LifeWatch

E-Science European Infrastructure for Biodiversity and Ecosystem Research

Scientific and Technical description of LifeWatch ERIC

July, 2015

TABLE OF CONTENTS

1. Vision

1.1.- General background

Biological systems are self-organized, complex entities. Their evolution through time in association to other environmental phenomena results in great variety of forms and functions, which, in turn, encompasses what is termed as "Biodiversity".

Understanding the evolution and function of biodiversity is highly needed, not only for scientific reasons, but also given the urgent challenges the world faces, for instance in buffering environmental change, coping with disease epidemics and the provision of food and natural products by our living environment.

In addition, mitigating biodiversity loss as currently experienced is a one of grand societal challenges. Biodiversity loss is increasingly influenced by anthropogenic-induced impacts, which can be summarized in Population Pressure and Climate Change, resulting also in environmental constraints such as Desertification, Reduced Water availability, and Land-use change, among others (see figure 1).

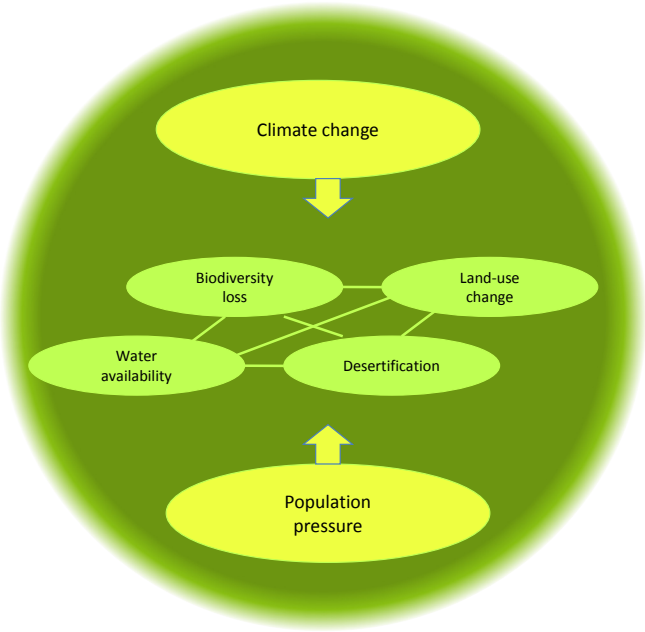

Figure 1. Main Anthropogenic impacts on Earth's environment.

Biodiversity loss is one of the top societal challenges today, and a matter of concern at global, regional and local levels. The UN declared 2011-2020 the decade of Biodiversity, after the global failure to meet targets proposed for 2010. The Europe's response to meet the new Aichi Biodiversity Targets is included in the European 2020 Biodiversity Strategic Plan. The plan drives new challenges to the future biodiversity research agenda in Europe, as expressed by the League of European Research Universities (LERU).

Four great challenges for biodiversity preservation have been identified: Climate Change, Habitat Fragmentation/Loss, Species Invasions, and Compound Impacts. Biodiversity preservation is not only a matter of environmental concern. It is at the heart of the provision of vital ecosystem services, with implications on human health and well-being, and on multiple economic sectors such as agronomy, forestry, fisheries, drug and chemical production, and other industrial applications.

1.2.- Current gaps in biodiversity research

Due to the above-mentioned challenges, environmental policy makers and managers are increasingly asking for scientific-based tools that can support them in taking sound decisions to avoiding or mitigating anthropogenic impacts on biodiversity and ecosystems.

Answering this demand requires the analysis of impacts and managerial actions at different spatial and temporal scales. Its achievement entails observation (and monitoring) data from ecosystems, data from manipulative experiments, the relevant appropriate data storage and curation, the setting of standards to ensure the interoperability of data, accurate models on ecosystem dynamics, and e-Infrastructures where models devoted to specific environmental components can be coupled.

However, there are presently severe constraints that prevent this scheme from being accomplished. The major limitation is that the processes underlying biodiversity are not yet completely understood, and therefore accurate integrative models cannot be constructed unless more research is carried out. In fact, a fifth, overarching challenge in biodiversity research is to understand Biodiversity Ecosystem Functioning (BEF), taking into account all the different organizational levels related to biodiversity: Molecules (genes and proteins); Species; Ecosystems; Time and evolution; and their corresponding scale factors.

In-silico research has a great potential to overcome those limitations through the creation of specific Virtual Research Environment (VREs), which enable to combine large series of data from different sources (data on biodiversity, geomorphology, climate, land use, etc.), and support the execution of integrated models at the meso- or higher scales.

1.3- Virtual Research Environments - A new approach to address current gaps in biodiversity research

The five challenges related to biodiversity research and management are inducing a change in the way research and decision making is conducted. Since they are not related to particular domains or time scales, Big Data from different sources have to be combined and analysed. This new approach represents a change of paradigm on biodiversity research and also demands a new type of facilities where it could be conducted.

Virtual Research Environments (VREs) will be integrated into the LifeWatch distributed ICT e-Infrastructure in order to analyse those data, and to construct and assess models that could account for the factors related with biodiversity evolution. They will be delivered in the form of specific:

- Virtual Laboratories (a.k.a. e-Labs) able to provide the required services and tools to support advanced scientific work in the hot biodiversity research topics. Researchers may combine these e-Labs into multi-step computational tasks for a range of analytical purposes.
- Decision-support applications demanded by environmental managers and other stakeholders to address issues on policies and strategies of (local) governments as well as private companies.

1.4.- Benefits from the construction of an e-Infrastructure for biodiversity research

The role of Environmental Research Infrastructures is essential in setting the facilities to develop basic and advanced science. However, presently there is not any appropriate facility in Europe where large-scale complex models considering the association between environmental domains could be run for biodiversity research and/or management.

Only by implementing an adequate e-Infrastructure present limitations and obstacles for new approaches in frontier research on the biodiversity systems can be overcome.

Its construction enables research needed to understand the processes related to biodiversity functioning, which relies on the construction and testing of associated-models, and to providing the results of those models in the form of tools for environmental managers.

In addition, the implementation of such an e-Infrastructure will have clear indirect benefits: The enhancement of data standardization to ensure their interoperability beyond disciplinary and national boundaries, the promotion of technological developments dealing with both the ICT and the research components of the facility, and the acquisition of new knowledge through the interactions between researchers of many different domains, and the transition to open access and open data, to name but a few. Also, this facility and its new way of performing biodiversity research will be central for educational and training purposes.

Finally, the construction and operation of the proposed e-Infrastructure revolutionizes the way the biodiversity research is currently conducted by offering to the researchers: (a) a working environment with unlimited computational capacity, (b) transparency of the research process at all stages (from data collection to the interpretation of the results), (c) generic applications which allow multidisciplinary research and the development of the "trading zones" between them.

LifeWatch is addressing those challenges by establishing and operating such an e-Infrastructure at the European level.

2. Mission

The mission of LifeWatch is to advance biodiversity research and to provide major contributions to addressing the big environmental challenges, including knowledge-based solutions to environmental managers for its preservation.

