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Accelerating Science-Driven Blue Growth via a Competitive Intelligence Cloud/HPC Platform for AI-Based STI Policy Making †

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Abstract: SDSN Greece, the Black Sea and the Mediterranean, supported by SDSN Europe, have established the Sustainable Euro-Asian Seas Initiative (SEAs) to accelerate science-driven blue growth and SDG implementation in the Euro-Asian Seas and beyond. IntelComp (H2020 project) seeks to build an innovative Cloud Platform that will offer AI-based services to public administrators and policymakers across Europe for data- and evidence-driven STI policy design and implementation. One of IntelComp's main focus areas is the climate change challenge, targeting the Blue Growth perspective. Within the project's framework, Living Labs will take the role of implementing a co-creation approach and engaging all relevant stakeholders to explore, experiment with and evaluate STI policies at all stages.

Keywords: blue growth; blue economy; sustainable seas; SEAs Initiative; IntelComp; STI policy; living labs

1. Introduction

The IPCC 2018 Report [1] warns that exceeding a 1.5 °C increase in global temperature above pre-industrial levels will lead to unprecedented effects to health, livelihoods, food security, water supply, human security and economic growth. This will be catastrophic for our seas and oceans, which are drivers for the European economy and have great potential for innovation and growth. Two essential components to provide knowledge, legal certainty and security in the blue economy are the following: ensuring marine knowledge to improve access to information about the sea and enforcing maritime spatial planning to ensure efficient, sustainable, job-based and inclusive management of activities at sea. The SDSN Sustainable Euro-Asian Seas (SEAs) Initiative seeks to accelerate science-driven blue growth

and the implementation of the United Nations Sustainable Development Goals (Agenda 2030) in the Euro-Asian Seas and beyond. SDSN SEAs Initiative is led by SDSN Greece, SDSN Med and SDSN Black Sea via SDSN Europe. IntelComp (funded by H2020) is setting out to build an innovative Cloud Platform that will offer Artificial Intelligence-based services to public administrators and policymakers across Europe for data- and evidence-driven policy design and implementation in the field of Science, Technology and Innovation (STI) policy. One of the three pilots of the IntelComp project is the climate change challenge, targeting the Blue Growth perspective. IntelComp proposes a framework for a co-creation ecosystem to make policies "with people", seeking to bridge the gap in information flow and empower a broad group of stakeholders to actively participate in agenda-setting and policymaking, implementation and monitoring. Instrumentally, Living Labs are proposed to implement this co-creation approach, engaging public policymakers, academia, industry, SMEs, local actors, civil society and citizens to explore, experiment with and evaluate STI policies at all stages.

2. Climate Change in the Mediterranean, Caspian and Black seas

The Mediterranean Sea is one of the ocean regions that is warming fastest [2] due to its geographical position between the semi-arid and arid climate of North Africa and the temperate climate of Central Europe, leading to a climate particularly vulnerable to minor modifications of the general circulation [3]. Additionally, the Mediterranean's semi-enclosed nature restricts the hydrological exchange with the open ocean, allowing the Mediterranean to store heat. This semi-enclosed nature makes the endemic marine biota extremely vulnerable to alterations to their environment, as several pieces of research have shown [2,4–6]; this has led to significant decreases in local populations of cold-water species, while easing the arrival and adaptation of alien species through the Suez Canal.

The mean temperature of the Mediterranean basin has increased 1.4 degrees Celsius since the late 19th century, compared with the global average of 1.1 degrees. This value is projected to increase by an additional 1.5 degrees by 2050 [7], leading to an increased risk of drought, water stress and extreme natural events, such as wildfires and floods. Climate change affects the Mediterranean Sea on multiple levels. The already uneven distribution of water resources will pose a greater challenge as freshwater resources will be less available due to significant expected increases in the length of meteorological dry spells [8]. As a result, river flow and lake levels will be reduced and combined with the sea-level rise and the increased groundwater use for agricultural purposes will aid in salt-water intrusion, which is already a major issue in regions located by the sea. Seasonal changes that already take place in the Mediterranean area in a combination of mixed land use, are responsible for drier lands and a higher fire risk, longer fire seasons and severe fire events, which can already be seen in the latest forest fire events that took place in Italy, Greece and Turkey. Another major challenge arising from climate change and the interconnection of land and sea is food production, as extreme events may bring losses to crops, while ocean warming and acidification directly impact fisheries and aquaculture. Finally, due to temperature increases, new challenges in human health are emerging. Increased temperature eases the transmission of vector-, water- and food-borne diseases in the Mediterranean, while droughts, water scarcity, food redundancy and economic instability are expected to increase human insecurity and lead to increased migration rates within the Mediterranean region [9].

