The Contribution of Science in Implementing the **Sustainable Development Goals**

German Committee Future Earth

DFG

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SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

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Figures:
p.20, 30: DKN Future Earth ■ p.22: UN ■ p.43, 44: Future Earth

Graphic design by
Maro Haas / MH Design

Editing/Proofreading by
Dr. Jutta Bachmann / Bachmann Consulting

Financial support for conferences and report provided by
Deutsche Forschungsgemeinschaft (DFG)

December 2016
ISBN 978-3-9813068-5-9

Suggested citation: Schmalzbauer B., Visbeck M. (Eds.) 2016. The contribution of science in implementing the Sustainable Development Goals. German Committee Future Earth, Stuttgart/Kiel.

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PERSPECTIVE ON THE ROLE OF SCIENCE IN 2030 AGENDA

While the world is currently facing many challenges and crises ranging from global inequality, complex economic turbulence to large-scale migration as a consequence of underdevelopment, war and terrorism, 2015 has also seen strong signs of cooperation and shared responsibility for the future. The adoption of the Sustainable Development Goals (SDGs) and the Paris Agreement on climate change are both examples of far-reaching agreements between heads of state and broader societal groups. These agreements set forth an ambitious global agenda intended to be both aspirational and practical. After almost thirty years of political discourse on sustainability, which began on the world stage with the Brundtland Commission in 1987, we can now identify substantial shifts in turning words into actions as we delve deeper into the challenges and opportunities of implementation.

The 2030 Agenda for Sustainable Development and the move towards decarbonisation both require a transformational agenda. The process of identifying and negotiating these two global frameworks has made it very clear that civil society, business, and, indeed *all individuals*, have a central role to play. Similarly, in the world of science, concepts and perspectives such as transdisciplinarity and co-creation are gaining ground. As a consequence, the strict division between those actors establishing goals and norms on one hand, and identifying research questions on the other hand, and actors who comply with these goals and norms or conduct the research, is becoming blurred. If decarbonisation and the 2030 Agenda are seen as laying the groundwork for implementation, then science, politics, economics and civil society now need to develop a robust *common* understanding of the issues at stake and possible solutions compatible with ecological boundaries and democratic principles.

Much has been said in science and politics about the problems that could arise from "crossing the lines" in this way. It is neither desirable nor useful for science to become overly politicised or, conversely, for government policies to be designed by scientific principles and worldviews. However, as the social sphere, including the sub-systems of science and politics, does not operate according to strict "either-or constellations", pragmatic *and* critical reflections are required for testing and (re-) configuring science-policy interactions.

If one accepts the premise that a fundamental shift towards more participatory approaches in policymaking occurred in the lead-up to 2015, the question that needs to be asked is whether science has learned similar lessons to politics. What is the state of play in research processes in terms of practitioner involvement and broader *practice*?

While this debate is ongoing and in the absence of any final solution, as it is the case in both science and politics, we can identify some early initiatives and processes. Two examples are the conferences organised by the German Committee Future Earth and DFG on "Measuring Sustainable Development" (2015) and "Science needs for implementing the SDG framework" (2016).

By focusing on topics such as "measurability of SDGs", "nexus challenges" and broader "science-policy relationships", the two initiatives showed how science, and only science in this case, can make useful contributions to such complex and multi-dimensional agendas. As science is not politics and politics is not science, it goes without saying that solution-oriented research needs a broad basis in fundamental upstream research, embedded in a diverse research landscape and funding structure. This report provides important insights into how collaboration beyond disciplines and between science and policy/society is possible in more concrete terms and can be highly useful for implementing the 2030 Agenda and the Paris Agreement.

The German research community and its institutional landscape seem to fulfil many of the requirements for a productive knowledge base for the challenges ahead. Martin Visbeck, Chairman of the German Future Earth Committee, and Jörg Hacker, President of the German Academy of Sciences Leopoldina, are two extremely dedicated figures at the helm of two fundamental activities. Jörg Hacker also provides strong representation for Germany on the UN Scientific Advisory Board – a high-level committee and one of the key global level entry points highlighting the crucial role that science can and should play by providing timely and substantial advice to our common agenda. Any assessment of the current state of the UN system and specifically its ability to support the implementation of the two agendas underlines this crucial role science can play, and serves to remind the UN and member states that science will need to be strengthened further in order to deliver what is required. We need sound assessments and concrete options for action that not only address science-policy challenges related to the multi-facetted relationships between excellence and relevance on the national level, but also help build trust and ultimately legitimacy between countries and continents. This will then turn the best possible knowledge into a global common agenda for globally relevant actions that also takes into account local realities.

Klaus Töpfer

Founding Director and Executive Director emeritus of the
Institute for Advanced Sustainability Studies,
former Executive Director of the United Nations
Environment Programme

THE CONCEPTUALISATION OF RESEARCH IN GLOBAL SUSTAINABILITY

Deutsche Forschungsgemeinschaft

Almost thirty years ago, in 1987, the United Nations World Commission on Environment and Development published a report with the title *Our Common Future*. Also known as the Brundtland Commission Report, named after commission chair Gro Harlem Brundtland, the report soon became a milestone policy document. For the first time it put sustainable development on the global agenda, defining it as an effort "to meet the needs and aspirations of the present without compromising the ability to meet those of the future."

The Brundtland Commission's call to build a sustainable world still resonates with us today. It has lost none of its urgency, nor has it lost any of its relevance. On the contrary: What was still a new idea thirty years ago has now turned into a collective global value and a common mission shared by international organisations as well as governments, non-governmental organisations, and other civil society actors. Not least, sustainable development has also become an important concern for scientists and researchers.

As a knowledge society, we necessarily rely on scientific research when we try to chart the course towards a sustainable future. Knowledge societies depend on the knowledge, the expertise, and the reflexivity that the sciences and humanities have to offer. That said, the growing importance of scholarly knowledge in respect to sustainable development has at least two important implications for the scientific and scholarly endeavours themselves.

First, it affects the concepts of the sciences, social sciences, and humanities: of what they are, of what they ought to do, and of the ways in which they should be organised. This leads to the questions of "What kind of research do we need in order to meet the challenges of climate change and global sustainability? And how should we organise our research systems to be able to live up to those challenges?" Both of these questions defy easy answers, yet it is important to think them through.

In the current public discourse, proponents of the "sustainability movement" in research around the world call for a better realignment and a normative turn of our entire research systems towards the issue of sustainability. Researchers and scientists should investigate sustainability questions that society defines as important and move beyond a purely technological approach to sustainable development in all dimensions. Researchers are often supposed to privilege the practical handling of concrete problems over curiosity-driven research, and they are expected to concern themselves with producing usable and actionable knowledge. If this claim were understood as a call for a complete normative turn of the public research system, it would imply several problems. This research concept

merely replaces the technological instrumentalism it criticizes with a new form – environmental instrumentalism. Accordingly, it conceptualises all research as a practical tool to work out scientific solutions to problems that society has already defined. With that, it reduces the potentially endless range of questions and issues that researchers may legitimately deal with to one single overarching purpose. However, any such form of instrumentalism not only underestimates the complexity of the challenges that society faces. By conceptualising research as a matter of predefined problems and predictable solutions, it also underestimates the importance of those surprising scholarly insights that society needs to meet the challenges of sustainable development. This new, unpredictable knowledge creates the real transformative breakthroughs that change the ways of society's thinking and acting. To answer the questions, research systems should be as pluralistic as possible in order to be able to contribute to sustainable development. Only then will society be able to handle short-term and long-term perspectives as well as predictable and unpredictable developments.