This mission is achieved by providing access through a single infrastructure to a multitude of sets of data, services and tools enabling the construction and operation of Virtual Research Environments (VREs) linked to LifeWatch, and where specific issues related with biodiversity research and preservation are addressed.

3. Brief history of the LifeWatch development

LifeWatch was included in the Roadmap of the European Strategy Forum on Research Infrastructures (ESFRI)[1], the body that identifies the new research infrastructures (RIs) of pan-European interest with the goal of promoting the long-term competitiveness of European Research and Innovation.

The concepts behind this European e-Infrastructure were developed in the 1990s and early 2000s, with the support of EU Networks of Excellence related to biodiversity and ecosystem dynamics and functioning. They initiated the design plan for LifeWatch with their understanding that breakthroughs in biodiversity science require a sufficient large European-scale research infrastructure capable of providing the advanced capabilities for data integration, analysis and simulations to complement reductionist experimentation.

Those concepts were formally described during the preparatory phase of LifeWatch (2008-2011) which was funded by a specific project from the 7th Framework Programme. This phase included preparing a Master Plan of the infrastructure and detailing both its building blocks and associated costs.

Subsequently, those concepts were refined taking into account a realistic provision of funds, the existing research facilities which are presently supported by the different countries that have expressed their interest in participating in LifeWatch (see Figure 4 on the right below, e-

[1] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri-roadmap

Infrastructure Resources layer which are mainly based on the National LifeWatch Centres and Third Parties contributions), and the suggestions and comments provided by both the ESFRI high-level Assessment Expert Group and the ESFRI Strategic Working Group on Environment.

Further inputs for fine-tuning of the LifeWatch construction plan arise from the conclusions of recent LifeWatch operational meetings held in Lecce (Italy, November 2013), Granada (Spain, February 2014), Crete (Greece, July 2014) and Málaga (Spain, February 2015).

Its statutes and governance were modified following the comments provided by the European Commission in January 2014 resulting from the step-1 submission of LifeWatch ERIC application back in July 2013.

4. Structure

The LifeWatch ERIC legal entity is established to coordinate the operations of the LifeWatch e-Infrastructure, and to develop, monitor and integrate its activities (see Figure 2). The Statutory Seat of LifeWatch ERIC is placed in Seville, Spain.

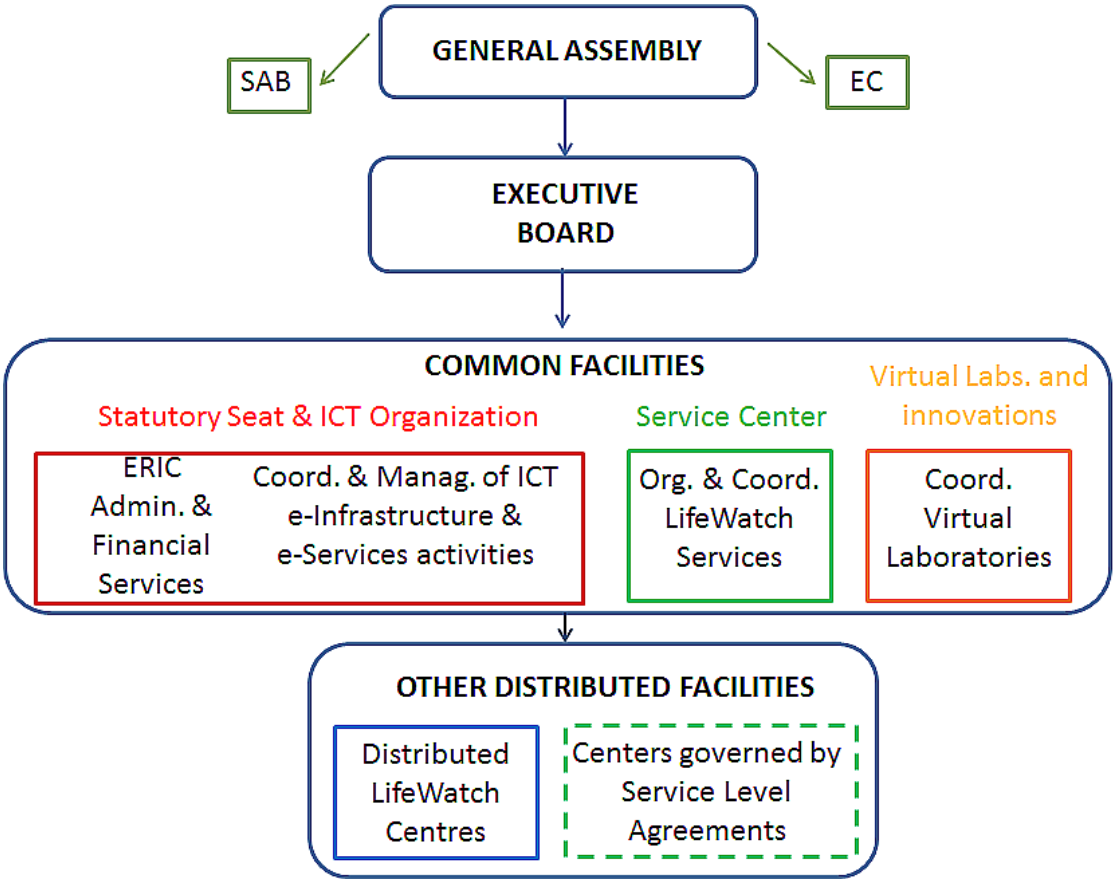

Figure 2. Organisational structure of LifeWatch ERIC and associated e-Infrastructure.
SAB and EC stand for Scientific Advisory Board and Ethical Committee, respectively.

LifeWatch is an e-Infrastructure of distributed nature, composed by Common Facilities and other Distributed LifeWatch Centres, operating at multinational and national level respectively.

Common Facilities - They are located in Spain (Institutional relationships - including organizations acting as data providers and coordinating monitoring sites; ERIC Administrative, Legal, and Financial Services; Organization and Coordination of ICT e-Infrastructure activities and of its distributed construction and operations), Italy (Organization and coordination of LifeWatch Services for the biodiversity community) and The Netherlands (Coordination of Virtual Laboratories and innovations).

More in detail:

The **Statutory Seat and the ICT e-Infrastructure Technical Offices** will jointly assist to the coordination and management of the day-to-day institutional relationships, administrative, legal, and financial issues. Those include, among others, technology transfer, procurement and IPR matters, and the formal agreements with all the external data and e-Services suppliers, and the Service Legal Agreements (SLA) with local, regional, national and international entities, including decision makers and environmental managers. Also, they will coordinate and manage the ICT e-Infrastructure distributed construction, maintenance and deployment operations, including coordination of the design and implementation of e-Services demanded by the Service Centre, the Virtual Laboratories and Innovations Centre, as well as other Distributed Facilities.