Similar consequences are expected in the planet's largest inland seas: the Black and Caspian Seas. As is expected, global warming will affect their circulation, temperature and freshwater balance, thus impacting coastal and marine ecosystems.

The Black Sea is a meromictic basin with anoxic conditions below 200 m. As a result, biological life is supported by the upper thin layer (0–200 m), as the deeper and denser water layers are saturated with hydrogen sulfide. An analysis of the circulation patterns in the Black Sea Basin has shown that through the years, a warming trend has been observed in the middle layer of the Black Sea that may alter the stratification of the Black Sea. This means that sulfide, noxious and corrosive chemicals from the bottom of the Black Sea will

be freed to the upper surface layer, ensuing hazardous consequences on the Black Sea's biota [10]. Furthermore, a reduction in wind stress curl over the basin of the Black Sea is expected, which will lead to a speed decrease of the Rim Current circulation, thus affecting water quality, larvae and pollutant dispersal [11].

In contrast to the Mediterranean and the Black Sea, the Caspian Sea is a closed basin. As an endorheic basin that does not have an outflow, its water levels are determined by balancing precipitation, run-off input from the Volga River and evaporation. Models show that global warming will lead to a freshwater imbalance that, integrated over 50 years, will result in a 5 m drop in sea level. This will lead to a great retrieval of the shoreline, greatly impacting the Caspian Sea ecosystems [11]. Other studies argue that in medium to high emission scenarios, the projected fall of the Caspian's water level ranges from 9 m to 18 m [12]. This means that a great area will emerge from under the sea's surface, leading to severe stress on biodiversity and the economy [13]. Specifically, shallow-water habitats will disappear, removing a major food source for fish, migrating birds and the endangered Caspian Seal, as well as spawning grounds for endemic and/or endangered species. Moreover, this decline in the water level will directly affect the economies of the region, especially the shipping activity inside and outside of the Sea via the Volga-Baltic Waterway and the Volga-Don Canal [13]. A qualitative assessment has shown that environmental shifts have already made their impact on the Caspian ecosystem structures and functioning [14].

3. Systems Innovation Approach

Section 2 provided a detailed description of the situation in the three seas, namely, the Mediterranean, Caspian and Black Seas, and this is an essential starting point for the living labs that will follow. The approach that we use to run the living labs is the Systems Innovation Approach (SIA). Systems innovation is defined as an "interconnected set of innovations, where each influences the other, with innovation both in the parts of the system and in how they interconnect" [15]. The SIA represents a fundamental shift in how knowledge generation is perceived, and, as a result, accepted. It turns the focus away from technological breakthroughs and research and onto the entire innovation process, of which research is just one of the components. This framework lays the groundwork for the IntelComp platform's evolution, which will necessitate active engagement in agenda-setting and policy-making, as well as execution, monitoring and collaboration among key stakeholders.

The foundations of the SIA include creating a conducive environment for stakeholders to express their opinions and achieve a holistic understanding of their demands. The first step in deciphering the interactions and thinking about how to solve them is to agree on what the problems are. In this paper, we employ a series of bi-monthly sessions with two stakeholder groups: one for the Mediterranean case study and one for the Black and Caspian case studies, as presented in Figure 1. Stakeholders from countries coloured in yellow will be invited to both living labs and represent the connecting players among the two stakeholder groups. The target groups of these living labs are representatives from the government at the national−regional−international level, policymakers, academics, researchers, experts, experienced professionals and technology providers, ensuring scientific support, analysis and democratic feedback on the design of commonly accepted metrics and actions for a sustainable future [16].