Second, it may also change the way in which relationships between academia and society are conceptualised. To take the tough and wise political actions needed to implement the 2030 Agenda, options and scenarios should be based on sound empirical evidence. Scholarly knowledge can help to formulate, question, or criticise competing knowledge claims. Researchers are in the best position to offer their scholarly knowledge, their expertise and their reflexivity to political decision-makers, particularly by outlining the range of options for actions and their respective implications, before policymakers then actually take the decisions. Thus, researchers can enable them to come to smart and sound decisions. In order to be able to do so, however, researchers have to build relationships with policymakers and politicians. They need opportunities to exchange ideas and to put forward their scientific concepts to the political field. On an international level, institutions such as the UN Secretary-General's Scientific Advisory Board ensure that the best scientific knowledge is available to decision-makers.

Likewise, joint conferences bringing together both sides – researchers and policymakers – may open up such a space of interaction and stimulating discussions, which is increasingly needed for a sustainable future. In this sense, the conferences "Measuring Sustainable Development" and "Science Needs in Implementing the Framework", both documented in this report, were an effort to explore the potential input of science – in particular the contribution of fundamental bottom-up research – to support decision-making in the 2030 Agenda process. The conference topics focused mainly on the measurability and implementation of Sustainable Development Goals, nexus challenges and effective science-policy relationships. The conference results presented in this report demonstrate that science can contribute in two ways: on the one hand, to better understand the interlinkages between the Sustainable Development Goals and their underlying challenges and to understand thresholds, rebound effects and tipping points; on the other hand, to support the evaluation of Sustainable Development Goals and track the progress of their achievement.

Peter Strohschneider
President of the Deutsche Forschungsgemeinschaft

CONSOLIDATE THE RELATIONSHIP BETWEEN SCIENCE AND UNITED NATIONS

Deutsche Forschungsgemeinschaft / German Academy of Sciences Leopoldina – National Academy of Sciences

This report – bringing together the results of two conferences on the advancement of the United Nation's 2030 development agenda – comes at a timely moment: Last year we witnessed two remarkable events that ought to be seen as important moments in the history of our global community. In December 2015, we observed the World Climate Summit in Paris, an event that will hopefully turn out to be the most impactful of its kind ever. As we know, the European Union ratified the Paris Agreement in October 2016, and under its terms, there are currently enough signatory countries producing a large enough share of the world's greenhouse gases for the agreement to enter into force. The agreement, therefore, took effect on 4 November 2016. The second globally influential event last year was held in September, when member states of the United Nations adopted the new Sustainable Development Goals to chart the course for the United Nation's 2030 development policy.

The member states of the United Nations not only successfully negotiated and formulated the Sustainable Development Goals, they also stated repeatedly that the new post-2015 development policies of the United Nations – also known as the 2030 Agenda for Sustainability – should be based strictly on a scientifically sound and effective approach. To this end, the member states and particularly the United Nation's Secretary-General Ban Ki-moon have called upon the global scientific community to help establish the scientific basis for evidence-based implementation of this agenda.

Sustainable development, in general, has become an important concern for scientists and researchers. Around the world, they work broadly and intensely on questions of sustainability and contribute to sustainable development in numerous ways. They do so, for example, by developing new crops that enable rural societies to shake off the yoke of famine; or by exploring new ways to improve energy efficiency; or by testing and developing new vaccinations and antibiotics to fight off the scourges of disease. Beyond that, the idea of sustainability has become a collective global value and a common mission shared by international organisations as well as governments, non-governmental organisations, and other civil society actors.

In order to further explore and underpin the importance of scientific contributions to the success of the 2030 development agenda, the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) and the United Nations University – both strongly committed to sustainability issues – have also responded to the UN Secretary-General's request by organising events for leading scholars, practitioners and policymakers in the United Nations system to come together, exchange ideas, and discuss new scientific approaches to measuring, assessing and implementing sustainable development.

We started out in 2015 with a conference held in New York, at the German House and the United Nations Headquarters. The main purpose of this conference was to further develop the science-policy interface and to identify possible contributions of the scientific community to the 2030 agenda implementation process. The conference was then supplemented by an international workshop series by the German Committee Future Earth in collaboration with Future Earth and other partners to debate and elaborate possible research questions, frameworks and collaboration models. Furthermore, a lecture series together with the University of Bonn was organised to discuss with members of the Scientific Advisory Board to the UN Secretary-General and the broader public current research findings and recent advancements in sustainable development.

Large parts of these gatherings would not have been possible without the support of the Permanent Mission of Germany to the United Nations, the various UN representatives, as well as the contributions of the representatives of the Secretary-General's Scientific Advisory Board. Thanks to the Scientific Advisory Board, the UN system has placed so much emphasis on issues such as health, development, economics, gender, education, and sustainable development that conferences like ours have been highly appreciated and broadly supported by numerous people and organisations.

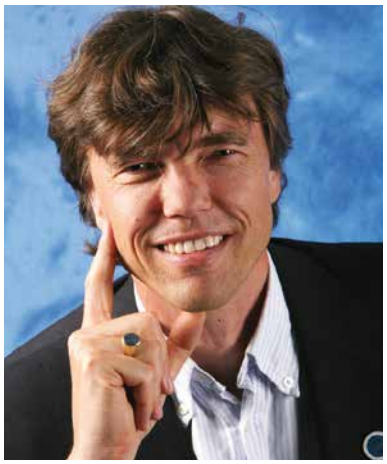
We would like to thank all partners, collaborators and participants for their excellent work and numerous stimulating discussions. We will continue to provide support for scientific input on climate change and global sustainability, and for strengthening the science-policy interface in the 2030 agenda process.

Dorothee Dzwonnek
Secretary General of the
Deutsche Forschungsgemeinschaft

Jörg Hacker
President of the German Academy of Sciences
Leopoldina – National Academy of Sciences

BENEFITS OF INTERNATIONAL COOPERATION IN SCIENCE

German Committee Future Earth



Challenged to provide answers to some of the world's biggest societal and environmental problems, the scientific community has consistently delivered exciting and solid information that is often used to assess the situation in many different parts of the globe to document the anthropogenic cause of environmental changes and to provide perspectives on possible development scenarios. Looking towards the future, societies will face a growing number of challenges, which will include finding ways to address climate change, achieve food security, counteract the scarcity of raw materials and maintain and improve public health. Rapid growth of the world's population, increasing affluence and an ageing population are all factors that contribute to these challenges. More science based information ideally coordinated at the global scale is required to inform sustainable development strategies to counterbalance these developments, especially considering the increasing complexity of decision-making related to global and regional agreements.

The new Paris Agreement on addressing climate change and the 2030 Agenda for Sustainable Development are providing high-level political frameworks for global transformation to a more sustainable society, and are expected to shape policies for the next decade. To successfully implement these global agreements science can play a role by explaining the benefits and trade-offs of a range of development pathways that could lead to a more sustainable global society, contribute to achieving global Sustainable Development Goals (SDGs) and help address climate change issues for a more positive outlook on the future. The scientific community will be called on to contribute more than ever before to provide innovative ideas and information in the context of global problem solving. In order to increase efficiency and impact it might be beneficial to explore new forms of scientific partnerships that can provide relevant information to support the needed transformation of global society.

For example, international scientific cooperation in the World Climate Research Programme (WCRP) and the newly launched Future Earth programme is geared towards providing the knowledge and support needed to accelerate the transformation to a more sustainable world. These programmes focus on challenges that are too complex for a single nation or institution to deal with alone. Research in Future Earth is expected to generate knowledge that will enable societies worldwide to deal effectively with the challenges of global environmental change. Future Earth supports solution-oriented, upstream-integrated and fundamental research as well as international engagement, all aimed at addressing sustainability challenges and generating new knowledge in partnership with society. Over the next

few months, Future Earth will establish a number of Knowledge-Action Networks (KANs). One KAN will focus on integral aspects of SDGs such as how to achieve policy coherence when planning the implementation of particular actions related to one specific goal; on integral aspects of the indicator framework for SDGs that would benefit from being more scientifically based. Future Earth and WCRP are expected to deliver the scientific basis needed to effectively reach the goals set out in the 2030 Agenda for Sustainable Development and the Paris Agreement on Climate Change.