The **Service Centre** will provide the interface with the Biodiversity Scientific Commun ity, identify the needs of the multiple users groups from different domains and areas of interest and coordinate the development and operation of those Services related. Also, they will assist in deploying the Services provided by the LifeWatch Research Infrastructure, including those enabling discovery, visualization, and download of data and applications for analysis, synthesis and modelling of Scientific topics. Thus the Service Centre will identify new data resources, incorporate vocabularies, semantics and Services to aggregate larger typologies of data. It will also provide the optimization of the access and use of Service Centre facilities as a whole, and offer web-based tools to facilitate Social Networking and Social Learning (including e-Learning). Finally it will promote the awareness of LifeWatch for users and general public, and the enhancing the visibility of LifeWatch scientific outcomes, by publicizing and disseminating them.

The **Virtual Laboratories and Innovations Centre** will coordinate and manage the requirements and needs analysis, design and implementation of the scientific case studies and productions of the LifeWatch Virtual Laboratories. These e-Labs will be implemented and deployed through the LifeWatch ICT distributed e-Infrastructure facilities, and made accessible through the Service Centre to the Biodiversity Scientific Community. This procedure will guarantee the overall coherence of the Research Infrastructure by promoting synergies in regards to the semantic interoperability among data, services and their final users.

Distributed Facilities - Member countries of the LifeWatch ERIC and scientific networks are encouraged to establish LifeWatch Centres to serve specialized facilities in the framework of the LifeWatch services and in accordance with the overall LifeWatch architectural scheme. They can be established as part of the LifeWatch ERIC or acting as independent entities. As such these LifeWatch Centres may also operate as regional partners.

These Centres are new infrastructures or upgrades of existing facilities **providing access** to:

- Distributed observatories/sensor networks;
- Interoperable databases, existing (data-)networks, using accepted standards;
- High Performance Computing (HPC) and Grid power, including the use of state of-the-art of the so-called Cloud and Big Data technologies;
- Software and tools for visualization, analysis and modeling.

5. Tasks and activities

The main task of LifeWatch is to establish and operate the infrastructure and information systems necessary to mobilize and integrate data and algorithms for biodiversity and ecosystem research, and to provide analytical capabilities (as reflected in Article 2.1 of proposed Statutes).

The list of principle tasks of the ERIC is provided in Article 2.2 of the proposed LifeWatch ERIC statutes. The text of this article is reproduced below in italics, followed by a short explanation.

Proposed LifeWatch ERIC statutes: Art. 2.2.: "To this end LifeWatch ERIC shall undertake and coordinate a variety of activities, including but not limited to:

A. The operation of a single, but distributed, research infrastructure, encompassing: enabling capabilities for demand-driven biodiversity data mobilization; integrated access to distributed data resources; the provision of services for data discovery, analysis, modelling and visualisation; web-based and site-based support for users; and digital environments for scientific cooperation and experimentation."

Biological systems are characterized by self-organization resulting in a high variety of diversity and complexity in order to adapt to external constraints (environments). The LifeWatch infrastructure for biodiversity and ecosystem research is meant to provide advanced capabilities for research on the complex biodiversity systems. These capabilities allow scientists to tackle the major basic questions in biodiversity research, as well to address the urgent societal and fundamental scientific challenges concerning our living planet. Services are directed at offering researchers access to dedicated virtual environments or capabilities to create their preferred e-Laboratory or e-Service, enabling integrated access to biodiversity and ecosystem data, analytical and modelling workflows and computational capacity. Through such virtual laboratories, the infrastructure offers new and faster ways for working together in simulation and scenario development and testing experiments. While researchers will also contribute to novel workflows and new virtual laboratories, their research priorities will shape the further development of the research infrastructure. This in turn will promote demand-driven biodiversity data mobilization. Generic enabling technologies for data generation are promoted by the LifeWatch research e-Infrastructure. Figure 3 summarizes the technical architecture of the LifeWatch e-Infrastructure. LifeWatch will be built to a large extent upon its ICT e-Infrastructure services and technical capabilities, in order to support biodiversity and ecosystem research through the usage of VREs for the support to e-Labs/VLabs and Decision Making Tools, and provide proper e-services. Data and computational Resources are served by contributing facilities and integrated in an e-Infrastructure capability also supporting shared workflows. Composition offers capabilities for new workflow development in a semantic metadata framework. User groups can create their own e-Laboratories and they may share their data and analytical and modelling tools with others while keeping a controlled access.

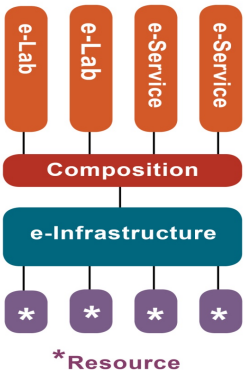

Figure 3. Basic architecture of LifeWatch e-Infrastructure.

LifeWatch is a distributed research e-Infrastructure. Specific VREs with their preferred workflow services can be constructed in by distributed local specialists. Since LifeWatch has the characteristics of an e-Infrastructure it is possible to integrate these construction components in a single infrastructure service through the Internet.

Access to the infrastructure services is open to all users and not restricted. Application and selection procedures will apply when capacity for user support is limited. See also paragraph 5C of this document.

B. The support of and cooperation with national and international facilities on the basis of service level agreements, with respect to data mobilization and data sharing; computational capacity; and development of new infrastructure capabilities- including exploration of a role as a broker coordinating requirements and delivery plans between national and international facilities, institutions and organisations.

National LifeWatch Centres ("Nodes"), established in the member countries of the LifeWatch ERIC, contribute to the infrastructure construction and operation with specialized capabilities.

LifeWatch Centres, established as independent entities in the member countries of the LifeWatch ERIC or as thematic services for scientific networks, contribute to the infrastructure construction and operation with specialized capabilities (e-Labs). These contributions are part of the LifeWatch research infrastructure and have to meet the standards and protocols according to the LifeWatch Reference Model. Construction contracts and Service-Level-Agreements (SLAs) secure effective operations and provide the basis for calculating national in-kind contributions.

LifeWatch research infrastructure benefits from international facilities in regards to data mobilization, data sharing, computation capacity and development of new e-Infrastructure capabilities. The concept of SLAs also applies for these facilities.

C. The building of capacity in order to foster new opportunities for large-scale scientific development; to enable accelerated data capture with new technologies; to support knowledge based decision-making for the management of biodiversity and ecosystems; and to support training programmes.

The LifeWatch research infrastructure offers substantial new opportunities for researchers. As the first infrastructure of its kind, LifeWatch will enable its users to enter new areas requiring an advance support from the infrastructure capabilities. However, the infrastructure services will have to invest in capacity building in order to promote full and optimal use of the new capabilities. Therefore, training actions encompass one of the main pillars of the LifeWatch Service Centre, including physical and e-learning activities. To this end, the Service Centre will organize and implement capacity building with emphasis on new and young researchers.

The Service Centre also promotes large-scale scientific cooperation on urgent scientific questions. The LifeWatch infrastructure is designed to support large-scale cooperation in dedicated virtual research environments. This in turn will enable targeted and accelerated data capture for the scientific priorities.

