+++) and symbolic regression (refs +++), ignoring eco-evolutionary biology-inspired computation from where causal inference can be obtained. On the other side, experimental evolution data shows the importance of rapid structural trait changes beyond plasticity for new functional information processing capabilities of the interactions and traits (refs +++). The classical view on biology-inspired information processing is to consider plasticity without structural changes, or without co-evolution among many interacting components (refs +++). Recent studies indicate that rapid trait changes and information processing as a consequence of these changes is far more complex (refs +++). For example, eco-evolutionary dynamics strongly affect feedbacks between ecological and evolutionary processes, which in turn influences trait changes to open new functional properties of populations with new information capabilities (i.e., new adaptations to new habitat or niche biotic or abiotic conditions, refs +++). Furthermore, recent studies suggest that the interplay between trait dimensionality (biotic, abiotic, migration traits, etc), and adaptation is key to understand the emergence of new traits and information processing abilities to elaborate new computation strategies in ecosystems (Box 1, and refs, +++).
Going beyond ROBHOOT will, for the first time, employ eco-evolutionary biology-inspired solutions to implement AI process-based methods to create spatiotemporal causal inference in systems containing large heterogeneity and dimensionality (Figure 2). Using the above models, this will be extended to deep process-based learning networks including trait and interactions as evolutionary changes and coevolution to implement diversification patterns in these systems. The search for causal knowledge discovery will be applied to the sustainability of the Seas case study containing 9 million entries, 1612 species (around 50 variables and traits per species), around 20 countries and 11 sampling methods (Figure 2). Our approach will explore broad classes of evolving functions from evolutionary biology-AI-inspired algorithms combining them to automated Bayesian machines ensuring the search, the evaluation of models, trading-off complexity, fitting to the data and quantify resource usage (Deliverable D2.3, [20, 30]).

Discovery in federated networks (WP3) Integrating data and causal knowledge graphs provide a mechanistic understanding of how the balance of cooperation vs. competition might alter sustainability in our exploration of the Seas case study. However, causal knowledge graphs are not enough if they only represent isolated contributions and can not "learn to learn" to find novel, emergent solutions in neural biology-inspired networks composed by highly heterogeneous groups. In this regard, federated objects can be seen as "neural networks" containing many types of heterogeneous nodes with varying degrees of learning, connectivity and firing probabilities [23, 24]. Technologies in digital ecosystems around federated networks are scarce and mostly focus on decentralization, scalability and security fronts [8, 9, 13, 14, 19, 25]. In the science ecosystem, only a few applications of open decentralized technologies exist [21]. Yet, the discovery of novel algorithms in biology-inspired federated networks for cooperative forecasting of global sustainability problems when heterogeneous groups learn and share from each other is currently not in place. Recent studies have shown the importance of evolutionary search of mathematical and symbolic operations as building blocks to discover ML algorithms ([20, 27]). Evolutionary biology-inspired search for algorithmic discovery can help to decipher how interactions among heterogeneous groups evolve and learn to solve complex sustainability problems. For example, evolutionary dynamics can explore open-ended language of models with varying trait evolution functions to discover biologically inspired solutions in multidimensional systems ([27],+++). ROBHOOT v.3.0 deploys biology-inspired federated networks accounting for heterogeneous agents to discover novel biology-inspired solutions for the exploration of the Seas federated network (Deliverables D3.1 and D3.2, Tables 3.1a-c)
Going beyond: Our understanding of the outcomes from evolved information processing systems formed by highly heterogeneous groups, a kind of large-scale meta-learning in the federated setting [13], is currently quite limited. Therefore, new science-enabled approaches accounting for information processing with diversification of heterogeneous and highly dimensional systems in federated networks are required to develop science-enabled technologies where heterogeneous agents with different interests find (non optimal) solutions that allow sustainable explotation of ecosystms. ROBHOOT v.3.0 con-