Future Earth and WCRP are supported at national level by the German Committee Future Earth that brings together the scientific community with other expert groups with the aim of defining, establishing and implementing new and innovative global sustainability research activities.

In its second term (2016-2018), the German Committee Future Earth is focusing its activities on scientific aspects related to the 2030 Agenda, and engaging in and intensifying partnerships with other national advisory bodies and networks such as the German Sustainable Development Solutions Network, the German Advisory Council of Global Change and the German Council for Sustainable Development. The German Committee Future Earth also contributes to shaping the international research agenda by organising flagship activities such as the foresight workshop on scientific needs for implementing the SDGs.

Over recent decades, members of the German Committee Future Earth and the German science community have played key roles in the effort to align research on global change, and have identified the need for an integrated research approach. We are convinced that international collaboration between researchers is essential for generating global and regional knowledge in new and exciting ways. This report shows that research collaboration across nations, disciplines and knowledge domains can work extremely well to suggest possible pathways for enhancing global sustainability.

Martin Visbeck

Chairman of the
German Committee Future Earth

I. RECOMMENDATIONS FOR ACTION

Major issues in the successful implementation of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) are likely to be: consistency with other political processes (e.g. UNFCCC), implementability (e.g. interactions between goals) and measurability (e.g. indicators). Science can contribute to all these aspects by providing the fundamental knowledge base necessary for decision-making and practical implementation of the goals. Rapid advances in science can best be achieved with an integrated, cross-sectoral and engaging scientific agenda that connects upstream fundamental research with solution-oriented research. The DFG (German Research Foundation) has joined forces with a number of partners to further strengthen the role of science in the SDG agenda.

Two conferences have proved to be inspiring platforms for future action. The conferences were organised in cooperation with partners from science, government, the UN and civil society. The first conference focused on "Measuring Sustainable Development" and was run by the DFG and UNU in 2015; the second was a "Foresight workshop on science needs in implementing the SDG framework" and was organised by the German Committee Future Earth, Future Earth and SDSN in 2016.

The organisers believe that the implementation of the 2030 Agenda will benefit from existing and up-coming research results and other types of knowledge. The recommendations summarised on the right hand side highlight possible contributions that science can make in the broader context. These recommendations focus in particular on internationally coordinated upstream fundamental research.

A more comprehensive and detailed account of the discussions and recommendations will be given in the following chapters.

The recommended core fields of action are:

- **To encourage interdisciplinary science** to increase the knowledge base needed for the most efficient and coherent sustainable development pathways.
- **To prepare problem- and solution-oriented synopses** in order to better understand, analyse and cope with different types of potential conflicts concerning the SDG implementation process.
- **To establish platforms for free and open data** sharing with transparent metadata that are available to all stakeholders, and can also be used as the basis for creating flexible indicator frameworks.
- **To foster increased international collaboration and exchange of knowledge** and scientific capacity on the global level by intensifying projects such as Future Earth.
- **To reinforce the science-policy process** by building on good examples such as the UN-SAB (United Nation Secretary-General's Scientific Advisory Board) national science advisors and the committees that have been set up to ensure that the best scientific knowledge is available to decision-makers.
- **To develop more partnerships** between academia, business, civil society and governments in order to find innovative sustainable development solutions through networks such as SDSN.
- **To understand the implementation of the SDGs** as a continuous learning process that needs close and regular scientifically based revision.

II. EXECUTIVE SUMMARY ON "MEASURING SUSTAINABLE DEVELOPMENT"

– a conference jointly organised by DFG and UNU with the aim of reinforcing the science-policy interface in the context of the Sustainable Development Goals

In April 2015 the DFG joined forces with the United Nations University (UNU) to hold a conference on "Measuring sustainable development" in New York. This two-day conference was aimed at reinforcing the science-policy interface in the context of the Sustainable Development Goals, which are the core of the 2030 Agenda, and discussing the role of science along with current practices in government and civil society. Around 60 people attended the conference including representatives from government and civil society organisations, UN policy makers and scientists from various disciplines.

The debate on the 2030 Agenda for Sustainable Development, its goals, targets and indicators, as well as how they are measured, monitored and reviewed, necessarily includes discussion on the role played by science in sustainable development, what science has to offer policymakers and how the science-policy interface can be improved. Research on global sustainable development has been recognised as scientifically important as well as societally relevant. However, implementing SDGs poses a series of particular challenges as far as monitoring, measuring and assessment of goals is concerned. The DFG-UNU conference focused on these issues and provided a unique opportunity to discuss institutional boundaries and for science to engage with practices in government and civil society. The conference was aimed at scholars as well as experts and practitioners in relevant political arenas (UN bodies, the Diplomatic Corps, NGOs, academia and the business community) and sought to bring them together with key players in the global sustainability, including the Future Earth research initiative, the Scientific Advisory Board to the UN Secretary General and the Sustainable Development Solutions Network.

The DFG-UNU conference focused on thematic sessions that form the basis for key recommendations given in this section: indicators and monitoring, assessment and evaluation, synergies and tough choices, and ownership. The main outcome of the conference was that science must provide the factual basis for the SDGs and can make significant contributions towards their implementation in four specific areas: First, progress on SDG implementation needs to be supported by a **meaningful indicator framework**, and this framework needs scientific input. In 2016, the UN adopted a set of 230 indicators. However, due to lack of data, only a third of the indicators were suitable for inclusion in the first report entitled "SDG Index & Dashboards – Global Report" that was produced to help countries implement the

ABOVE **JAKOB RHYNER, GUILHERME DE AGUIAR PATRIOTA, ROBERT C. ORR, AMINA MOHAMMED, JÖRG HACKER, DOROTHEE DZWONNEK** AND **PETER STROHSCHNEIDER**

BELOW **AMINA MOHAMMED**, SPECIAL ADVISOR OF THE SECRETARY-GENERAL OF THE UNITED NATIONS ON POST-2015 DEVELOPMENT PLANNING

new SDGs. Second, science can support the establishment of **evidence-based procedures for evaluating the SDGs** and track achievement progress. Third, sound scientific input is needed for **co-designing and executing scientific assessments** in the context of the SDG process (going beyond the good examples set by IPCC and IPBES). Fourth, deep and integrated scientific knowledge is needed for **better understanding key interlinkages, synergies and trade-offs** embedded in the SDGs. This area would also benefit from foresight.

Key recommendations are:

Indicators and monitoring: Incorporate better data and indicators to improve policy decision-making. This requires building technical capacity around the world, especially in developing countries, and includes training scientists as well as creating institutions that can provide indicators and are sufficiently strong and transparent to remain politically independent.

Assessment and evaluation: Include (i) regular SDG evaluations that provide continuous information to member states and other stakeholders on their progress in reaching goals and targets; and (ii) on-demand assessments that provide feedback to member states and other stakeholders on key scientific issues concerning SDGs. Assessments need to be (1) multi-level, integrated, transparent, participatory and consensual; their guiding questions need to be jointly framed by the policy and science communities; (2) "go the extra mile" by assessing interlinkages and trade-offs embedded within the SDGs, and policy options for transforming trade-offs into synergies; (3) open data platforms.

MICHAEL KAHN (STELLENBOSH UNIVERSITY), **MARKUS GEHRING** (UNIVERSITY OF CAMBRIDGE), **MARIANNE BEISHEIM** (GERMAN INSTITUTE FOR INTERNATIONAL AND SECURITY AFFAIRS), **ANITA ENGELS** (UNIVERSITY OF HAMBURG), **NORICHIKA KANIE** (UN UNIVERSITY), **SARAN KABA JONES** (FACE AFRICA), **THOMAS POGGE** (YALE UNIVERSITY)

Synergies and tough choices: Exchange with science enhances learning processes with science. As science is a continuous learning process, it can play a pivotal role in terms of data, analysis and scenario building. Short-term vs. long-term trade-offs between SDGs can be handled through suitable incentives and/or temporary focused support. Other trade-offs should be approached by more efficient use of resources, often requiring behavioural changes. Furthermore, a multi-stage approach to indicator development should be envisioned and explored, from a goal-related to a policy-related indicator framework, which should utilise synergies and handle possible trade-offs.

