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Special Theme: The Climate Action: Mathematics, Informatics and Socio-Economics Accelerating the Sustainability

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Special Theme: The Climate Action:

Mathematics, Informatics and Socio-Economics Accelerating the Sustainability

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This special issue focuses on the use of Climate Informatics and Mathematics in supporting the development of models, tools and solutions that can support the urgently needed sustainability transition.

The 2018 IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, idicates clearly that climate change is an existential threat. Anthropogenic emissions continue to cause further long-term changes in the climate system, such as sea level rise, increased frequency in extreme weather conditions and biodiversity and ecosystems services loss, are evident around the world. These significantly increase the risks for catastrophic events and loss of food security for the world's growing population. According to the IPCC's report, we have 10 years to limit climate change catastrophe and keep global warming to a maximum of 1.5C, beyond which even half a degree will significantly worsen the risks of drought, floods, extreme heat and poverty for hundreds of millions of people.

The UN Sustainable Development Goals (SDGs) have become the world's framework for sustainable development and for countries and individual organizations to take action to address the growing need to reduce global warning and the undesired climate changes. Efforts are made to bring clarity on how to implement these SDGs and how countries could make the necessary changes and track progress towards these 17 goals. In the last few years, there has been an increased awareness among the research community on implementing these goals and supporting countries, organizations and industry reduce their contributions to global warming and the emission of greenhouse gases. Importantly, the 2019 United Nations Sustainable Solutions Network (UN SDSN) report on the "Six Transformations to achieve the Sustainable Development Goals" lays out integrated framework for implementing the SDGs and the Paris Agreement on Climate Change. The six UN SDSN transformations provide an integrated and holistic framework for action that reduces the complexity, yet encompasses the 17 SDGs, their 169 Targets and the Paris Agreement. They provide a new approach to shift from incremental to transformational change; to identify synergies using sustainable development pathways; formulate actionable roadmaps; and a focus on inter-relationships to uncover multiple benefits and synergies. They focus on (1) education, gender and inequality, (2) health wellbeing and demography, (3) energy decarbonization and sustainable industry, (4)

sustainable food, land, eater and oceans, sustainable cities and communities and (6) digital revolution for sustsainable development. The six SGD transformations are underpinned by the principles of leaving no one behind and circularity and decoupling.

Just before 2020, the European Green Deal (EGD) was announced by the president of the European Commission. The EGD is the European response to the climate crisis. It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy. The explicit aim of the EGD is climate neutrality (no net emissions of greenhouse gases) by 2050, while economic growth is decoupled from resource use. It also aims to protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. At the same time, this transition must be just and inclusive. As part of the Green Deal, the Commission will refocus the European Semester process of macroeconomic coordination to integrate the United Nations' sustainable development goals, to put sustainability and the well-being of citizens at the centre of economic policy, and the sustainable development goals at the heart of the EU's policymaking and action.

The figure below illustrates the various elements of the Green Deal.