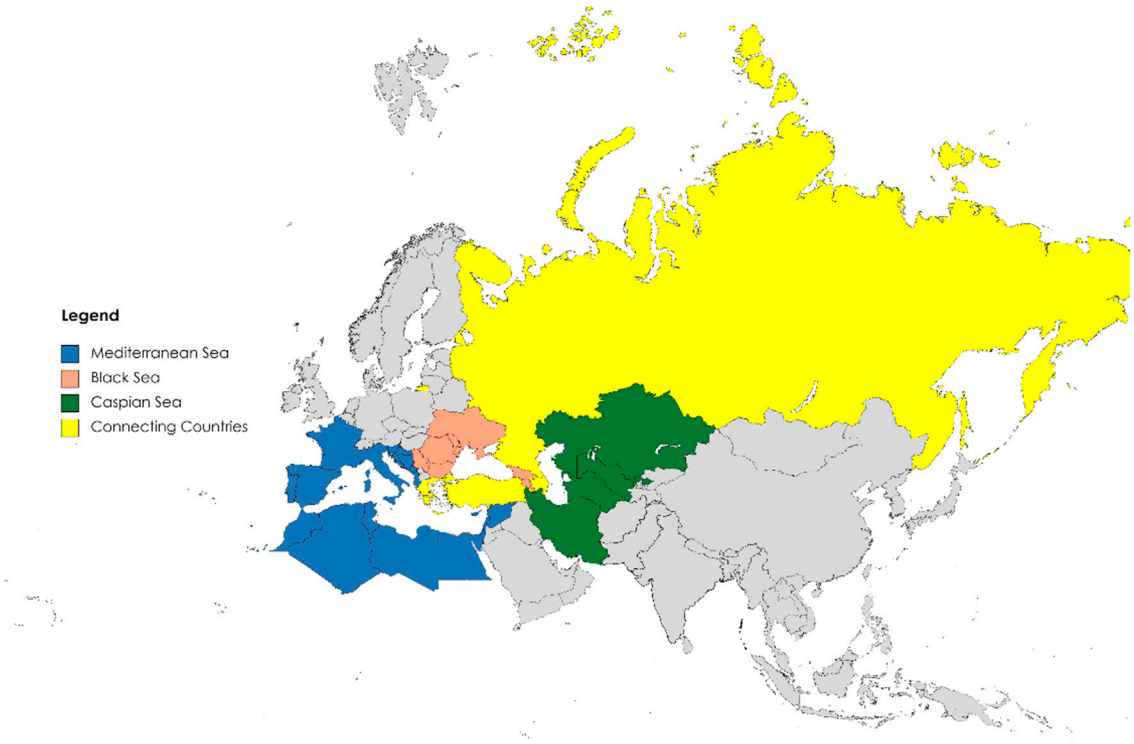

Figure 1. Division of countries into groups (Map created with mapchart.net).

As mentioned above, the first step of the proposed methodology is to present the issue from a scientific perspective based on the literature. The cases of these three Seas are very interesting as the frequency and impact of climate disasters (floods, droughts, extreme weather) will increase within Europe, North Africa and East Asia in the coming decades. To face this challenge and reduce the cost and impact of resulting damage, Europe, North Africa and East Asia need a systemic network offering easily accessible information.

The next step is the stakeholder management process. This process is composed of two steps: stakeholder analysis and stakeholder engagement. Stakeholder analysis aims to identify desired stakeholder groups, as well as their behaviours, their initial preferences, their requirements and the relationships that govern these groups. At this stage, we employ tools to rate stakeholders on two or three essential traits, identify possible synergies or conflictive relationships and create patterns of knowledge and resource flow, which may be interpreted as power flows [17]. Stakeholder engagement refers to both the approach we will utilize to bring all parties together and the level at which they will be fully incorporated into the process. Stakeholders will be invited to form the core stakeholder group that will engage in the Living Labs based on their preliminary interest, relevance and expertise in the field, or they will be considered latent.

