

## Executive Summary

Human welfare depends on the availability of ecosystem services, the provision of which is in many cases seriously threatened by anthropogenic activities. The key to anticipating and predicting the consequences of these unprecedented changes in our Earth system lies not only in a better understanding of the complexity of ecosystems processes and their drivers, but also in acquiring the necessary knowledge to better plan for a changing future. Without a sufficient understanding of the interdependencies between ecosystems and the environment, Europe will remain unable to assess the impacts of anthropogenic change, mitigate the risks and plan accordingly. For example, further analysis has yet to be conducted on process-level changes affecting ecosystems structures and functions, which would help optimize the production of nutritious foods, goods and services, in a way both environmentally sustainable and compatible with our population growth and energy demands. Expected changes are typically non-linear or stochastic in nature and as such, a complete analysis requires new integrated approaches beyond those of a typical research project, which operates on short funding cycles (that is, no more than a few years at a time). Fully integrated infrastructures would indeed allow us to elucidate these unknown processes and develop new decision-making tools. This would also provide actionable insights into greenhouse gas mitigation, climate adaptation, water resource management, food security and changes in regional biodiversity.

The Analysis and Experimentation on Ecosystems project (hereby referred to as AnaEE) is a Research Infrastructure (RI) designed to provide the necessary research to advance our ecological literacy and analytical and decision-making tools for societal benefit. At the core of AnaEE are experimental facilities with the capacity to subject ecosystems to expected future conditions and states and ascertain the role of individual forcing variables and their interactions on ecosystems processes. To achieve these goals, AnaEE's experimental approach is grounded in the integration of Manipulation, Measurements, Modelling, Mitigation and Management. AnaEE's infrastructure includes state-of-the-science experimental approaches from novel manipulation facilities and process-level measurements, to innovative statistical studies and models. Replicated experiments can be paired in both controlled environments and natural *in situ* conditions throughout Europe, being co-located with other existing long-term observational networks providing high-quality data to parameter our experimental models and extrapolate beyond the boundary of the experiment itself. Thus, AnaEE directly confronts the socio-ecological concepts of resilience, adaptability, transformability, recovery and mitigation.

Expanding on the introduction of AnaEE to the ESFRI roadmap in 2010, the AnaEE ERIC will be established to become a cornerstone in building a sustainable future for Europe and, the creation of a viable bio-economy. AnaEE's stakeholder engagement policies include building a global community of researchers, science managers, policy-makers, public and private sector innovators and citizens. AnaEE partnerships lie at the nexus of the environmental, health and food, policy, management and decision-making domains. AnaEE's wide range of partners also provides the infrastructure with a unique opportunity to leverage further resources, tools and expertise in multidisciplinary integrative studies, in conjunction with economic models, business strategies and societal benefits.

AnaEE also aims to transcend traditional barriers to work together, by realizing a broader vision of international collaboration where AnaEE would resonate in Europe and globally. The importance of global environmental research emanates from the interconnectedness of worldwide problems, issues and implications. AnaEE collaborations will contribute to pool our knowledge together and share lessons-learned in crafting large-scale research infrastructures, as well as expand on our results and findings globally. At the EU level, AnaEE operates as part of ENVRIPlus, to develop interfaces with other

ESFRI roadmap RIs including ICOS, ACTRIS and LIFEWATCH. International and inter-ESFRI partnerships extend our sphere of inference even further, which is so essential to addressing today's global challenges. Such collaborations also reduce the duplication of efforts. Worldwide, AnaEE cooperates with large scale international RIs to establish a sustainable cooperation between environmental research infrastructures. Doing so will allow us to pool our knowledge together and share lessons-learned in crafting large-scale research infrastructures, as well as expand on our results and findings globally. Taken in concert, broader EU and international integration of RIs will develop our capacity to address cross-continental questions and challenge our theories, in ways previously impossible. This realigns EU ecosystems (and the services they provide) in the broader context of the ever-increasing connectedness of the world.

AnaEE will end its Preparatory Phase in 2016 and plans on becoming an ERIC by 2018. It will be governed by a Central Hub that will coordinate access to the experimental, analytical and modelling National Platforms and the collaborations with European facilities which are together the very fabric of AnaEE. The hub will also facilitate the implementation of joint projects and provide an interface for multiple stakeholders, including researchers, universities, ministries, governmental authorities and NGOs. The AnaEE ERIC will include 3 Supranational Service Centres, respectively in charge of (1) developing technology, harmonizing methods, building industrial partnerships and facilitating knowledge transfer, (2) data standardization and modelling, and (3) the interface with stakeholders, scientific results synthesis and dissemination.