Urgent scientific questions also have societal relevance in regard to tackling biodiversity loss and the resulting negative effects on ecosystem services. Capacity building is also required to engage applied researchers in the LifeWatch capabilities for knowledge based decision-support for the management of biodiversity and ecosystems. The user basis from the new EU member states and underrepresented regions is especially encouraged. The distributed structure of the LifeWatch RI is suited to offer a decentralized, but federated-based model support. Since the interest in LifeWatch is also in growing outside Europe, special attention will be paid to providing access to knowledge and expertise to developing countries (e.g., in Latin America, Africa, etc.), which have large Biodiversity resources and will thus benefit from LifeWatch research facilities oriented to study the underlying processes.

D. The maintenance of a capacity for the upgrading of the research infrastructure, the innovation and valorisation of knowledge and technology, and the development of new analytical capabilities.

The LifeWatch research infrastructure wants to define its ambitions with a target to enable new scientific and technical developments beyond our current knowledge. Only in this way the infrastructure can continue to act as a leading research environment and will attract the scientific excellence capable to achieve major breakthroughs. This in turn will foster innovations and also secure upgrades of the infrastructure. In accordance with Article 3.2 of Regulation (EC) Nº 723/2009, some of those developments may be form part of the limited economic activities of LifeWatch ERIC (see section 10 of present document for more details).

6. Architecture

LifeWatch infrastructure will meet a number of key requirements:

- 'Fit for Purpose': flexible, secure, adaptable, robust, resilient, scalable, and maintainable.
- Integration of "external resources", provided by institutions and networks concerned with ICT technologies and biodiversity research.
- Offering an attractive set of capabilities to users and other stakeholders.
- User-friendly at different levels of knowledge in both science and policy domains.
- Non-proprietary – based on open standards (in application of EU Openness Directives).
- Based on existing technological solutions wherever appropriate, and Adaptive to the heterogeneous IT landscape of Europe wide research IT.
- In selected areas, parallel research into cutting-edge technologies to ensure adoption of new approaches and to contribute to ERA bioinformatics development.
- Staged approach to construction and deployment. Long term outlook on all desired functionality within a realistic, controlled and manageable construction process.

LifeWatch e-Infrastructure is composed by four major layers (see Figure 4).

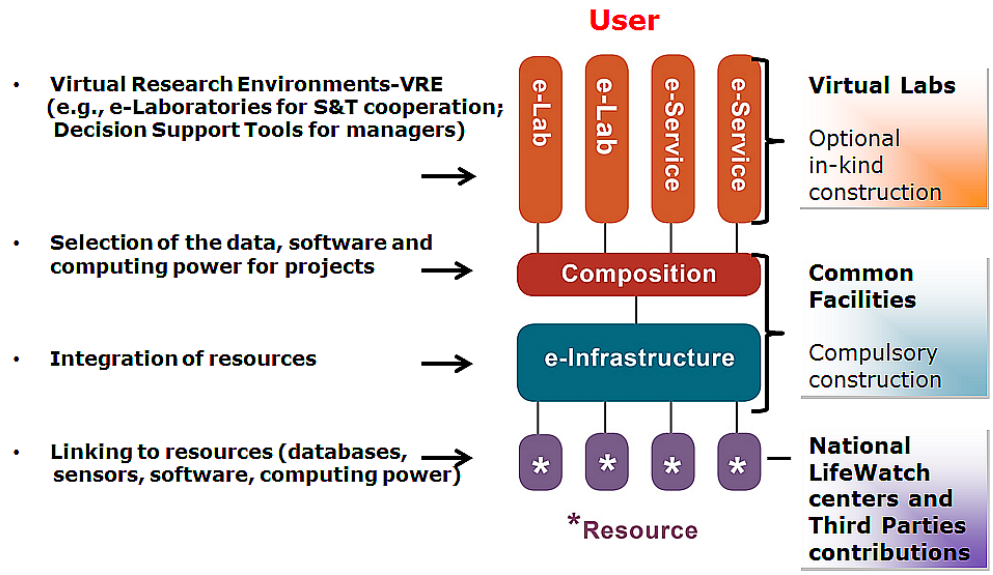

Figure 4. Detailed architecture of LifeWatch e-Infrastructure.

The coordination and management of the LifeWatch ICT e-Infrastructure distributed construction operations and its further operational incremental (ITIL[2]-based) maintenance will be carried out by an ICT e-Infrastructure Technical Office located at the common facilities placed in Spain, which will support the ICT Director of LifeWatch ERIC.

[2] It is an acronym of "IT Infrastructure Library"

The ***Resource*** layer contains the specific resources, such as data repositories and collections (i.e., LTER, GBIF, CETAF), computational capacity and sensor networks, and High Performance Computing (HPC) resources, which contribute to the LifeWatch system. It is supported by contributing facilities and in turn integrated in an e-Infrastructure layer which also serves shared workflows. The Resource and e-Infrastructure layers will incorporate tools from existing networks and e-Infrastructures such as, LTER, GBIF, CETAF, among others. This will provide a basis for interoperability between LifeWatch and other existing and future systems.

The ***e-Infrastructure*** layer enables to share the specific resources as generic services in a distributed environment spread across multiple administrative domains. Some of the capabilities of this layer will be provided by underlying Europe-wide e-Infrastructures (for example, EGI.eu and its supporting IBERGRID through a proper LifeWatch EGI.eu Competence Centre) and these will also play a prominent role in delivering the Composition layer of LifeWatch, under the coordination and supervision of the above-mentioned ICT e-Infrastructure Technical Office of the common facilities. Similarly, in order to ensure commonality of data management modalities for differing data sets / data providers, the ICT e-Infrastructure will have to take into account the data management guidelines that are likely to emerge over the coming years.

The ***Composition*** *layer* supports the selection and combination of services for task completion. It offers resources for new workflow development in a semantic metadata frame.

The ***User*** layer enables the different research communities to create their own Virtual Research Environments-VRE (e.g., e-Labs, decision making tools, etc.); users may share their data and analytical and modelling tools with others while controlling access to them.

At the Composition and User layers, LifeWatch expect to adapt and extend mechanisms from existing networks and e-Infrastructures, as well as from relevant e-Science projects.

Figure 5 provides further vision of the main activities performed at the different layers.

