e.g. composition and diversity at multiple levels of biological and physical organisation) whereas functions refer to their relationships, fluxes and balances of matter and energy. Hereby, a novel feature of eLTER in comparison with existing environmental RIs is to integrate approaches focused on (1) fluxes and concentrations and (2) biodiversity related functions and structures of ecosystems with (3) appropriately scaled RI elements to investigate human-environment interactions in the long term (socio-ecological research).

The **eLTER ESFRI process, leading to a formal eLTER RI, aims at** securing a European ecosystem RI with high quality services and impact on the European Research Area (ERA). It will integrate and streamline substantial national investments in long-term research and observation activities at sites throughout Europe, representing a key legacy and asset of European environmental research. Long-term (i.e. multi-decadal) data series providing unique information on trends, causes and effects of earth system change will be harmonised and interoperably continued. The eLTER RI will secure the operation of research sites used by multiple disciplines and communities, providing fundamental infrastructure components and services such as access to permanently operated sites and their physical infrastructure, reliable, harmonised baseline ecosystem observations, *in-situ* experimentation and access to quality controlled data, knowledge and expert support.

The **improvement in efficiency brought about by this RI compared to the pre-ESFRI** status will be accomplished by (1) maximizing the return of previous investments through multiple RI and legacy

data usage, (2) securing a sound coverage of benchmark ecosystems at the European scale, (3) integrating the generic backbone RI on the basis of key contemporary scientific questions, common concepts, and shared services, (4) consolidating long-term strategies among European, and global, LTER networks for harmonised geo-eco-socio-system and biodiversity observations, and thereby (5) reducing redundancies and total Continental RI costs, *inter alia* through complementarities and alliances with related RIs (e.g. Memorandum of Cooperation between LifeWatch and LTER).

Many of the **building blocks of the eLTER RI** already exist, but are fragmented and only partly interoperable. In proportion to the cumulative efforts up to now, relatively modest further construction is needed to ensure the benefits derived from the RI will be greater than the sum of its parts. The National Research Infrastructures (NRI, i.e. national *in-situ* facilities) and services they provide are funded through dedicated national funding mechanisms or suitable European funding (e.g. Regional Development Funds). These will be complemented by Central Services comprising Topic Centres, a Service Portal and the eLTER RI Head Office. These Central Services will deliver the long-term vision and efficient strategies of the whole RI, as well as providing added value services, integration and coordination of the *in-situ* network. The detailed structure and funding mechanisms are being jointly developed by partners in the Preparatory Phase Project (PPP).

The eLTER RI will provide **a cost-efficient environment for** (1) **targeted individual research projects** and (2) **co-location with „sister" research infrastructures**. In achieving the latter, it will contribute to the generally raised need for integration of environmental RIs and will act as a hub fostering multidisciplinarity and the joint use of well-equipped sites by multiple research communities (as reflected by the eLTER RI consortium). Given the hierarchical design and global governance of LTER, the **eLTER RI secures** both concerted **national contributions to a Continental scale RI** and a highly visible **European input to the global scale** ILTER.

Shareholders (e.g. ministries, funding agencies) expressing their support **will drive the development of the detailed RI design**, business plan and governance structure during the ESFRI Preparatory Phase Project.

Pan-European and global relevance

The eLTER RI will operate a cost-efficient, pan-European, distributed research infrastructure, able to address multiple environmental research issues and challenges related to the current and future state of the European geo-eco-socio-system. This will be done by integrating approaches, from long-term *in-situ* observations to experimentation and remote sensing at a continental scale, and in collaboration with global and related European research infrastructures. By providing coordinated access to numerous sites (and their existing and legacy data) located in relevant ecosystems at European scale, the eLTER RI will be able to utilise national infrastructures efficiently to provide best value for national investments.