Among the platforms that expressed their interest in AnaEE, more than a hundred National Platforms were identified on the basis of their excellence. Because each platform has its own suite of protocols and instrumentation they will proceed to any necessary upgrades prior to joining the AnaEE RI. This will both optimize the cross-use of platforms in pan-European experiments (in a way that is both consistent and feasible) and ultimately engage individual platforms to take an active part in meeting AnaEE's key challenges. The National Platforms are of 4 types:

1. Natural, open-air platforms that host well designed *in-situ* experiments, representing a large range of managed and natural ecosystems across Europe's different climatic and land use gradients;
2. Enclosed-platforms with highly controlled environments and automated process measurements, such as Ecotrons, to experimentally test the response of ecosystems to projected extreme events, natural hazards and climate change;
3. Analytical platforms that provide novel techniques and high-tech equipment to better characterize the state of ecosystems and explore unknown processes and non-linear behaviour; and
4. Modelling platforms that specialize in model building and simulation. This requires the development and implementation of integrated data workflows as well. This wide array of scientific models/tools provides a competitive advantage to AnaEE scientists, institutions, SMEs (etc.) and fosters the integration of the corresponding stakeholder communities.

AnaEE will target the following user groups:

- First and foremost, AnaEE is intended to enable the research community to respond to the challenges highlighted by the ecosystems science community, meet national and international imperatives and support the advancement of the European Research Area (ERA).
- AnaEE will also support industries, as innovation developers and contractors, or as customers (*e.g.*, to mobilize national platforms as testbeds).
- Governments and local administration will profit from AnaEE's reporting, consulting and decision support activities.

- Funding research agencies will profit from AnaEE's foresight activities and reporting to plan their strategy and will be able to launch research programmes enabled by the high quality platforms of AnaEE.
- Finally, AnaEE's outreach documents will help educators to play an essential role in developing tomorrow's experts through formal curricula, student internships, graduate assistantships, visiting scientists, citizen science activities and the overall promotion of environmental literacy.

AnaEE activities are targeting the development of a European bio-economy, which has an estimated worth of 2 trillion euros and accounts for 22 million jobs in the EU. Each euro invested in EU-funded bio-economy research and innovation is expected to yield a 10-fold return by 2025. The bio-economy markets most likely to be impacted by AnaEE results include agriculture and food security, forestry (inclusive of biomass), risk insurance and climate change adaptation. AnaEE, in turn, will strive to develop green technologies, produce valuable data to inform risk-management strategies and provide the scientific tools to advance R&D activities in relevant fields.

Lastly, experimentation technologies and methodologies (including ecotrons, analytical platforms, integrated data workflows and modelling factories) are the foundations of AnaEE's programmatic structure. AnaEE will continue to innovate with regards to such technologies, as well as optimize its business model (operations) through technological advancements. We expect that our scientific and technological developments will lead to new designs of commercial and custom-made instrumentation. AnaEE's innovation potential will raise the interest of world experts and benefit the field of instrumentation and experimentation, *e.g.*, optical- and remote-sensing techniques, NanoSIMS technology, and advanced spectroscopy. AnaEE innovation activities will naturally be extended to new markets, for example cost-effective and novel spectroscopy and gas monitoring instrumentations, industrial production applications, agribusiness, and the insurance market. The AnaEE-ERIC's strategic approach to nurturing industrial partnerships will be based on collaborations among its members and SMEs. These strategic efforts will be road-mapped and co-developed so as to become part of a sustainable business model. Technology transfers and support sustainable joint public-private ventures will also take advantage of the emerging technologies developed by the RIs.

AnaEE's success will depend on a strong and shared governance. To this end, an Assembly of Members will vote on high-level, strategic decisions and oversee the management and operations of AnaEE. The Director General will work in close cooperation with the Directors of all 3 Service Centres so as to ensure a close cooperation with the operational elements of AnaEE and all associated personnel, inclusive of National Node Coordinators (one per country) and platform representatives (one per platform type). In addition, AnaEE will seek out external advice from experts on scientific, ethical, and financial issues.

Through the AnaEE pan-European network, national investments will derive all the more visibility and political importance through AnaEE's results informing science and society. The financial sustainability of AnaEE will be maintained through the contributions of committed Member States and countries hosting the Central Hub and Centres, in accordance with the rules defined in the ERIC statutes. Member States supporting AnaEE will also benefit from:

- An improved, optimized and coordinated use of research resources;
- A larger talent and resource pool, allowing for a greater return on research investment;
- Access to comprehensive data from different European ecosystems types and climatic zones;
- Greater possibilities for the development of national research programs.
- Decision-making tools for natural resource management, policy and governance.

In conclusion, the key strength of the AnaEE ERIC is that it is the first attempt of such a scale to coordinate research and experimentation on the environment. This will attract potential users

requiring AnaEE support to develop complex projects on the one hand and research and innovation on the other. The AnaEE ERIC will contribute both to national and European policies and research mandates, to develop a predictive environmental understanding of anthropogenic impacts. AnaEE RI will offer a substantial contribution to the overall environmental sustainability and food security of our society and provide assistance in meeting the many societal imperatives depending on our capacity to understand and adapt to anthropogenic change. AnaEE ERIC will directly contribute to the ERA 2025 vision by building further knowledge and understanding, as we set out to craft future societies.