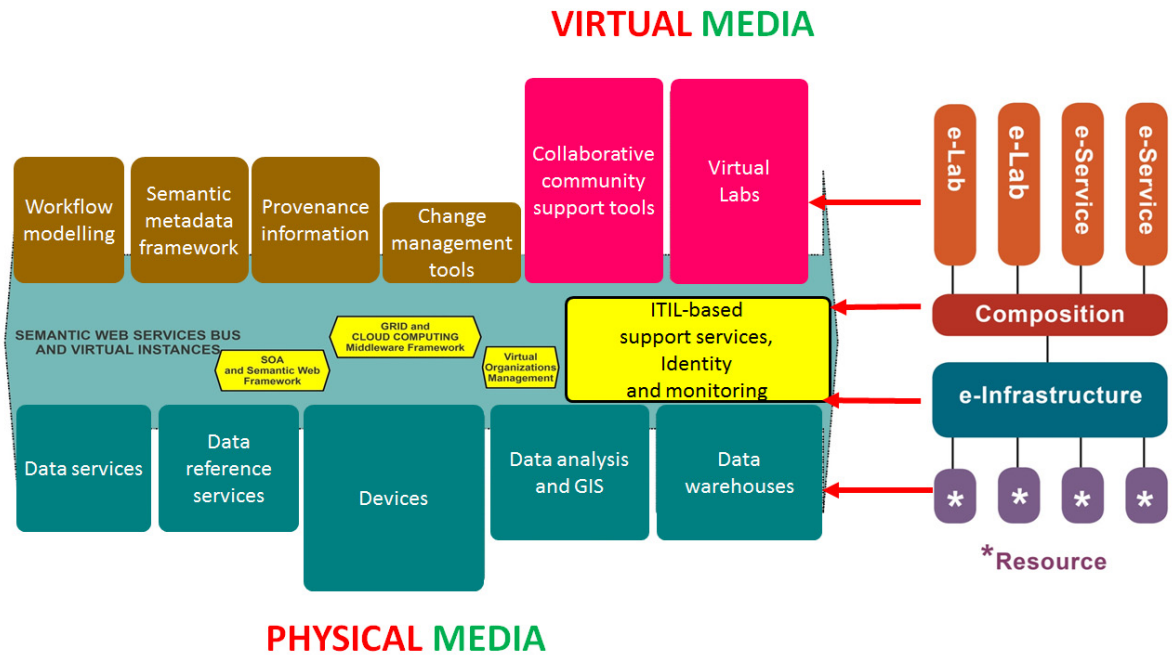

Figure 5. Main activities performed at the different layers of LifeWatch e-Infrastructure.

The Construction of the LifeWatch Technological Infrastructure will proceed in multiple strands of delivery based of the following services, which will be delivered:

- Support Services
- Data Services
- Tools integration
- Workflow Services
- e-Infrastructure (Grid and Big Data) middleware deployment
- Semantics-based Mediation Services
- VRE (e-Labs & Decision Support Tools)
- Temporary Collaborative Networks management

Figure 6 shows some examples of data, modelling and analysis capabilities based on the expected e-Services provided by LifeWatch distributed e-Infrastructure:

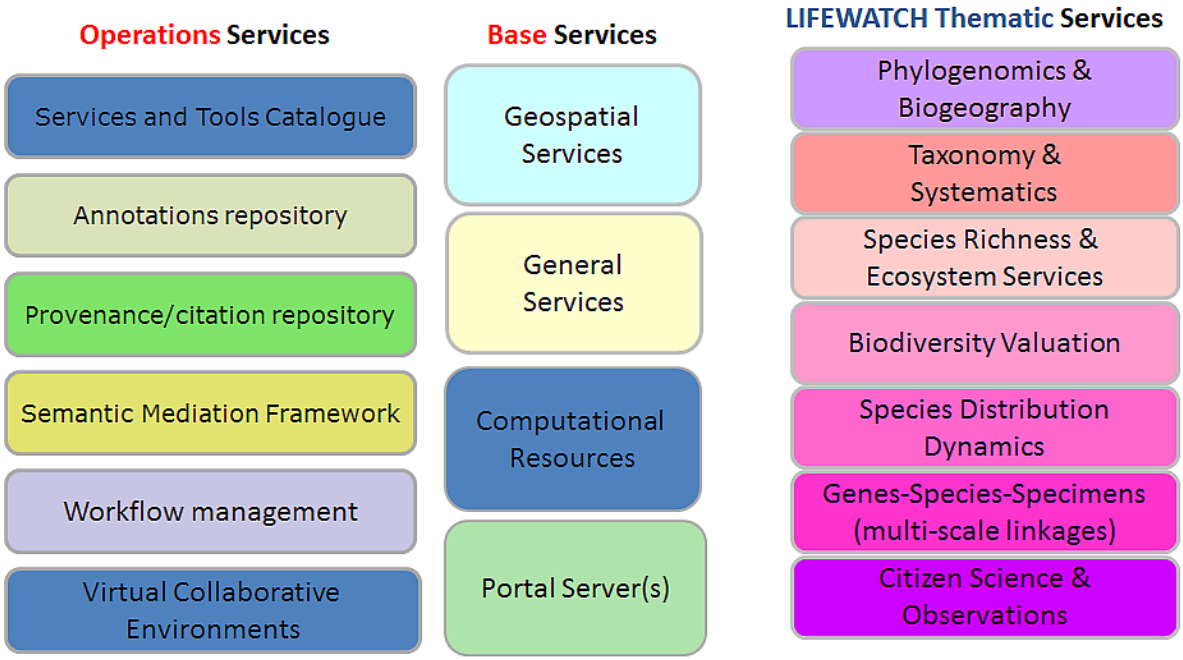

Figure 6. Examples of main services provided by LifeWatch e-Infrastructure.

The guidelines of the construction of the LifeWatch Technological e-Infrastructure will be based on an incremental but iterative delivery ITIL model-based Methodology; the strands, being mutually dependent, will be developed simultaneously in stages in response to user needs. Agile processes will be used to implement new functionalities based on the users' requirements and feedbacks, so robust and secure can be deployed at scale, if feasible at both technical and financial level.

7. Specific ERIC requirements relating to Article 4 of the ERIC regulation

7.1. Necessity

The infrastructure is necessary for carrying out European research programmes and projects, including the efficient execution of Community research, technological development and demonstration programmes.

The League of European Research Universities (LERU) clearly expressed that "biodiversity research would greatly profit from a synthesis of the data on taxonomic identity, species' indicator values, geo- physical data, distribution data, climate data, remote sensing observations, and sensor networks". Its Advice Paper of June 2010 stated: "The transition to a transparent, efficient, open access infrastructure where data, resources, analytical and modelling tools and, foremost, people and expertise come together is imperative to meet the

challenges of the future. Europe must invest in adequate infrastructures to support biodiversity research to increase our knowledge of the impact of biodiversity on the functioning of ecosystems and hence help decision makers in devising cost-effective management plans to reach the stated goals. European-wide biodiversity infrastructures, such as LifeWatch, are of key importance".

The main EU Networks of Excellence initiated the design plan for LifeWatch with their understanding that breakthroughs in biodiversity science require a sufficient large European-scale research infrastructure capable of providing the advanced capabilities for data integration, analysis and simulations to complement reductionist experimentation.

Only by implementing the LifeWatch research infrastructure it would become possible to overcome the present limitations and obstacles for new approaches in frontier research on the complexity of the biodiversity system.

7.2. Impact on strengthening and improving the European Research Area

As one of the first infrastructures of its kind, LifeWatch will allow its users to enter new research areas supported by its e-Infrastructure, which represents an added value in strengthening and structuring the European Research Area (ERA) and a significant improvement in the relevant scientific and technological fields at international level.

One of the objectives of the LifeWatch research infrastructure is to promote improved structuring of the research area and adding value in strengthening of the ERA. LifeWatch is addressing the recommendations of the European Research Area report as published in its strategic view "Preparing Europe for a New Renaissance" (2009). The report is stressing "A new, **holistic way of thinking** is required as technological answers alone are not the end-solution to a given problem". It also states that "we need to develop better tools to predict trends, to supply evidence for decisions". LifeWatch provides the instruments to empower scientists and other users, as its Virtual Research Environments (VREs) will enable ideas and people to move in an open way within a digital context.

