TOWARDS GLOBAL SUSTAINABILITY: THE ROLE OF RESEARCH ACROSS DISCIPLINES AND NATIONAL BOUNDARIES

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Abstract
Despite major scientific advances and insights, the world continues to develop along dangerous trajectories, undermining the life support systems that provide economic growth, and placing coming generations at risk of major regime shifts in the Earth System. Global sustainability is a key to food security, energy access, freshwater availability, poverty alleviation, human health, etc., which requires new thinking and scientific knowledge. Bending the curves of global environmental change will require transformative change in societies. Meeting these challenges also require long term and concerted research efforts across disciplines and national boundaries, as well as strategic investments. Are we ready for these?

Introduction
Sustainable development is generally understood as a concept that integrates the economic, social, and environmental dimensions of development. Even though the world's economy has continuously grown at an annual rate of 3.5 % for more than half a century, global disparity still exists. Socially, from 1990 to 2005 the number of people living on less than $1.25 a day (defined as extreme poverty) decreased from 1.8 to 1.4 billion according to a UN Millennium Development Goals report. Nevertheless, progress is uneven, with poverty remaining an enormous problem, for example, in sub-Saharan Africa, where 50.9 per cent of the population is poor by this

measure. Additionally, in evaluating environmental progress, achievements have not fared well since Rio 1992 either. The more than 20-fold growth in global CO_2 emissions since 1750 has not yet been addressed successfully. Besides climate change, human activities have further intensified the damage to other environmental fields, like biodiversity for example. According to Rockström et al. (2009), some safety boundaries of the Earth System might have already been breached by human activities.

Over the last decades, the global scientific community has established four Global Change research programmes to study the past changes and to project future scenarios of the Earth System. The International Council for Science (ICSU) was at the heart of the planning that led to the establishment of the four main programmes: the World Climate Research Programme, WCRP (created 1980), the International Geosphere-Biosphere Programme, IGBP (1986), DIVERSITAS: an International Programme of Biodiversity Science (1991) and the International Human Dimensions Programme on Global Environmental Change, IHDP (1996). The four programmes described above together launched an Earth System Science Partnership (ESSP) in 2001 to facilitate Joint Projects and Integrated Regional studies.

In 2009, ICSU, co-sponsors and representatives of the interdisciplinary programmes themselves started a strategic planning process to summarize the achievements of and to plan future activities in international and interdisciplinary research on global change, with the help of interested scientists and institutions worldwide (ICSU, 2010a,b). This inclusive visioning process identified five 'Grand Challenges' facing Earth System Science during the years and decades ahead (ICSU, 2010a). Behind this process is the belief that 'business as usual' in terms of international environmental science is not an option; instead, new ways of managing scientific research must be found and put into practice.

This process led to the realisation that the current pace and magnitude of human-induced global change is unprecedented and is manifest in increasingly dangerous threats to societies and human well-being. At the same time, understanding the global risks facing humanity creates new opportunities for transformative change, innovation and green economic development. Decision-makers and citizens have an urgent need for knowledge and solutions that will enable effective responses to these threats, in order to generate opportunities that may provide the basis for sustainable development. The sheer scale of threats and transformation needs means that depending on opportunistic and ad hoc measures alone will not suffice. Science plays a critical role in providing the understanding

of the trends and risks facing humanity and insights for shifts in development pathways.

The aim of this article is to briefly describe what we have learnt from this exercise, with a focus on the idea to have a reorientation towards a new research set-up that better allows science and society to address the needs of decision makers and citizens at global, regional, national and local scales.

Lessons learnt

In recent years there has been near-universal recognition that many of the major challenges facing society demand a holistic scientific approach. They are complex, do not usually respect our artificial boundaries and frontiers, and need the talents of the broad scientific research community if they are to be fully understood and properly addressed. It is important to bring these various talents together and to facilitate interdisciplinary approaches for their resolution. And here I am not just talking about fostering cooperation between the disciplines of the natural sciences. Increasingly there is a need to integrate social science and engineering science to extend and broaden the approaches we take. One concrete example is a recognised and absolute need for interoperability where observation, data handling and information management in different societal sectors, scientific disciplines, and management structures are involved.

Another important realisation is the importance and necessity of international cooperation and funding mechanism, in taking on the immense task to achieve a vision of a future guided by science and embedded in the needs of societies. Mobilising the resources and knowledge of the international scientific community is increasingly important. Huge challenges such as climate change, biodiversity loss, food and water supply, energy and pandemics must increasingly be confronted in ways that transcend borders. But resources are quite limited at national level. We have to have more international efforts to achieve the goals necessary for society. Furthermore, resources are unevenly distributed. Only by integrating different disciplines and facilitating more international collaborations can we hope to achieve universality in science and global sustainability in society. It is generally agreed that progress is currently at a crossroads, where the right path could bring greater collaboration, research output and societal benefit, while the wrong path could see scientific progress stagnate and fail to connect with problems in the real world.