Ownership: (1) Participation of all national stakeholders and participatory monitoring of country-level implementation will be instrumental for achieving local ownership. Beyond that, it is necessary to explore ways to strengthen ownership of the SDGs that are dealing with global common goods. (2) The international legal framework for SDGs should have a reinforcing loop to support stakeholders. (3) Efforts should be made to engage local communities and utilise local knowledge as much as possible.

EXECUTIVE SUMMARY ON "SCIENCE NEEDS FOR IMPLEMENTING THE SDG FRAMEWORK"

– a German Committee Future Earth, Future Earth and SDSN joint foresight workshop to identify research requirements for supporting the implementation of SDGs

The international foresight workshop, held from 18-21 April 2016 at Villa Vigoni, Italy, aimed to identify research needs in support of SDG implementation. The workshop was organised by the German Committee Future Earth in close collaboration with Future Earth and SDSN (Sustainable Development Solutions Network), and is one of a series of possible workshops to be held in collaboration with the international Future Earth research programme. This first workshop involved the support and participation of 35 international experts from the natural and social sciences and the public sector.

Over the past few decades, research has helped create a better understanding of the linkages and possible impacts of human development on a regional and global level. There has been rapid progress within sectors and along single dimensions, but much slower developments in interlinked areas such as nexus fields. The objective of the "Foresight workshop on science needs for implementing the new SDG framework" was to further develop a research framework that would contribute to identifying potential comprehensive (global, sustainable in all dimensions) solutions in the coming (5+) years to support the successful implementation of SDGs. A research framework can help to develop societally, economically and environmentally efficient instruments and achieve better policy coherence. Using foresight as a thinking and learning process before strategic decisions are taken can reveal possible interlinkages between sustainable development goals as well as the contribution that can be made by research. This was discussed with a particular focus on the three following interlinked areas of global concern: (1) socio-economic & biophysical dynamics of the humanity-nature nexus, (2) migration and SDGs, and (3) food security & sustainable production and consumption – ocean and land. The key findings of the foresight workshop given below are based on the prominent issues currently being discussed rather than a priority list.

Key findings of the workshop are:

- Science can make valuable contributions to better understanding and identifying relevant options for SDG implementation. This requires fragmented knowledge communities to come together in order to **provide a synthesis** of the current state of scientific knowledge in the context of global sustainability (it needs to be examined whether this synthesis could be organised along similar lines to IPCC/IPBES processes or whether it has to be more flexible and interactive). Solution-oriented and contextual upstream fundamental research need to work together to help **understand posisitve and**

negative relationships between sustainable development goals and targets, and what this means on a national level (e.g. in the form of pilot and comparative studies aimed at identifying context-specific challenges and opportunities). Science also needs to **advance methodological approaches to nexus challenges and nexus methods** in order to improve policy coherence.

Migration nexus topic. Migration is a cross-cutting phenomenon related to diverse sustainable development goals. Migration can be interpreted as a reaction to the problems that the 2030 Agenda sets out to solve. In some cases it can help to achieve the SDGs and in others it may create additional difficulties. As there is a huge lack of knowledge in this field, **research on migration patterns and push and pull factors across countries and biomes is urgently needed. This needs to take into account how such migration dynamics may impact efforts to achieve the SDGs.** Spatialised socio-economic migration databases need to be merged, expanded and coupled with environmental datasets as well as with governance and fragility data to support meta analysis.

Humanity-nature nexus topic. In terms of the conditions required for the emergence of a sustainable economy that supports the achievement of the SDGs, science can contribute in four different overarching fields: **co-designing development pathways** that encompass the dynamics of biophysical and social system dynamics; **harnessing the power of business and providing SDG-compatible business model designs**; adopting a **systematic approach to assessing the implication**s of public policies and business strategies for achieving SDGs; **decision-making in uncertain conditions**.

Food security nexus topic. Society's greatest challenge will be to ensure a well-balanced and healthy diet for the future world population while avoiding significant ecosystem degradation and

The SDG agenda is likely to be a turning point not only for the UN system, but also for the international science system. It is probably the most comprehensive international framework that has ever been formulated and necessarily embodies all the tough questions humanity faces when formulating perspectives for sustainable and prosperous development. There will be no single straight path towards global sustainability and prosperity involving simultaneous advancement of all the indicators within the 17 goals and 169 targets. This is where science comes in, and takes a holistic approach to identifying and understanding trade-offs between different targets, as well as detecting synergies that can mobilise and boost action. This will require a goal- and solution-oriented scientific approach. Inter- and transdisciplinarity will be a consequence rather than the founding principle of such an approach. At the United Nations University, we see this again and again in our projects at the interface of academia and the UN system.

That said, inter- and transdisciplinary science is not the only approach required. Most of the tools and methodologies that are urgently needed and being used today – such as telecommunications, renewable energy production and medical technologies – have their roots in purely curiosity driven, deep-rooted disciplinary research undertaken in the fields of biology, physics or mathematics in the last century. We will continue to need this type of research in our search for answers to questions that have not even been asked yet, but will require solutions by the late 21st century.

Therefore there is no point playing off fundamental against applied research, disciplinary against inter- and transdisciplinary projects, or social against natural science. A successful long-term implementation of the SDG agenda needs all of these, plus the corresponding diversity of scientists and funding mechanisms that value all the different approaches and foster interaction between them.

Jakob Rhyner
United Nations University (UNU)
Vice Rector in Europe and Director of the Institute for Environment and Human Security

WORKSHOP PARTICIPANTS OF THE FORESIGHT WORKSHOP ON "SCIENCE NEEDS FOR IMPLEMENTING THE SDG FRAMEWORK"

pollution and keeping remaining forests and wetlands intact, without overexploiting land and ocean resources. Science can contribute by analysing options in five different overarching fields: reforming **global regulatory frameworks**; measuring **risk and introducing insurance** on different scales; integrating **environmental and ecosystem services into decision-making** on farming; elaborating **technological approaches towards sustainable intensification** of agricultural production; reducing **food waste and improving food security.**

In terms of monitoring and review, the scientific community needs to work on the SDG narratives, as easy-to-handle innovative indicators are required. This could mean working on issues such as "What does development mean on a national scale? How does national prosperity contribute to global cumulative effects, and are there feedback effects from global to national and local levels? How do national strategies affect other countries? What are the most effective ways of overcoming existing institutional and other barriers at national level in order to achieve an interlinked (e.g. socio-ecological) approach to SDG implementation?".

New types of knowledge interaction between relevant stakeholders are needed in order to successfully implement SDGs. For instance, one starting point could be a knowledge generation model that describes a comprehensive way of looking at complex challenges and includes repeated and dynamic interaction over time between upstream fundamental research, solution-oriented research, policymakers, the private sector and civil society.

Foresight can help handle the complexity and time pressure involved in implementing SDGs in two ways. First, by reflecting on research methods and tools in a multidimensional way (e.g. adequacy of toolboxes). Second, by informing decision-makers and developing scenarios by bringing together strategic thinkers from different knowledge domains.

III. RESEARCH OPPORTUNITIES

1/ DISCUSSING THE ROLE OF SCIENCE IN THE IMPLEMENTATION OF SDGS

The new SDG framework is much broader than the Millennium Development Goals framework; it integrates economic, social and environmental issues and is universal in its approach. The SDG framework will provide policy guidance to all nations on Earth with the aim of improving cooperation on human welfare and the global commons, and promoting transformative change (UN, 2015). Even before the adoption of the SDGs, scientific reports raised concerns about the quality of the SDGs and their targets. For example, Griggs *et al.* (2014) suggested using focused and measureable SDGs based on the experience of the Millennium Development Goals. Other reports indicated that roughly half of the targets would be easier to implement and progress could be measured more clearly if the formulation of targets had benefitted from more input from the scientific community (ICSU & ISSC, 2015; Loewe & Rippin, 2015). These shortcomings, which have not yet been fully acknowledged, can be attributed to the dynamics of the negotiation process, and will need to be dealt with during the ongoing implementation process of the Agenda for Sustainable Development up to 2030.