Following the aforementioned gathering of stakeholder representatives, we enable their active involvement in organized workshops, aiming to unravel the problem of climate change in these Seas from a variety of viewpoints (environmental, political, technological, social and economic). During this step, we try to break down the problem into its constituent parts. This stage has two objectives: first, to uncover secret causes and problems that cannot be found in the literature and, second, to unblock the process of deep listening (i.e., the process of listening to learn). The latter has far-reaching implications, as to advance to the next phases of the SIA, the involved stakeholders must be able to comprehend the perspectives of the other parties for the greatest benefit.

Next comes the multi-level perspective (MLP), which is an analytical method aimed at defining how innovation is generated and the major characteristic of transition in socio-technical systems. The MLP divides the system into three levels: the macro-level (landscape), the meso-level (regimes) and the micro-level (niches of innovation). Exogenous,

long-term, autonomous tendencies and big crises, such as climate change, urbanization and unanticipated catastrophes are depicted at the macro-level (landscape). The landscape can produce tension, which has a huge impact on the other two layers. Regimes are made up of powerful stakeholders who want to keep things as-is. They decide the aspects around which the system is organized, such as legislation, institutions (political, financial, social), user behaviours and cultural values. Finally, the niches of innovation, such as universities, research institutions, R&D departments and the Military, can be thought of as places where innovative inventions and ideas are born. We are trying to figure out how the system surrounding the problem works to identify opportunities or serious risks [17].

After comprehending the problem and its surrounding stresses in a holistic manner, we proceed with the vision development, which is a foresight method that endeavours to create a feasible and desirable future scenario where the current problem is solved. To understand the power of a vision, we should take a deeper look at its foundation, which is expectations. Visions are formed based on collective expectations and, by their very nature, cannot be fully realized, as expectations are adaptable and open to reinterpretation to some extent until the point at which they are realized [18]. Nevertheless, co-developing a vision is essential for agreement on the measures and changes that need to be done.

Finally, to accomplish the co-developed vision, we create change trajectories, that will strive to untangle how the system changes and where innovation originates from. The stakeholders will have the chance to co-develop the needed trade-offs during this phase. We employ methods to aid in the interpretation of sources of resistance and resilience to system changes, as well as the distance between options that co-evolve simultaneously in distinct trajectories and the optimization of co-decided actions under various scenarios using time frames.

Stakeholder co-development of change trajectories can provide credibility to national and sectoral interpretations, while also revealing significant uncertainties or flows. Pecl et al. (2019) argue that involving and educating the public on scientific topics may help to transform people's minds, attitudes and behaviours [19]. This strategy aims to ensure stakeholder commitment to the co-developed solutions by testing the hypothesis that a sense of "belonging" and "co-developing" will lead to behavioural change. The SIA process is followed by leading conversations during meetings and the tools mentioned can be applied using visual collaboration platforms, such as MIRO, which allows for the efficient and effective intuitive cooperation of stakeholders.

4. Primary Results and Future Results

These Living Labs are supported by the UN SDSN SEAs Initiative, which intends to boost science-driven blue growth in the Euro-Asian Seas and beyond, as well as the realization of the United Nations Sustainable Development Goals (Agenda 2030). The initiative aims at gathering the efforts of SDSN National and Regional Networks on Blue Growth in an interdisciplinary framework. A regular annual report on Technological, Economic and Social Transition Pathways of systemic transformation will be introduced, as it is required for the realization of Agenda 2030 in our seas and oceans, including Science-Technology and Innovation-Policy interface agenda-setting, model design, implementation, monitoring and evaluation. This initiative builds on SDSN Greece, SDSN Black Sea and SDSN Mediterranean, which brought together the 4-Seas Initiative, the Global Roundtable for Sustainable Shipping and Ports, the Plastic Busters Initiative, the newly formed Global Maritime Accelerator and several Blue Growth research projects.