There are a number of obstacles for the interdisciplinary and international researches. For example, the rigid structures in place for career paths

of scientists and also those in place for many funding, evaluation and overall coordination activities worldwide do not really match these needs. Career paths for young scientists are still fairly traditional. It means that if you want to have a scientific career, you have to conform to the traditional way of doing science. Otherwise you do not have a future. The same is true with the funding mechanisms, not in all countries but in general this is the case. These barriers can affect creativity and progress in a negative way. Further, on an international level there are not enough innovative platforms bridging disciplines. Global platforms are really important in creating a research environment that is both productive and creative. To achieve these, there must be coordination at the international level.

Science for policy through an interface between the two can be an effective tool to promote interdisciplinary and international science, and scientific assessment on a specific issue has demonstrated a great value in making this happen. When we carry out assessments, looking at the scientific knowledge in relation to societal needs, we often try to address societal needs with our scientific knowledge. The IPCC assessment is a good example demonstrating the great need of an integrated approach involving both social and natural sciences. It is also a successful case where policy makers interact closely with researchers. But unfortunately, we simply do not have enough people trained in both fields, and there are only few such examples demonstrating the meaningful use of science in policy making.

One such example is the global climate research community under the umbrella WCRP which has taken advantage of and met challenges in international research for scientific and societal development over the last decades. The community has been making progress in developing global climate models as a basis of climate change science and, in turn, the provision of information to decision-makers. And it has achieved much in building knowledge on the challenges societies face and making clear policy options at national, regional, and international levels (Shapiro et al., 2010). We live in a knowledge society today. Innovation and scientific development are very important for sustainable development.

Grand challenges in Earth System Research for Global Sustainability

The identification of five Grand Challenges in Earth System Research for Global Sustainability through the visioning process has been a remarkable achievement (Reid et al., 2010). The process has not only outlined a vision and future directions (see Figure 1), but also generated a lot of momentum

by engaging the international scientific community to explore options and propose steps to implement a holistic strategy for Earth system research. The implementation of the outcomes of this process calls for involvements and commitments of the full range of sciences and humanities as well as active engagements of stakeholders and decision makers.

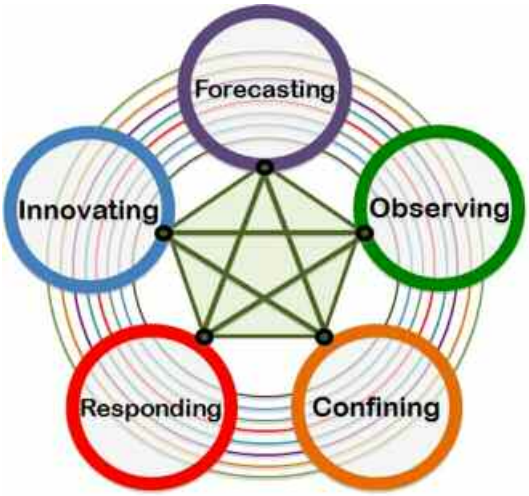

Figure 1: Grand Challenges in Earth System Science for Global Sustainability. The concentric circles represent the disciplinary research needed in the social, natural, health and engineering sciences and the humanities that must be carried out alongside interdisciplinary and transdisciplinary research in order to address the challenges. The lines linking the grand challenges show that progress in addressing any challenge will require progress in addressing each of the others. Source of the figure: ICSU (2010). For details about the five Grand Challenges and associated research questions, please refer to ICSU (2010a) and Reid et al. (2010).

Ways forward

In order to achieve global sustainability, the society as a large must

- realise the urgent need for greater action on sustainable development,
- ensure that policy making uses the best available knowledge from across the natural, social and engineering sciences,

- strengthen science and technology as an essential measure to accelerate the implementation of sustainable development.

At the same time, the global scientific community needs to work towards the realisation of the potential that is associated with the following key issues:

- Natural science, social science and technology together have crucial roles in finding solutions to the challenges of sustainable development.
- A much greater proportion of research must be solution-oriented and interdisciplinary, addressing the integrated social, economic and environmental pillars of sustainable development.
- Research agendas must be defined through broad-based, participatory approaches involving those in need of scientific information. The scientific and technological community must improve cooperation with other parts of civil society, the private sector, governments and intergovernmental bodies.

The scientific community must now deliver the knowledge that will enable countries, regions, and economic sectors to embark on transitions to sustainability in order to secure human development in the face of rapid global change. While deepening our understanding of the Earth System and of human impacts, we must build the capacity to deliver solutions to pressing sustainability challenges at regional to global scales. Several decades after the creation of the first global environmental change programme, there is a realization that the planet is in a 'no-analogue' state. While there has been much progress in the understanding of the complexity and vulnerability of the Earth System, there is the growing recognition that research needs to be translated into action. Science is urgently needed to address how complex social-ecological interactions, including tipping points, play out across scales – impacting the Earth System, and subsequently affecting local livelihood conditions among all the world's citizens. There are three billion poor people in urgent need of improved social and economic development. The world's population is expected to increase by another three billion by 2050, on a planet that is increasingly showing signs of limits of its carrying capacity. More than ever before, science can inform societal decisions on mitigation and adaptation. The situation poses new constraints and challenges in the quest for poverty alleviation, development, and, ultimately, global justice.

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