An agenda as broad as the 2030 Agenda poses many challenges on the national level in terms of implementation, measurement, monitoring and accountability. Due to the strong interrelationships between different SDGs, these challenges occur in particular around possible trade-offs between short-term development achievements and long-term sustainability (Griggs *et al.*, 2013; Rockström *et al.*, 2013; Kanie *et al.*, 2014). While SDGs provide a coordinating and synthesising framework for public (and private) sector decision-making, science can play a pivotal role, for example in representing sustainability challenges in different contexts (data, analysis and scenario building), creating models that explore how different targets interact, and tracking progress towards goals (Dasgupta *et al.*, 2014; Beisheim *et al.*, 2015; Yonglong *et al.*, 2015; Nilsson, 2016; Nilsson *et al.*, 2016).

For instance, in many cases there may be a need to prioritise SDGs from a local and regional perspective in the areas where they are going to be implemented. Due to complex dependencies between goals, conflicting issues may lead to tough choices (Beisheim *et al.*, 2015). In such cases, decision-makers could benefit from one of science's biggest strengths: holistic systems thinking. In the context of SDGs, systems thinking is essential for identifying knowledge gaps, initiating solutions-oriented research as well as developing integrated assessments with the participation of multiple stakeholders (TFM, 2016). Research could contribute to identifying critical interactions between policies aimed at achieving specific SDGs and how possible negative interactions can be mitigated through synergy solutions and possible multipurpose actions. Insights into both of these areas will have an impact on deciding which criteria need to

be prioritised. In this context, researchers should be encouraged to develop analytical models and other tools for evaluating these aspects (Giovannini *et al.*, 2015). It is therefore vital to pursue an integrated approach using datasets from the natural sciences as well as the social and behavioural sciences (Nilsson, 2016).

The UN-SAB (United Nation Secretary-General's Scientific Advisory Board) also stresses the importance of basing evidence-based policymaking on an integrated scientific approach. Moreover, the UN-SAB calls for a new global research architecture that supports interdisciplinary collaboration and links science with both policy and society. However, there is still no common understanding of what a successful science-policy or even science-society interface entails (Beisheim *et al.*, 2015). Many multi-stakeholder platforms differ in set-up and goals, such as, for example, the Stakeholder Forum, the UN Partnerships for SDGs platform, the Independent Research Forum and Future Earth, the new flagship initiative of the Science and Technology Alliance for Global Sustainability that aims to enhance the contribution of research towards achieving the SDGs (further details in section III.4).

There is therefore tremendous opportunity and need for the scientific community to engage in and develop forward-looking research that has the potential to support new interconnected development pathways, particularly in highly interlinked areas of global concern. The following questions therefore arise and will be addressed in the following sections: How can science best foresee dependencies, synergies and possible conflicts between goals and targets? Do challenges of this type require a more nimble global science and innovation system with more efficient science-policy dialogues?

2/ MEASURING SUSTAINABLE DEVELOPMENT: A DFG-UNU CONFERENCE[1]

The international conference on "Measuring sustainable development" was organised by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) in collaboration with the United Nations University (UNU) and with the assistance of the Permanent Mission of Germany to the United Nations (UN) in New York in April 2015. It focused on issues of global sustainability and in particular on the contribution of science to achieving the Sustainable Development Goals. This two-day meeting brought together more than 60 international experts from all scientific disciplines, as well as relevant UN institutions and representatives from both government and civil society organisations.

The conference opened with a talk by DFG President *Peter Strohschneider* at the German House in New York. Strohschneider emphasised in his speech the intellectual freedom that has been at the core of the concept of academic research for many decades. It is "now not an obstacle to building a sustainable world. Quite the contrary, it is the basis for the very success of this mission". He pointed out that critical advances can only be achieved if upstream fundamental as well as solution-oriented research are included in decision-making processes.

The conference sessions focused on topics such as "Indicators and monitoring", "Assessment and evaluation", "Synergies and tough choices" and "Ownership" and addressed the question of how scientific research can contribute to this field because, as Deputy Secretary-General to the United Nations *Jan Eliasson* explained in his introductory speech, "the source of wisdom is knowing the facts." Discussions also explored possible conflicts between the implementation of individual SDGs. *Jakob Rhyner*, Vice-Rector for the UNU in Europe, identified two such conflicts as "the trade-offs and potential conflicts between different objectives as well as the conflicts between short and long-term prospects. A highly targeted and sensitive approach to addressing such issues is critical for the successful implementation of the SDGs."

The final session took place at the United Nations headquarters in an event jointly organised by the Permanent Missions of Brazil and Germany. In her opening address, DFG Secretary General *Dorothee Dzwonnek* pointed out that bringing together relevant expertise and diverse perspectives in a single programme is an essential feature of this conference: "The goal of the conference has been to do just that, to bring in science and open a forum of debate for scholars, practitioners and policymakers. Over the last two days, they have discussed various concepts and approaches, often passionately, but always with a clear focus on applicability." In this final session, the outcomes from the four academic sessions were discussed with several UN representatives. *Stefan Schweinfest*, Director of the UN Statistical Division, stressed the importance of expanding statistical capacities in individual countries and developing an "informative global indicator framework". *Thomas Gass*, Assistant Secretary

1. All information given in this section is based on a background paper by Marianne Beisheim (SWP, Berlin), Hedda Løkken (University of Hamburg), Nils aus dem Moore (RWI, Essen), László Pintér (IISD, Canada; CEU, Budapest), and Wilfried Rickels (IfW, Kiel). The paper by Beisheim et al. (2015) was prepared prior to the adoption of the Sustainable Development Goals and provided the basis for discussions at DFG-UNU conference.

General of the UN for Policy Coordination and Inter-Agency Affairs, endorsed findings on synergies and trade-offs, which held that they are always context specific and therefore have to be dealt with in a pragmatic fashion that is subject to a continuous learning process. Of equal importance were the conclusions drawn from the discussions on ownership. He said "Building ownership by different stakeholders in different phases of the process is a continuous and time-consuming process but one which is essential to the implementation process as a whole." *Amina Mohammed*, Special Advisor to the Secretary-General of the UN on Post-2015 Development Planning, stressed in her speech that "2015 is the time for global action. This is our opportunity to take global action towards sustainable development and the future we want – and need. (...) The broad consensus that is emerging is encouraging." *Jörg Hacker*, President of the German National Academy of Sciences Leopoldina and member of the Scientific Advisory Board to the Secretary-General of the UN, was equally optimistic in his closing remarks: "The participation of members of the UN Secretary General's Scientific Advisory Board was certainly helpful for introducing science into the political process." The conference concluded with the insight that science must provide the factual basis for the SDGs in order for the goals to be achieved on the national and international level, and to advance political, economic and social changes in the context of the 2030 Agenda.

As a result of the discussions relating to "Indicators and monitoring", "Assessment and evaluation", "Synergies and tough choices" and "Ownership", the following recommendations were given.

2.1 Indicators and monitoring

As part of the preparation for adopting the SDGs in September 2015, member states discussed how to precisely measure and monitor the implementation of the SDGs and targets. The specific choice of goals and targets was very closely scrutinised by various observers and institutions during the preparation period. The areas subject to criticism included the high normative character of the indicators, the fact that they tended to be isolated and fragmented, and also the huge quantity of them. In 2015, ICSU and ISSC, for instance, claimed that only 29 percent of the indicators were well-founded scientifically, while 54 percent were deemed to require greater specification, and 17 percent possibly warranted significant revision (ICSU & ISSC, 2015). It was also recognised that scant attention had been paid to conceptual issues, despite the fact that a more uniform conceptual framework could offer a more optimal outcome without requiring any significant changes to the 2015 proposed indicator base. However, conceptual issues regarding the selection and aggregation of indicators were just a small number of the challenges related to achieving the SDGs at that time. In order to achieve far-reaching (sustainable) outcomes, properly structured implementation and financing plans will be needed at country level for all, and not just selected, goals.