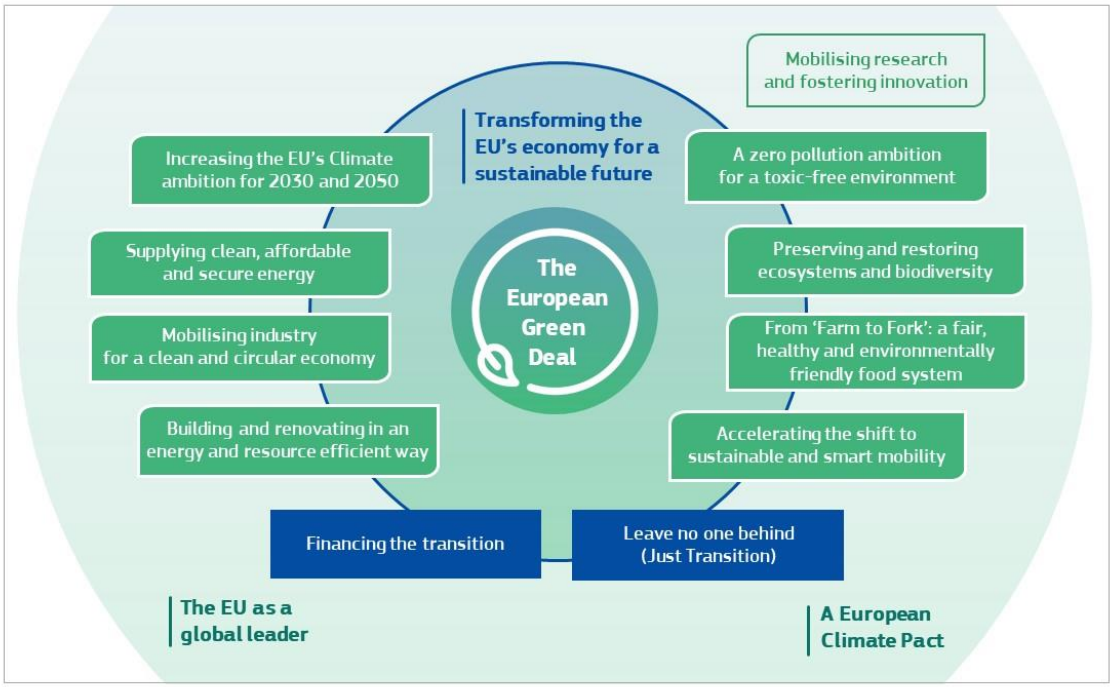

Figure 1: The European Green Deal

The response of governments to the climate crisis thus far has not been sufficient and the world is not on track to meet the objective of the SDGs, the Paris Climate Agreement and the European Green Deal. The IPCC report explicitly refers to the need for "rapid far-reaching and unprecedent changes in all aspects of society". Incremental changes will not be enough. What is needed now is a fundamental transformation of research, innovation, financial, economic, and social systems that will trigger exponential change in decarbonization rates and strengthen climate resilience. We need big thinking and big changes. We need systems innovation and science has a big role to play! The world needs to catalyse systemic change for climate action through innovation (technological and social[1]) by connecting the supply of innovation with demand-side actors, problem owners and those with a high ambition for change. Europe is currently leading the efforts in the sustainability transition and hopes to become an illustrating case study of the possibility achieving economic growth and socio-economic prosperity, while transitioning to a sustainable, circular, climate resilient economy and society.

The current global crisis caused by the pandemic of COVID-19 has clearly proven the ability of governments to take dramatic measures to mitigate an existential threat, as well as people's ability, at least in the short run, to adapt to new restricted lifestyles imposed by these measures. Importantly, there is serious scientific speculation that COVID-19 might be connected to the climate crisis and the related loss in biodiversity. Indeed, the measures that can help solve the health crisis can make the economic crisis worse and vice versa. What is the way forward and the effect on the potential implementation of the EGD? We can use the science -as we are using science currently for designing measures to restrain the diffusion of CONVID-19- to design economies that will mitigate the threats of climate change, biodiversity loss, and pandemics. The economic measures and fiscal packages (mainly financed by public debt) that are being designed to sustain and restart the European (and global) economy, should embrace EU taxonomy for sustainable investments (2019) and direct finance to those who are sustainable or have the potential to become sustainable, but also those who are willing to commit and be monitored henceforth, to learning how to become sustainable.[2]

Researchers have focused on developing energy efficient industrial process and material that has less emissions and innovative and efficient use of existing material and solutions. The role of models and simulations are explored in many disciplines to make predictions and determine sustainable transitions and the optimal solutions in many situations. This special issue focuses on the use of Climate Informatics and Mathematics in supporting the development of models, tools and solutions for sustainable transitions and transition pathways to support climate action. The research featured in this special issue covers a broad range of applications ranging from electrical vehicles and smart grids, smart water distribution to methods and frameworks for describing an overview of the different technologies and ICT solutions (e.g. models). Research activities in the following themes have been included:

[1] Social innovations are new social practices that aim to meet social needs in a better way than the existing solutions, resulting from - for example - working conditions, education, community development or health. These ideas are created with the goal of extending and strengthening civil society.

[2] Koundouri, 2020: Never waste a good crisis: For a Sustainable Recovery from CONVID-19. https://www.unsdsn.org/never-waste-a-good-crisis-for-a-sustainable-recovery-from-covid-19

- Green spaces in urban areas and forests
- Smart Energy Management
- Models for marine, coastal areas and climate change
- Big Data analysis
- Methods and Approaches for sustainable solutions

An important aspect of a healthy lifestyle and a good urban design is the availability of green spaces for the urban population. Laan and Piersma explored the availability of urban green spaces for the inhabitants in the Municipality of Amsterdam, by taking into account the population density and green spaces within the area and by using Open Data (p. x). These models also provide an insight to urban planners and the municipality to make decisions about incorporating facilities such as restrooms and play areas in the green spaces. Ponsard's and Nihoul's contribution focuses on understanding the diverse roles of a forest for different stakeholders; thus highlighting the need for supporting multiple stakeholders, goals and objectives of forests and not restricting forests to a single use or group of people (p. X).