The Initiative is coordinated by:

- Phoebe Koundouri, Professor and Director of the ReSEES Research Laboratory, Athens University of Economics and Business; Director of Sustainable Development Unit and EIT Climate-KIC Hub Greece, Athena RC; Fellow of the World Academy of Art and Science; President-Elect of the European Association of Environmental and Resource Economists; Co-chair of UN SDSN Europe and UN SDSN Greece

- Nikos Theodossiou, Professor at the Aristotle University of Thessaloniki, Chair of UN SDSN Black Sea
- Yannis Ioannidis, Professor at the National and Kapodistrian University of Athens, Former President at ATHENA Research and Innovation Centre, UN SDSN Greece Strategic Advisory Board Member
- Andreas Papandreou, Professor at the National and Kapodistrian University of Athens, Co-chair of UN SDSN Greece

Following the process in Table 1, each stage is accomplished through monthly workshops. Due to COVID-19 restrictions, the meetings are held on Zoom and MIRO software is used for the analysis. Each stage is enriched and supported by a variety of tools based on the needs of each workshop and the specificities of the living lab (i.e., what are their interests, needs, conflict points etc.).

Table 1. Living Labs workshop planning (Med is for the Mediterranean Group and BS+CS is for the Black Sea and Caspian Sea Group).

No. of Workshop	Goal of the Workshop
#1 June 2021—Med & BS+CS	The goal of these workshops and introduction to the climate change challenge and the Blue Growth
#2a July 2021—Med #2b September 2021—BS+CS	Understanding the gap between Knowledge and Action
#3a October 2021—Med #3b November 2021—BS+CS	Understanding the environmental challenges
#4a December 2021—Med #4b January 2022—BS+CS	Understanding the technological challenges
#5a February 2022—Med #5b March 2022—BS+CS	Understanding the societal challenges
#6a April 2022—Med #6b May 2022—BS+CS	Understanding the economic challenges
#7a June 2022—Med #7b July 2022—BS+CS	Understanding the policy challenges
#8a September 2022—Med #8b October 2022—BS+CS	Understanding the role of networks
#9a November 2022– Med #9b December 2022—BS+CS	Understanding various stakeholders' perspectives
#10 January 2023—Med & BS+CS	Bringing together all stakeholder groups and discussing the findings of the challenges
#11a February 2023—Med #11b March 2023—BS+CS	Macro-level, meso-level and micro-level perspectives
#12a April 2023—Med #12b May 2023—BS+CS	Vision development
#13a June 2023—Med #13b July 2023—BS+CS	Trajectories of change—Figuring out the way and brainstorming suggested trajectories opportunities
#14a September 2023—Med #14b October 2023—BS+CS	Co-creation of the Socio-Technical Roadmap
#15 November 2023—Med & BS+CS	Final workshop

During our first workshop, we invited stakeholders from both the Mediterranean and the Black−Caspian Seas groups and we asked the participants to introduce themselves and their work after introducing the climate change challenge and its impacts on the seas, as well as the preliminary goals and objectives of the project. We stressed the need for the cooperation of representatives of the state, civil society, scientists, researchers and investors to jointly formulate action plans in line with European and national strategies that will facilitate the acceleration of science-driven blue growth and the implementation of the United Nations Sustainable Development Goals (Agenda 2030) in the Euro-Asian seas and beyond. In this context, Prof. Phoebe Koundouri (Athens University of Economics and Business) briefly presented the political framework for sustainable development, namely the UN Agenda 2030 and the 17 Sustainable Development Goals, the Paris Agreement,

the European Green Deal and the Recovery Fund, which lay the foundations and the financing tools for the creation of synergies and acceleration of sustainable development in these areas.

Dr Haris Papageorgiou (Research Director ATHENA RC) presented the IntelComp (Horizon 2020) Project, titled "A Competitive Intelligence Cloud/HPC Platform for AI-based STI Policy Making", which will support the SDSN SEAs Initiative through a dedicated case study on Sustainable European and Asian Seas and Oceans. IntelComp is setting out to build an innovative Cloud Platform that will offer Artificial Intelligence-based services to public administrators and policymakers across Europe for data- and evidence-driven policy design and implementation in the field of Science, Technology and Innovation (STI) policy. Large STI datasets are processed in High-Performance Computing (HPC) environments that are part of the European Open Science Cloud (EOSC) initiative. Public administration at all geographical and organizational levels, STI stakeholders and civil society produce a great amount of dynamic, multilingual and heterogeneous data (e.g., national STI strategies, plans and work programmes, calls, projects, reports, scientific publications, patents, dissemination articles, etc.), so understanding and analyzing this data is crucial for evidence-based policymaking. The main objectives of IntelComp are to understand the challenges of Science, Technology and Innovation (STI) policymaking in the development of a co-designed, co-creative manner framework with the relevant stakeholders (including the participants of the Living Lab) and the creation of a data space, data-pool or data repository on STI-related data sources and datasets.