In March 2016, the United Nations Statistical Commission's Interagency and Expert Group on SDG Indicators agreed on 230 individual indicators that will be used to monitor the 17 Sustainable Development Goals and their 169 targets. To support the initiation of SDG implementation, SDSN and Bertelsmann Stiftung jointly published the "SDG Index and Dashboards Report" in July 2016. The report offers a preliminary look at 149 (out of 193) UN member countries. However, at the moment, many indicators cannot be sufficiently underpinned with data, which is why this first SDG index only includes 77 indicators (Sachs et al., 2016).

Recommendations:

- A sound and informative indicator framework is needed to help member states track progress towards the accomplishment of individual SDGs. The indicator framework needs to be suitable for and applicable to all countries in order to make developments comparable across countries/regions. It should be able to aggregate numbers at different spatial levels, and needs to take into account the various current stages of development in different countries/regions in order to get a reasonable sense of progress made.

This recommendation has almost been fulfilled. In 2016, the UN Statistical Commission approved the indicator framework as a practical starting point and suggested continuing the discussion on e.g. refining the global indicators suggested by member states or methodologies for indicators for which definitions and standards need to be developed.

- The number of indicators needs to be distilled down to a relatively small set of "essential sustainability variables", the basic idea being that each variable/indicator could be applied to more than one target or goal.

The UN therefore adopted a smaller set of indicators, resulting in a still very comprehensive set of 230 indicators.

- The added value of evidence-based decision-making can be demonstrated, i.e. incorporating better data and indicators can result in improved policy.

- Technical capacity needs to be built around the world, particularly in developing countries; this includes training scientists and building indicator-enabling institutions that are strong and transparent enough to remain politically independent.

2.2 Assessment and evaluation

Evaluation reports that focus on goals, targets and indicators are important to monitor progress on different levels. But indicator-focused evaluation reports are not necessarily sufficient by themselves as decision-support instruments, because they may not provide a synthetic perspective on how multiple, interacting forces of change have led – or could lead in the future – to specific outcomes. Assessments are needed to bridge this gap between general aspirations underlying global goals and the specific needs of implementation. They are designed to bring together science and policy perspectives for analysing current trends and future policy options.

With regard to SDGs, it is expected that all assessments need to take into account the full scope of agreed goals, targets and indicators at the relevant scale and in context. This is done by structuring the assessments around an analytic framework that enables interlinkages to be recognised and assessed. The framework builds on pre-existing conceptual frameworks used by other assessments, and will probably require the use of integrated models.

Scientific input is needed on multiple fronts e.g. building an integrated assessment system that fits both the normative ambitions of the SDGs and the operational needs of SDG implementation. New science and research will be required to generate an integrated assessment system. Both the social and natural sciences will need to contribute to improving

modelling approaches (tightly coupled social-economic-financial-ecological systems), monitoring and indicator analysis, participatory construction of integrated policy scenarios and transition pathways, and the usefulness of assessments for strategy development and governance, as well as contributing to a better understanding of critical risks and uncertainties. As far as data is concerned, another equally critical issue for policy- and solution-oriented integrated assessments will be securing the necessary high quality reliable data for indicator-based SDG reporting. It will also be important to find ways of making better use of citizen science data (Kasemir et al. 2003; Kates et al. 2000). A key lesson from the study of global integrated assessments is that indicator-based progress reports require careful planning to ensure they lead to effective and lasting sustainable development governance policies. Furthermore, institutions and institutional capacities will need to be developed to produce integrated assessments that transcend indicator-based progress reports in purpose, mechanisms, outputs and utility. This will be needed in order to bridge the gap between the normative aspirations of the SDGs and the practical needs of those who are implementing the SDGs.

Recommendations:

- To be successful, SDGs need: (i) regular evaluations that provide continuous information to member states and other stakeholders on their progress towards reaching goals and targets; and (ii) on-demand assessments that provide necessary feedback to member states and other stakeholders on key scientific issues concerning SDGs.

- Assessments need to be multi-level, integrated, transparent, participatory and consensual in the summaries they make; their guiding questions need to be jointly framed by policy and science communities. The methodology for carrying out these assessments is readily available from the scientific community.

- Assessments in support of SDGs need to "go the extra mile" by assessing interlinkages (positive or negative) embedded within the SDGs as well as policy options to transform possible trade-offs into synergies.

- All underlying assessment data should be made widely available on new digital platforms (e.g. UNEP Live).

2.3 Synergies and tough choices

A central feature of the concept of sustainability is a holistic, systemic perspective that integrates the economic, social and environmental dimensions as well as the prerequisites of human welfare and development. Using the SDG framework as a guiding system for sustainable development is a fundamental priority for clarifying the relationships between different goals and targets, within and, in particular, between the three dimensions. From an

analytic perspective, individual objectives set at SDG level can be related to one another in three different ways: they may be independent and pursued in isolation; they may be characterised by a synergetic, mutually reinforcing relationship; or they may display a conflicting, even mutually exclusive relationship. In practice, however, it is rarely sensible to assume independence: there is ample evidence that failures in one area of sustainable development can quickly undermine progress in other areas. And even if progress on economic, social and environmental objectives is achieved simultaneously, it can be reversed all too easily by poor governance, escalating conflicts and insecurity (SDSN, 2013). It therefore seems worthwhile to: (i) identify synergies between goals and ways of overcoming obstacles to achieve them; and (ii) identify where objectives may be in conflict with one another and how to deal adequately with such challenges through prioritisation and sequencing. The identification of positive or negative interlinkages is also inextricably linked with procedural and governance issues.

In this context, science can contribute by providing a knowledge and evidence base that enables interactions between goals and targets to be identified (see section 3). However, the identification of interlinkages within the SDGs in terms of their aims and the language used is merely a preliminary step. Context-specific research is needed if we are to assess which positive effects can, in fact, be achieved, and the nature of any likely negative effects. This knowledge can inform decision-makers and help them choose the policy options that best meet the SDGs at a given location and a given time.

Recommendations:

- Positive or negative interactions are always context-specific, because there is no robust ex-ante knowledge on how to exploit synergies or deal with trade-offs. Science can play a pivotal role in implementing SDGs, in terms of data, analysis and scenario building, as science is a continuous learning process.

- Short-term vs. long-term trade-offs between goals can be handled through suitable incentives and/or focused temporary support. Other trade-offs should be approached by increased efficiency in the use of resources, often requiring changes in behaviour.

Achieving the SDGs and implementing the Paris Climate Agreement may well rank as the most important but also the most complex challenge humanity has ever faced. These issues can only be addressed by applying more knowledge and greater financial and human resources. This report lays out the critical challenges that science must address in order to achieve the SDGs.

In recent decades science has made great progress in describing essential Earth systems and understanding human impacts, though essential gaps do remain. At the Sustainable Development Solutions Network (SDSN) we strongly agree with the conclusion that more research is needed to develop sound and easily usable indicators for the Sustainable Development Goals.

The report underscores another critical challenge for interdisciplinary science: improving our understanding of how countries can design and implement long-term pathways towards sustainable development. As one example, policymakers around the world have accepted 2°C as the absolute temperature limit that must not be surpassed, whilst lacking an understanding of how their countries can achieve zero net emissions over the next fifty years. Better answers to these questions are urgently needed, now that countries have committed to preparing long-term low-emission development strategies under the Paris Climate Agreement. We agree that there is a tremendous need for science to support careful backcastings of countries' energy systems and land-use change by drawing on a broad range of disciplines. Similar transformations and supporting pathways are needed for sustainable cities, ocean management, and other transformations to sustainable development.

