Sustainable Earth System Manifesto by Grand Challenges & Northern Societies Initiative*

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Earth's system is facing several environmental challenges on a global scale, so-called "Grand Challenges". The growing population needs more fresh water, food and energy, which will cause challenges such as climate change, declining air quality, ocean acidification, loss of biodiversity and shortages of fresh water and food supplies. Grand Challenges are the main factors controlling human well-being and the security and stability of future societies. Since the Grand Challenges are highly connected and interlinked, they cannot be solved separately. Therefore, a framework is needed in which a multidisciplinary scientific approach has the required critical mass and is strongly connected to fast-tracked policy making. The potential solutions are typically tightly coupled with each other. To avoid the collapse of Earth's system we estimate that mankind has a 40-year window of opportunity to find a common mind-set and practical solutions to answer these Grand Challenges.

Grand Challenges &Northern Societies Initiative members are issuing a Sustainable Earth System Manifesto which addresses three strategic tasks:

(i) Constructing a novel infrastructure to monitor and to make reliable predictions about the behaviour of critical environment parameters worldwide.
(ii) Finding a political consensus to overcome various geopolitical interests, so that the necessary research, mitigation and adaptation actions can occur without delay, ensuring sustainable living conditions in different parts of the world.
(iii) Providing the operating prerequisites for technology development and particularly energy and material flows to moderate on-going climate change and finding practical solutions for the Grand Challenges

We need to establish:

I. Global Observation Network

An advanced continuous and comprehensive research infrastructure is needed in order to understand in a reliable way the future climate, air quality, food and fresh water supply and the use of energy, mineral and ecosystem services. It is also crucial to have proper early warning systems. Although satellite remote sensing and global modelling have been set up, ground-based information is also needed. We currently lack a coordinated, coherent, multi-scale, multi-disciplinary global network of stations observing atmosphere–land surface interactions and feedbacks. From the global perspective, highly sophisticated individual stations and regional observation systems are under development towards common observation procedures and data formats. This is especially the case in Europe and the US. However, we have serious shortcomings and a lack of observations over key areas of change in Russia, China, Asia, Africa and South America. For example, in the future the arctic-boreal natural environment will have a major impact on the global climate via the albedo change, carbon sinks and emissions, methane emissions and aerosol production connected to the emissions of organic compounds from the boreal forests. The expected shifting of the bioclimatic zones towards the Arctic together with the replacement of boreal forests in the southern ecotone of the forest zone will lead to substantial changes in the land cover over the Russian regions. Establishing a global network of 200 stations (based

on the reorganisation of the existing infrastructure and including new station in the gap regions) would need an investment of 4 billion euros.

II. Hubs building bridges between science-based knowledge and political confrontation

A multi- and cross-disciplinary approach is needed to advance the solution-orientated understanding of the Grand Challenges. Over the last few years, Earth system science has emerged as one of the most rapidly developing scientific fields. This growth has been facilitated by the importance of understanding the fundamental scientific processes of climate change and air quality change as well as the increasing impact of this research area. The development has mainly taken place among the natural sciences and there has so far been insufficient collaboration between the natural and social sciences with regard to tackling climate change. At the same time, we need interaction between the scientific community and policy-makers in order to create fact-based guidelines towards sustainable policy-making. The current situation in international politics leans towards increasing confrontation and divisions between several coalitions. This includes an additional challenge to solving the Grand Challenges in more difficult circumstances with less common ground, but no less need, for tackling them. We need multi-tasking Hubs which coordinate interdisciplinary research and education, promoting interaction between scientists and policy-makers and converting scientific outcomes for more effective use by society.

III Joint global agenda supporting technological development to tackle Grand Challenges

New technologies and holistic approaches are needed to meet the Grand Challenges, and particularly to establish climate-neutral societies worldwide. A joint agenda will enable us to prioritise and find joint technological solutions. The world's biggest economies and polluters should thus seek a win-win energy and climate agenda that combines the strengths and weaknesses of each player. The relevant actors in energy production, energy efficiency, manufacturing, water resource management and ecosystem services, transport corridors and other infrastructures, urban planning and design, protection of natural carbon sinks, geoengineering etc., need to work together to make the most efficient global impact on stabilising the Earth system. If future technological development in these sectors takes place along separate pathways, this might even increase the Earth system's imbalance. The main global powers such as the USA, China, the EU, and Russia are in a pivotal position to create a joint agenda. Complementarities should be sought in energy trade and efficiency, as well as technology transfer. Natural gas as a transition period fuel is essential to enable lower direct emissions (compared to coal), but it is also vital as a source of variable power, making it possible for renewables to account for a higher share of energy production. However, at the epicentre of all energy agendas and cooperation should be state-of-the-art and technology and its transfer that go beyond energy-efficiency.

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