The stakeholders who participated in the first workshop came from the triangle of knowledge: namely, research, education and innovation, as well civil society, private sector and public and regulatory authorities. In particular, the following institutions attended the meeting:

- Institutes and Research Innovation Centres
  - Belgium: Centre for Social Innovation
  - Cyprus: The Cyprus Institute
  - Greece: ATHENA Research and Innovation Centre, Hellenic Centre for Marine Research (HCMR), Solmeyea, Machinor
  - Italy: Eurac Research
  - Kazakhstan: Ban Ki-moon Institute for Sustainable Development at KazNU
  - Netherlands: KWR Water Research
  - Spain: Basque Centre for Climate Change
- Universities and Educational Institutions
  - Greece: Athens University of Economics and Business (AUEB), Aristotle University of Thessaloniki (AUTh), National Technical University of Athens (NTUA),
  - Kazakhstan: Nazarbayev University, Narxoz University
  - India: ICFAI Business School (IBS)-Hyderabad
  - Italy: University of Siena, Università degli Studi di Cagliari
  - Moldova: Academy of Economic Studies of Moldova
  - Norway: UiT the Arctic University of Norway
  - Spain: Universidad Carlos III de Madrid, University of Santiago de Compostela
  - Turkey: Yeditepe University
  - U.K.: University of Plymouth
- Civil Society
  - France: SDSN Europe
  - Greece: SDSN Greece, SDSN Black Sea, ECOGENIA
  - Italy: SDSN Mediterranean
  - Kazakhstan: Solar Power Association of Qazaqstan (SPAQ)
- Public and Regulatory Authorities
  - Greece: General Secretariat of Research and Innovation

- Belgium: European Commission, Conference of Peripheral Maritime Regions (CPMR)
- Kazakhstan: Project Office of the Prime Minister of Kazakhstan
- Romania: General Secretariat of the Government—Department of Sustainable Development

The first phase of SIA started in our second workshop when the participants tried to unravel the challenge of data mining. Firstly, they provided feedback on the frequency and accessibility of the international datasets that are most used in research projects, such as the OECD database, the UN Stats relevant sites, Eurostat, the SDSN Index & Monitoring site, the World Bank and the European Policies site, in which someone can find all the EU policies categorized by topic. Next, participants were divided into two (2) breakout rooms, aiming to answer the following questions: What data platforms or monitoring tools exist in their country; how do they get informed; and what is missing. This discussion enabled us to define the problem and get a common ground for future discussions. In our case, most of the participants seem to understand the gravity and the depth of the data identification challenge and agree with most of the different components and details raised during the workshop.

5. Conclusions

The SIA is the hereby suggested methodology for solving complex problems, where system dynamics and stakeholder behaviour define the capability of the challenge to be solved. Policy formulation, adoption and implementation is a complex problem due to the interrelated nature of the stakeholders and their conformity, which they depend upon to achieve different social, economic and environmental goals. The SIA presents a conceptual approach to better understand and systematically analyse the interactions between the natural and economic environment and human activities and to move towards more coordinated management and use of these seas across sectors and scales.

The SIA with proper scientific support is a powerful tool. In the case of the ongoing research in the Mediterranean and the Black−Caspian Seas, it enhances an understanding of the different perspectives, approaches and systemic interlinkages. Moreover, it reveals and addresses deeper shortcomings of the institutional framework, the authoritarian behaviour of the State, misleading perceptions about the management of the seas and weaknesses in the cooperation between stakeholder groups. The co-development of a common vision is a key driver that builds on common understanding and goals under a common purpose, which is higher than individual interest without undermining it.

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