As the no. of electrical vehicles increases, the load on the energy grids increase too. One of the challenges currently faced by smart grid operators is balancing the load on the smart grids. Bons, van den Hoed and Piersma describe a pilot study conducted in Amsterdam, where flexible charging options were introduced on a proportion of the city's electrical charging stations. A time-dependent restriction on the amount of electricity that could be consumed by an electrical vehicle was implemented (p. x). The data from the charging stations and from the owners of the electrical vehicles showed that flexible charging patterns could be implemented without negatively impacting the vehicle owners. As many cities progress towards energy transitions in the transport sector, Groen and Piersma describe their contributions to match the charge infrastructures for electric vehicles with the energy demand, by using image data and by applying image recognition algorithms and Artificial Intelligence (p.x). Another article that describes smart energy management is the microgrid energy management system developed for a residential bottom-up community. Kaisers, Klein and Klauer describe the technologies developed for two neighbourhoods that have a combination of renewable energy sources and locally generated energy and a microgrid, where power is shared and jointly controlled by all the houses in the neighbourhood (p.x).

The oceans and the ecosystems around them are one of the areas that are most affected by climate change. Thus, understanding them and making predictions of the complex processes and phenomena related to them is an important research area. Several modelling methods and approaches have been included in this special issue. Vidard describes models for ocean coastal areas and discuss different approaches for reducing the uncertainty of these models (p.x). Modelling of the seabed and marine life is equally important to understand the evolution of marine ecosystems. Crommelin, Edeling and Jansson describe their research in applying superparameterization, a computational approach to multi-scale modelling and simulation of atmosphere and ocean, and its advantages over other modelling methods. Pavoni, Corsini and Cignoni descibe an application, TagLab, that uses underwater photogrammetry and Machine Learning to analyse images and data for semantic segmentation and annotations of coral reef maps (p.x).

Reducing greenhouse gas emissions, effective waste management and circular and bio economy are of utmost importance in taking climate action and a sustainable future. Tsachidou, Hissler and Delfosse describe their investigation of the contribution of biogas residues to climate change mitigation through carbon sequestration in agricultural soils (p.x).

Many of the models and solutions that are currently developed rely on numerus data sources and contribute to the vast amount of data that are around us. Data is analysed and leveraged to generate value from them in several ways. Dalamagas, Kokossis and Gentimis describe an application to harnesses the power of big data to bridge the circular economy with the data economy, by analysing large amounts of diverse data to determine where they may be industrial symbiosis and the potential for achieving a circular or a bio economy (p.x). In addition to data analysis, Artificial Intelligence and Machine Learning applications, numerous smart sensor technologies and ICT tools are used to monitor, assess and manage many applications. Tzagkarakis, Anastasiadou and Eliades describe an application that uses Internet of Things (IoT) and data analysis to monitor and manage, in real-time, their water distribution system to minimise loss of water through leakages (p. x). Indeed, analysis of existing data such as climate indexes, can provide valuable insights as to how a particular area has changed. Karavoulias and Argiriou analysed various climate indexes for Greece to better understand the climate changes and their potential impact on humans and the environment (p.x).

One of the challenges that organisations and municipalities face are the management of their own data, and to have an overview of other data sources that could be of relevance to their analyses and models; e.g. Open Data from municipalities. Bokolo, Petersen and Helfert propose an Enterprise Architecture Framework for modelling Sustainable solutions, where several organisations collaborate and a variety of data from diverse sources may be used (p.x).

Ofcourse, with the increase in new technologies, models and solutions, the social acceptance of these is an important part of a successful implementation of them and their contributions to affecting climate change. Indeed, many solutions that are developed today affect future generations and therefore should reflect the future. Tangari, Occhipinti and Briguglio propose a model to draw attention to the concerns and expectations of people who live today to consider the concerns of future generations (p.x). It is equally important that decisions made by municipalities, designers and planners are well-informed and align with the wishes and needs of the citizens. To achieve this, we often see innovative participatory approaches and practices, such as Urban Living Labs.

In conclusion, this special issue provides a glimpse of the diverse research activities that focus on mobilizing the research-innovation and innovation commercialization ecosystem, towards producing solutions for the much needed sustainability transition that aims to a sustainable interaction between the society the economy and the natural environment.