In addition, it will also benefit the ERA through:

- The design of infrastructure capabilities driven by scientific and societal needs.
- Enabling new ways for interaction and cooperation of science, policy and society.
- Providing the adequate environment for the interaction of user-driven research, training and innovation activities[3].
- Cooperating with the private sector in developing the best ICT technologies needed for its construction and operation and in providing innovative applications derived from the research carried out in the infrastructure.
- Delivering excellence, as a key principle by building capacity and by the priority of the most promising talent.

7.3. Effective access

Access to LifeWatch is open and effective for any user through the infrastructure portal. This portal facilitates joining existing virtual labs or the creation of new virtual labs, while benefiting from data sources and analytical tools.

When services have a limited capacity or the services provided by LifeWatch ERIC as an infrastructure need to be prioritized due to limited management capacity, the General

[3] Europe 2020 Flagship initiative "Innovation Union" identified the role of world-class Research Infrastructures such as LifeWatch for the completion of the European Research Area. It highlights their role to attract talent into innovative clusters and as a breeding ground for ICT, and key enabling technologies. Therefore they are also relevant drivers for national and regional economies. LifeWatch demands technological developments for the construction and operation which are the fore-front of present knowledge, enhancing the development of long-term sustainable innovation capacity and competitiveness. http://ec.europa.eu/research/innovation-union/pdf/innovation-union-communication_en.pdf

Assembly shall decide on the proposed use of the LifeWatch Research Infrastructure under its independent scientific and technical evaluation policy (see Article 15 of the proposed statutes).

7.4. Contribution to the mobility of knowledge and/or researchers within the ERA

The infrastructure is in principle unrestricted with respect to the mobility of knowledge within its digital environment. The concept of virtual laboratories is strengthening such mobility since they provide new approaches with respect to collaboration and interaction. When users want to work at a physical LifeWatch site, they will have access to the various distributed LifeWatch Centres of their choice. The independent scientific evaluation policy supports the priority for excellent researchers and their ideas.

7.5. Dissemination and optimisation of the results of activities in the Community research, technological development and demonstration.

LifeWatch has the objective of being a "first class" worldwide provider of contents and services for Biodiversity community by establishing:

- New opportunities for large-scale scientific development;
- Enabling of accelerated data capture with new innovative technologies;
- Knowledge based decision making-support for the management of biodiversity and ecosystems;
- Supporting environmental training, dissemination and awareness programmes.

In addition LifeWatch will:

- Support the generation of (open access) publications with on-line availability of the data and algorithms underpinning the interpretation of results and the conclusions in the publications.
- Provide a new environment where the detailed pathway taken by the scientist in order to test a hypothesis will be readily available for any kind of evaluation by any reviewer through the traces of the process left in the infrastructure.
- Promote that new data and algorithms will be shared with other users, finally resulting in the expansion of the infrastructure capabilities. Such public domain developments are embedded in the LifeWatch operations.
- Encourage the publication of scientific results in open access journals and comparable media.
- Provide e-services in order to facilitate different ways for the dissemination and transfer of results from scientific and technological research, support biodiversity management, perform technological demonstrations, and incorporate innovations.

8. Synergies and complementarities with other European and Global resources and initiatives

8.1.- International cooperation

The complexity of the above-mentioned challenges related with biodiversity research and the interlinkage of different scales and domains demands international cooperation. Therefore several high level world-wide initiatives have been developed in recent years to address those challenges, such as:

(a) The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES, doing what IPCC did for Climate Change for Biodiversity).
(b) The definition of the Nagoya 2010 CBD Targets to take effective and urgent action to halt the loss of Biodiversity, ensuring that by 2020 ecosystems are resilient and continue to provide essential services.

(c) The Global Earth Observation-Biodiversity Observation Network (GEO-BON) as established by the Group of Earth Observations in the framework of GEOSS.
(d) The fundamentals of the Economics of Ecosystems and Biodiversity (TEEB-2010).

Presently, there are large Networks of Excellence covering specific aspects of biodiversity, such as those related to terrestrial long-term ecological research and observations, marine reference and focal sites, natural science collections, etc. These networks currently provide large data-sets of excellent observational records on different environmental domains.
LifeWatch has taken into account current existing capabilities at the regional, national and European levels. It will put special attention to the initiatives promoted at the European level and their integration at the global scales, and their associated technical novelties.

Indeed, LifeWatch has already established linkages with several facilities and initiatives based on the contributions from International initiatives:

- *EGI.eu/IBERGRID-IBERLIFE through the **LifeWatch EGI.eu Competence Centre**:*
  - *EGI.eu* "European Grid Initiative"
  - *IBERGRID* - the joint initiative of Portugal and Spain National Grid Initiatives (NGI.PT and NGI.ES). In turn, these initiatives rely on EGI.eu. The *IBERLIFE* initiative (Iberian joint initiative PT-ES for LifeWatch) relies on *IBERGRID*.
- *EU BON "Building the European Biodiversity Observation Network"*
- *EUBrazilOpenBio "Eu-Brazil Open Data and Cloud Computing e-Infrastructure for Biodiversity"*
- *EUDAT "European Data Infrastructure"*
- *GBIF "Global Biodiversity Information Facility"*
- *GBIO "Global Biodiversity Informatics Outlook"*
- *iMarine "Data e-Infrastructure initiative for Fisheries Management and Conservation of Marine Living Resources"*
- *VECTORS "Vectors of Change in Oceans and Seas Marine Life, Impact on Economic Sectors"*
- *EMBOS "European Marine Biodiversity Observatory System"*
- *LTER.EU "The Long Term Ecological Research Network Europe"*
- *COOPEUS "Strenghtening the cooperation between the US and the EU in the Field of Environmental Research Infrastructures". In special, with the NEON "National Ecological Observatory Network" from USA.*
- *CETAF "Consortium of European Taxonomic Facilities"*
- *CReATIVE B "Toward a Global Virtual Environment for Biodiversity Research" Project. E.g: SANBI "South Africa National Biodiversity Institute", CAS "Chinese Academy of Sciences", DataOne "Data Observation Network for Earth", CRIA "Reference Centre on Environmental Information Brazil" and ALA "Atlas of Living Australia"*
- *PESI "A pan-European Species directories Infrastructure"*
- *EOL "The Encyclopedia of Life"*
- *COL "Catalogue of Life"*
- *ViBRANT "Virtual Biodiversity Research and access Network for Taxonomy"*
- *BioVel "Biodiversity Virtual e-Laboratory"*
- *ENVRIPLUS "Common Operations of Environmental Research Infrastructures"*
- *GLOBIS-B (Global Infrastructures for supporting biodiversity research)*

LifeWatch is following and complying with developments of EU policies and regulations regarding interoperability of data, Intellectual Property Rights (IPR), e-Infrastructures, etc. For this reason LifeWatch is contributing to the adoption of the guidelines proposed by the Research Data Alliance (RDA) in tightly connection with recent **OPENNESS European Union Directives.**

8.2.- LifeWatch in the pan-European Environmental Research Infrastructure landscape

The European Strategy Forum for Research Infrastructures (ESFRI) is working closely with the e-Infrastructure Reflection Group (e-IRG) to examine ways in which ESFRI Research Infrastructures and their users can engage and exploit common e-Infrastructure services to satisfy their requirements.