This report provides important ideas as to how such pathways can be designed. The Sustainable Development Solutions Network (SDSN) looks forward to working with Future Earth and other partners to advance better SDG metrics, promote integrated approaches to operationalising the SDGs at global, regional, and local levels, and taking up the other opportunities highlighted in this document to strengthen the role of science.

Guido Schmidt-Traub
Executive Director,
Sustainable Development Solutions Network (SDSN)

- A multi-stage approach to indicator development should be envisioned and explored, from a goal-related to a policy-related indicator framework (five years from now), which should utilise synergies and handle possible trade-offs.

2.4 Ownership

Successful implementation of SDGs arguably depends to a certain extent on whether a government feels it owns the SDGs, as well as on the involvement of business and civil society organisations. The need for ownership of the implementation process is as relevant for countries in the Global North as it is for those in the Global South. To achieve ownership, it will be necessary to ensure that a bottom-up, inclusive approach is adopted, rather than simply a top-down implementation plan. This raises the issue of how best to collect the opinions and experiences of the general public. Furthermore, it is important that the process around the SDGs does not become a power game, where those with the most power have the loudest voice. This process has been inclusive and transparent from the very beginning ("leave no one behind"). Another important issue, noted by the UN Development Group, is the need to take local and regional contexts into consideration because SDGs often simply merge into pre-existing national development plans or sustainability strategies. Scholars and policymakers alike have observed the need to translate global goals into national goals. At local level, this also requires capacity building and innovative thinking.

With regard to ownership, scientists can play an important role by delivering broad and deep understanding of the needs and challenges facing a particular society (in particular in southern research organisations). The political independence of research institutions and the local ownership of the research they produce could be two major factors in the successful promotion of ownership by research centres. Science and researchers also have an essential role to play in the transparency of the SDG implementation process, the need for broad and active participation, and the collection of information about the situation on the ground if SDGs are to be successfully implemented on a national level. Boosting ownership may be possible by enhancing the role of scientists, especially in the Global South. The Southern Voice (2015) on Post-MDG International Development, for example, is an open platform that contributes to the global SDG dialogue by drawing on studies from southern research centres. It is a network of think tanks from Africa, Latin America and Asia, which seeks to address the current "knowledge asymmetry" that exists in the world and include more quality local data from on-the-ground researchers who know the facts and see the needs from a different angle. There is a vital need for a new kind of global cooperation such as this on scientific and academic levels.

Recommendations:

- Ownership by countries and other players will be essential in order to translate global targets into national targets, strategies and policies. The participation of all national stakeholders and participatory monitoring of country-level implementation will be instrumental for achieving local ownership. Beyond that, ways to strengthen ownership of SDGs dealing with global common goods need to be explored.

- The international legal framework for SDGs should have a reinforcing loop to support stakeholders. International law relating to different societal areas can be used and integrated into national regulations and settings. For example, international conventions on gender and diversity could frame and guide country-specific laws on these issues.

- Efforts should be made to engage local communities and utilise local knowledge as much as possible. The time invested in this will ensure long-lasting ownership of the SDG process at all societal levels, this also requires building up the necessary large-scale capacities.

3/ SCIENCE NEEDS FOR IMPLEMENTING THE SDG FRAMEWORK: A GERMAN COMMITTEE FUTURE EARTH – FUTURE EARTH – SDSN FORESIGHT WORKSHOP

The international foresight workshop on "Science needs for implementing the new SDG framework", organised by the German Committee Future Earth in close collaboration with Future Earth and the Sustainable Development Solutions Network, was held at Villa Vigoni, Italy, in April 2016. The objective of the foresight workshop was to further develop a research framework to contribute to the identification of potential comprehensive (global and sustainable in all dimensions) solutions in the coming (5+) years to support the successful implementation of the SDGs. A research framework helps to develop societally, economically and environmentally efficient instruments and achieve better policy coherence. Foresight as a thinking and learning process oriented to the decision-making support profil (see section 3.4) was used to reveal possible interlinkages between sustainable development goals as well as the contribution that can be made by research. The overall question that was raised was: "Can we establish a foresight process which enables conflicting issues arising from the implementation of the SDGs to be identified more quickly as they emerge, so that at least part of the solution which requires new, more in-depth upstream fundamental research can be explored in a more timely manner?"

The three-day workshop could not cover the whole SDG agenda but was expected to focus on three nexus fields that would benefit significantly from a foresight process. It is believed that focused global scientific efforts could have the potential to provide improved and useful evidence as the basis for dealing with positive or negative interactions that come about when implementing the SDGs at the national, regional and global level. The workshop programme committee members chose the following interlinked areas of global concern: (1) migration & its impacts on or relevance for the implementation of the SDGs, (2) socio-economic & biophysical dynamics of the humanity-nature nexus, and (3) food security & sustainable production and consumption – ocean and land.

Foresight Workshop

Science needs in the context of tough choices in implementing the new SDG framework

Villa Vigoni, Italy, 18-21 April 2016

Organised by German Committee Future Earth *In cooperation with* futureearth *Supported by* DFG

This workshop brought together around 35 international experts from the natural and social sciences as well as the public sector. All participants had previously been involved in discussions on the 2030 Agenda on different levels (academia, government; international, national, regional). Perspectives for each of the interlinked areas and the role of science in SDG implementation were considered and discussed in keynote speeches and panel

discussions. Following the opening remarks by *Christiane Joerk*, Programme Director of Humanities and Social Sciences at the German Research Foundation, *Måns Nilsson*, Research Director at the Stockholm Environment Institute, stressed in his keynote speech the important role played by science in SDG implementation and explored in a discourse with *Jakob Rhyner*, UNU Vice Rector in Europe, possible working areas for science including the characterisation of SDG challenges, impact assessment and supporting public institutions (e.g. by building platforms for science-society engagement). In his talk, *Norichika Kanie*, a Professor of Decision Science and Technology at Keio University Japan, underlined the importance of multistakeholder approaches. He suggested regular foresight conferences as a possible helpful instrument to identify emerging problems. These could be organised by either an inter-governmental forum (HLPF) or a non-governmental scientific forum (e.g. Future Earth). *Jörg Mayer-Ries*, Head of division for strategy and fundamental issues at the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, critically questioned foresight mechanisms but suggested also that "Bringing together strategic thinkers could be much more efficient for SDG implementation processes than report writing". During panel discussions *Tanya Abrahamse*, Chief Executive Officer of the South African National Biodiversity Institute and member of the Scientific Advisory Board to the Secretary-General of the UN, stressed the importance of effective interplay between science and policy in order to successfully implement SDGs. She questioned the adequateness of scientific tools, the communication methods and processes of knowledge generation ('are they fit for purpose'?). *Lori Hunter*, Professor of Sociology and Environmental Studies at the University of Colorado, and *John Connell*, Professor of Human Geography at the University of Sydney, outlined the possible interconnections between migration and implementing SDGs using examples from South America and the Pacific Islands. The need

for more in-depth knowledge was highlighted in their talks and discussed in more detail in the breakout groups.

Breakout groups were formed to further discuss the three nexus topics in the context of SDGs. These interdisciplinary groups were asked to summarise their understanding of how to achieve progress in SDG implementation for one of the specific nexus topics, as well as their understanding of current knowledge on monitoring and interpreting change, the response to failings and existing potential institutional and governmental constraints. Participants were also asked to analyse the interrelated SDGs particularly with regard to any challenges likely to arise in their implementation and the possible usefulness of foresight processes. All results were reported back to the plenary sessions and discussed in a final stakeholder feedback session. In that session *Maria Ivanova*, Professor of Global Governance and member of the Scientific Advisory Board to the Secretary-General of the UN, and *Hartwig Kremer*, Senior Programme Officer at the United Nations Environment Programme, stressed the need for synthesis and new types of knowledge interactions between science and policy.

The following sections summarise the results of the breakout group discussions. The results focus on three nexus topics, and are the collective effort of all workshop participants. Rather than giving a comprehensive research plan, the sections indicate possible starting points for research activities in the context of complex SDG implementation that needs to be adapted to specific local, subnational, national and regional situations.