The eLTER RI will increase the scientific performance, efficiency, visibility and attractiveness of National Research Infrastructure components as well as the European Research Area in responding to global challenges and global sustainability. The eLTER RI secures Europe's innovative role in long-term global environmental research and provides the European building block for a global network of integrated environmental monitoring and research infrastructures. This is underpinned by the current European

leadership of the global LTER network (International LTER, ILTER) and its development to a Global Research Infrastructure, characterised by the adoption of substantial European conceptual and design elements, and the usage of European LTER services at the global scale (DEIMS site registry and documentation). Reflecting the increased importance and recognition, ILTER was in 2016 acknowledged as Participating Organisation of GEO (Group on Earth Observation) and element of the Global Earth Observation System of Systems (GEOSS)).

RI Components

The eLTER RI will be a distributed research infrastructure. The structure of the eLTER RI consists of A) National Research Infrastructures (NRIs) and B) the European level Central Services, operated either at national or at multi-national level. The eLTER RI will also include the legal entity consisting of at least the eLTER Head Office and the eLTER Service Portal.

A) National Research Infrastructures NRI

National building blocks and *in-situ* facilities of the RI, i.e. eLTER Sites and eLTSER (European Long Term Socio-Ecological Research) Platforms, will form the backbone of the research infrastructure. These will have a hierarchical structure and nested design (eLTER Sites may be nested within eLTSER Platforms and may have smaller, more specialised satellite sites) that allows efficient modular implementation of the RI and enables observations at multiple scales and taking into account regional ecosystem particularities, needs and co-location issues. The eLTER NRI will be highly integrated and follow commonly agreed policies covering data and site access, Intellectual Property Rights (IPR), data management, human resources and procurement and technological harmonisation.

The NRIs are funded at the national level and this funding will need to be continued in order to cover construction/upgrading and operation of NRIs. Requirements and concepts are being discussed and determined during the Preparatory Phase Project (PPP).

B) Central Services

The integration, harmonisation, dissemination and added value services of the RI will be provided through the Central Services that make the RI more than the sum of its national networks, according to agreed statutes and common rules and procedures of the RI consortium. The Central Services are expected to consist of the eLTER RI Head office, the eLTER Service Portal and Topic Centres. The Head office will be responsible for coordinating the RI at the European level in strategy building, concept development and implementation plans, as well as coordinating activities and relations with other environmental research infrastructures. The Service Portal will be responsible for data and transnational access matters, and the Topic Centres will provide support e.g. for technological development, capacity building, data processing and for linking researchers to suitable sites.

The requirements and concepts of the Central Services will be discussed and determined during the PPP. Costs of Central Services, once they have been constructed, will be in the form of personnel, premises, and costs related to operations. Appropriate funding models are being explored and negotiated during the PPP.

Users and services

The eLTER RI will serve a wide variety of user groups, the most important of which are the broad spectrum of ecological, critical zone, biological and socio-ecological research and scholarly

communities around the globe. The services of the eLTER RI will be implemented according to commonly approved strategies coordinated by the Head Office.

Services will include access to well-equipped and sustainably managed research sites and platforms. This will be serviced for the users through the eLTER Service Portal in a coordinated manner. The eLTER RI will also provide access to high quality, harmonised data, data products and tools, remote access (e.g. distributed experiments operated by local teams). The RI will provide training and capacity building, technological innovation, and research and development support. The Topic Centres will provide added value by supporting and working with the NRI in these tasks to provide the highest quality RI services.

Implementation of the RI

The eLTER ESFRI consortium has begun a European Commission-funded Preparatory Phase Project (PPP), that takes place from February 2020 to January 2025. Preparations at institutional, national, European and international levels will require careful planning. This phase will have two objectives: (1) to start upgrading the eLTER Sites and Platforms and to construct - as fully as possible -the central hubs (Topic Centres and Head Office, and (2) to develop the RI as a fully-fledged organisation with a business plan, a coordinating and integrating legal entity, an agreed role for the RI in the context of the landscape of existing European and global RIs, and secured funding, enabling the eLTER RI to proceed to the implementation and operational phases. The detailed structure and funding mechanisms are being jointly developed by partners in the PPP.