Figure 7 illustrates the central place of LifeWatch as the e-Infrastructure providing support not only to researchers and environmental managers focused on the analysis of biodiversity data of specific domains and spatial scales but also for those searching for an integrated view of the processes driving biodiversity at larger scales and domains and using a great set of parameters.

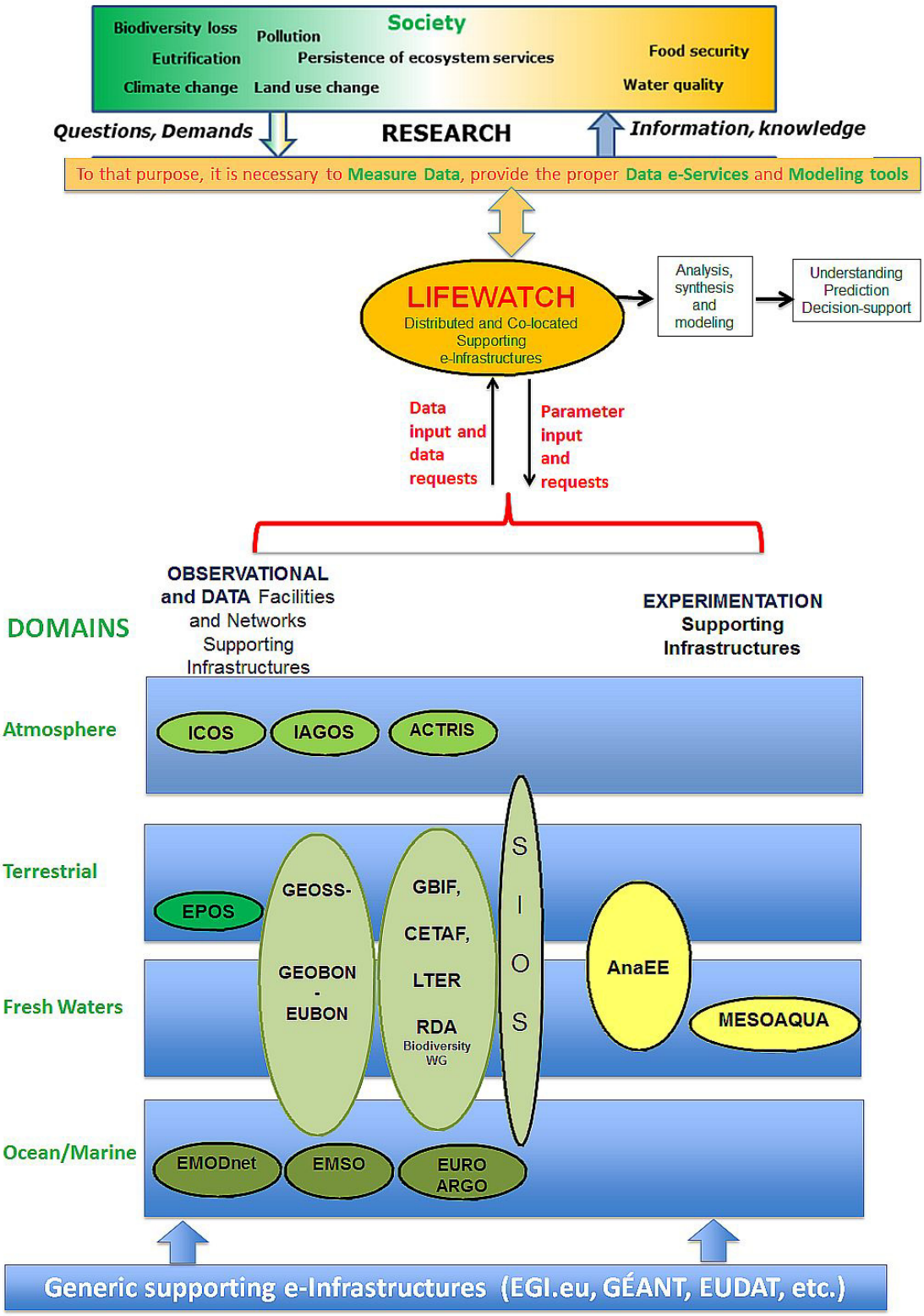

Figure 7. Relation of LifeWatch with other pan-European infrastructures and initiatives

The LifeWatch infrastructure is enabling the connection and analysis of the datasets as collected at different specific environmental facilities operating at regional, national and European level. Many of these facilities and networks are established to collect spatial and temporal series of data on specific environmental domains to support the analysis of trends and to identify the mechanisms and the causes behind relevant threats the society is now facing such as: Biodiversity loss, Eutrophication, Non-Indigenous Species, Climate change, Land use change, Food security and Water quality.

This is the case for the ESFRI Environmental facilities which are about to be implemented such as ICOS and IAGOS (greenhouse and trace gases in the atmospheric domain, respectively), EuroArgo and EMSO (in the marine and oceanic domain), EPOS (in the terrestrial and marine domains). To some extent this vision also applies to SIOS, a facility which looks for an integral observing system to evaluate the processes occurring in the Arctic Region, or EPOS, which is focused on data collection and analyses on parameters related with processes occurring at the European Plate.

LifeWatch is aware of the global initiatives related with the provision of data services such as GEOSS or GEOBON (and its European daughter project EUBON); GBIF, CETAF and the results of the RDA Biodiversity Working Group to this regard.

Based on the previous Figure 7, LifeWatch will contribute to the dissemination and optimisation of the results of activities in the Environmental (especially Biodiversity) Community. Such contributions are effectuated in various ways:

- By infrastructure support for the generation of (open access) publications with on-line availability of the data and algorithms underpinning the conclusions in the publications.
- By promoting that new data and algorithms ("modelling") will be shared with other users, finally resulting in the expansion of the infrastructure capabilities. Such public domain developments are embedded in the LifeWatch operations.

LifeWatch is cooperating with other pan-European initiatives recently proposed to enter the new ESFRI roadmap (2015-2016), such as DANUBIUS and eLTER.

8.3.- LifeWatch and Horizon 2020

From the research perspective, LifeWatch will be at the heart of the following Societal Challenges which have been identified in the current R&D & Innovation European Framework Programme – Horizon 2020 (H2020):

- Food Security, Sustainable Agriculture, Marine and Maritime research and the Bio-Economy
- Climate Action, Resource Efficiency and Raw materials

In fact this facility should provide support to the ERANETs which are specifically focused on Biodiversity (BiodivERsA & BiodivERsA2) or some Joint Programming Initatives (JPIs) such as JPI Water or JPI Oceans or BioDiv).

From the ICT perspective, and due to its nature of e-Infrastructure, LifeWatch is well positioned to influence and take benefit of the developments of the second Pillar of H2020, with a special focus on Information and Communication Technologies.

Indeed, LifeWatch wants to define its ambitions with a target to enable new scientific and technical developments beyond our current knowledge. Only in this way the infrastructure can continue to act as a leading research environment and will attract the scientific and technological excellence capable to achieve major breakthroughs. This in turn will foster innovations and also secure upgrades of the infrastructure in a sustainable way, taking into in mind it will deepen scientific and technological knowledge to find solutions for environmental issues.

The envisaged innovations associated to this chapter, such as a new generation of "smart" technologies (including components and systems), next generation computing, the future Internet, content technologies and information management, and advanced interfaces, will make LifeWatch especially suitable to incorporate and test those developments. In addition, LifeWatch could indicate private developers the needs of its users so they could take them into account while designing their products.

9. Challenges associated to LifeWatch construction

The following major challenges associated to the construction of LifeWatch e-Infrastructure have been identified:

(1) *Gap between current practice and future vision*: Currently a reductionist vision prevails in biodiversity research. A change of paradigm is needed to find patterns and define the underlying processes. LifeWatch will favour this new approach by enabling the analysis of enormous datasets, considering a wide range of scales.

(2) *Heterogeneity* of the community's requirements, data resources and tools, and how to deal with the complexity of the interconnected nature of Biodiversity and Ecosystem ideas, outputs and repositories.

(3) Fragmentation of the community as induced by the large variety and scope of actors (researchers, curators, managers, companies developing applications), habitats (marine, terrestrial, freshwater, etc.) and scales (biological organization, function, space, time) of interest. LifeWatch already greatly helps to reduce this fragmentation and support cross-disciplinary research by providing a common set of e-services, and promoting the adoption of standards.

(4) Fragmentation of data - In the last years a large number of European and national projects have produced relevant data, information and knowledge on the biodiversity and ecosystems domain. However, this information is fragmented. LifeWatch will improve the accessibility to dispersed and fragmented data, and provide the necessary analytical power to uncover new patterns from complex systems. Therefore, as a stable and sustainable RI it will foster research in environmental sciences.

(5) *Need of interoperability* among a wide spectrum of data, information, and knowledge repositories, and also considering the multiple ideas and outputs provided by model applications. As such LifeWatch will pay special attention to the recommendations provided by the Research Data Alliance (RDA).

(6) *Development of new model applications*; nowadays, the integration of the existing applications shows that the models they are based on are poorly linked, fed by not relevant or accessible data, which in turn do not provide enough synthesis and understanding. Therefore, new model applications must be developed in order to deal with the complexity associated to Biodiversity Data (Ecosystems, Species and Genes), Biodiversity Functions, the instruments that are needed for its study (Collections, Observatories, Analysis and Modelling tools), and their connections.

(7) *Scale of implementation of a pan-European infrastructure.* Connection with users and data generators through external liaisons with:

   a. Other research infrastructures such as ELIXIR, the "Integrated Carbon Observation System" (ICOS), the "European Multidisciplinary Seafloor and Water Column Observatory" (EMSO), and the "European contribution to ARGO Programme"-EURO ARGO, JERICO-Next), among others.

   b. Large Networks of Excellence (which in turn may also gather other relevant national countries initiatives) in the oceanic and marine, terrestrial, limnological research domains.

(8) *Fast pace of innovation in ICTs* – In order to avoid getting obsolete LifeWatch will need to implement the new ICT development. Its coordinated distributed architecture favours the application of those innovations.

(9) Fit with mainstream industry and Higher Education/Research sector directions for ICT service, that is, the composition of e-Services to provide new Virtual Research Environments (including Virtual Laboratories, eLabs, and Decision Making Tools) through Internet.

10. Economic sustainability and socioeconomic relevance

The economic sustainability of the infrastructure will be granted from the income provided form its economic and non-economic activities.

10.1.- Funds from non-economic activities

As stated in the proposed statutes of LifeWatch ERIC (see Article 14.1) its resources shall be derived from membership contributions, grants, donation, contracts, and any other source related with its non-economic activity. Annex 2 of the statutes establishes the principles for the contribution of each country as member of the ERIC, based on the share of the GDP in the total GDP scale, and will take into account the multiannual five-year Working Programme.

The contribution can be in cash or in-kind. The maximum percentage of the in-kind contribution cannot go beyond 85% of the national contribution. The annual 15% in cash contribution shall be directly allocated to the costs of common operations of LifeWatch ERIC.

Part or all of the in-kind contribution of a given Member country may be allocated to its Distributed LifeWatch Centre (see section 4 of present document), constructing new facilities or upgrading existing capabilities. To ensure the efficient use of LifeWatch resources, during the first-five years envisaged for its construction most in-kind contributions will be devoted to upgrade existing capabilities.The valuation of in-kind contribution shall follow objective rules, previously approved by the General Assembly.

In addition, the three countries hosting the Common Facilities will provide additional in-kind contributions to support them (site premium).

Construction contracts and service-level-agreements secure effective operations and provided the basis for calculating national in-kind contributions.

10.2.- Funds from economic activities

Although LifeWatch ERIC shall pursue its tasks on a non-economic basis, it may carry out limited economic activities closely related to its tasks, provided they do not jeopardize the achievement of its primary objectives (see article 14.1) in accordance with Article 3.3 of Council Regulation (EC) No 723/2009. To that end, it may be part of other entities or incorporate other legal entities under the Implementing Rules, Guidelines or Regulations approved by the General Assembly.

Any economic activities will be assessed against these provisions. Successful economic activities will be guided to a spin-off company. The LifeWatch infrastructure may decide to establish a company to process economic activities at its own risk.

10.3.- Socioeconomic relevance

LifeWatch will contribute to the overall improvement of European competitiveness, when considering a **globalised knowledge economy**. As a world class RI with linkages with international initiatives, LifeWatch will attract talent, and promote the development of ICT innovations with the support of interested companies. In addition, the research on biodiversity carried out in its facilities will improve the knowledge and management of biodiversity, enabling the sustainable use of natural resources.

Europe 2020 Flagship initiative "Digital Agenda for Europe", especially is Pillar V Research & Innovation (e.g., in Action 53), emphasizes the important role of e-Infrastructures to equip competitive research environments. The coordinated but distributed nature of LifeWatch is especially suited for **promoting regional competitiveness across Europe,** by maintaining or developing innovative clusters associated to ICT developments that could have applications in other domains as key enabling technologies. Those developments could be approached by their business sectors, particularly SMEs, to increase regional growth and employment.

In fact, many regions have become aware of its potential for capitalizing already existing investments and improving ICT developments and taking the benefit from trans-national cooperation. Moreover, some less favoured regions have specially mentioned LifeWatch in their **Research and Innovation Smart Specialization Strategies (RIS3),** acknowledging its potential to raise the academic, technological, economic and environmental standards of their administered territories**.** The adequate and coordinated usage of different funding resources, such as regional and national programmes combined with structural funds, H2020 or ESIF, will promote the development of those competitive research environments.