3.1 Migration & its impacts on or relevance for the implementation of the SDGs

BREAKOUT GROUP PARTICIPANTS: JOHN CONNELL, UNIVERSITY OF SYDNEY, AUSTRALIA ■ **KATHLEEN HERMANS**, HELMHOLTZ-CENTER FOR ENVIRONMENTAL RESEARCH – UFZ, GERMANY ■ **LORI M. HUNTER**, UNIVERSITY OF COLORADO, USA ■ **JENS NEWIG**, LEUPHANA UNIVERSITY OF LÜNEBURG, GERMANY ■ **MARIKA PALOSAARI**, UNITED NATIONS ENVIRONMENT PROGRAMME, SWITZERLAND ■ **JAKOB RHYNER**, UNITED NATIONS UNIVERSITY – INSTITUTE FOR ENVIRONMENT AND HUMAN SECURITY, GERMANY ■ **IMME SCHOLZ**, GERMAN DEVELOPMENT INSTITUTE (DIE), GERMANY ■ **MARK STAFFORD-SMITH**, COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (CSIRO), AUSTRALIA.

In the 2030 Agenda, migration is mentioned under goal 10 in terms of the economic contributions of migrants and the need to ensure safe, orderly and regular migration and humane treatment of migrants, refugees and displaced persons, and under goal 8 relating to the labour rights of migrant workers. Migration is a strategy that has been employed throughout human history as an adaptation to secure livelihoods under changing socio-economic and political conditions and shifting environmental contexts. A culture of migration has emerged in many settings (e.g. Polynesia, Mexico, South Africa).

Migration can thus be seen as a social phenomenon connected with differing levels of human development, environmental quality, and good governance and security. Migration also has an effect on efforts to achieve the SDGs – feedback effects go in both directions. Therefore, migration can be understood as a thread that connects several SDGs, and which could be a promising indicator of SDG implementation.

Research has contributed to our knowledge of migration flows between communities, countries and continents and has allowed migration streams to be quantified to a certain extent (Abel & Sander, 2014). Reasons for migration are often straightforward and linked to access to better employment opportunities, protection from war, conflicts and persecution. But reactions to migration change in both sending and receiving societies over time. On a global scale, there is a lack of knowledge about the composition of migration flows (who moves) and migration motives (why people move). Beyond migration,

environmental displacement is now increasingly on the agenda of UN organisations (e.g. United Nations Environment Programme (UNEP), International Organisation for Migration (IOM)) and within multilateral negotiations such as the UNFCCC (United Nations Framework Convention on Climate Change). A better understanding is needed of the environmental factors that, together with socio-economic and institutional factors, lead to displacement. In addition, a better understanding is needed of the effects of migration and displacement including the environmental impacts of in-migration, such as overuse of local natural resources. Research on the environmental impacts of refugee camps is also needed, including localised degradation, pollution levels and related health risks as well as issues relating to how to deal with protracted displacement since the average stay in refugee camps is 17 years.

Research issues & structural needs identified in relation to SDG framework

A thorough overview of existing research is required in order to be able to engage in analytical work and theoretical advances on migration and the SDGs. The construction of a descriptive basis will require **conceptual work on the relationship between SDGs and migration patterns** to understand how migration may impact efforts to achieve the SDGs. A **database that includes geo-referenced migration pattern data,** including return migration and SDG indicators (and other push and pull factors) in different layers, for urban and rural areas as places of origin and destination will have to be set up. Data should try to cover the last two or three decades and then continue to be collected on an ongoing basis in the future. Such data would make it possible to characterise patterns of SDG achievement and migration flows and relations between them. One example is the increasing number of displaced persons due to natural disasters in urban areas where rapid and unplanned urbanisation processes are associated with insufficient infrastructure and thus higher levels of vulnerability (while, at the same time, people who moved from poor rural areas into cities benefit from improved access to education, health and labour markets). Such data would help to understand the reasons for migration in terms of insufficient achievement of SDGs and resulting feedback effects on SDGs. The data should cover both sending and receiving countries and societies.

Research questions on migration could focus on the following areas:

(a) Migration and environmental change
What are the common factors and main characteristics of migration (e.g. households, behaviour) caused by changing environmental conditions and how do they relate to each other? What are the possible tipping points that make a household decide to migrate? What kind of meta studies do we need to identify common factors? How can these factors be adequately communicated?

(b) Fragile states and migration
How can countries (in particular, weak and fragile states) stabilise after periods of conflict and lack of legitimacy? How can relapses be avoided, as it is known that environmental factors and scarcities often play a role in this? What is the role of both of these endogenous factors and the relevance of external interventions by neighbouring states in the conflict or conflict resolution, foreign policy/security policy interventions by other states or multilateral actors, trade policy, development policy?

(c) Changing perceptions of migration
What are the changing perceptions and attitudes to migration in specific societal contexts in both sending and receiving countries over longer time horizons? What are the entitlements for compensation or legal residency permits, in particular with regard to a global facilitation of movements across borders? What factors produce changing perceptions and attitudes (e.g. social media, economic connections)?

(d) Governance and migration
What might a governance system for migration and displacement look like? Is it necessary and desirable? What would be the likely costs and benefits of this on different scales (local, national, regional, global)? What is the net impact of such governance systems on both sending and receiving countries? Which different migration types, including seasonal agricultural workers (which could target people from poor countries with difficult environmental situations, i.e. the Pacific islands), and other sectors (tourism, health sector) are affected, and how are they affected? What is the effect on permanent immigration?

3.2 Socio-economic & biophysical dynamics of the humanity-nature nexus

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This topic examined positive or negative interactions between, for example, goals 8 and 12 and goals 6, 7, 13 and 15. Building on this, the topic addressed issues such as achievable forms of sustained and sustainable economic growth, what decent jobs in the future will look like, and how these sustainable economic paradigms can be turned into actionable pathways at global and national levels. Three issues that penetrate deeply into the sustainability debate have been identified: Is a new socio-economic theory required to meet these challenges or do existing intellectual foundations provide sufficient leverage? How to take on board more substantially the many interactions between economic and social dynamics? How to analyse the topology of complex socio-ecological systems dynamics, for example their resilience to shocks?

Research has helped contribute to enhancing knowledge on economic and social dynamics, structures and dependencies in many ways. The development of sustainable pathways for economy and society need to take into account biophysical as well as social externalities of the current system and acknowledge the deep links between human and natural systems.

As the literature about sustainability science is exploding, there is a clear need for synthesis (incl. state of the art, robust trends, actual risks vs. deeper uncertainties) to inform the political process in a comprehensive, adequate way

(similar to IPCC and IPBES although neither covers the full SDG range). In particular, the core challenge in assessing biophysical consequences and/or implications of achieving all goals will be to gain a more systematic understanding of the socio-metabolic consequences and pre-conditions implied by the implementation of SDGs and to fully consider these in the context of planetary biogeochemical cycles.

Achieving goal 12 in particular, requires a much better understanding of the complex dynamics underlying social, not just natural, systems and their interactions, and of the institutions that enable paradigm shifts. In addition, highly aggregated analysis will not be sufficient and the results of such complex system dynamics must be reconciled with the actual situation (and dynamics) at regional, national, subnational and local levels.

To deal with the challenges of SDG implementation, scientists need to co-develop a certain set of toolboxes with and for stakeholders and decision-makers (politicians, practitioners, business people, etc.) to map out possible options (Edenhofer & Kowarsch, 2015). Equally, foresight processes could also be used to reflect on the adequacy of toolboxes and revisit and widen toolboxes as a result of previously unforeseen interactions, trends or new factors.

Socially relevant research could be institutionally strengthened as an instrument in the political process to reinforce the role of scientific analysis in the public debate on e.g. environmental policies with social objectives. Theoretically, the power of states and institutions is derived from social contracts for the common good. Such considerations clearly have the potential to address not just legal and constitutional matters as has historically been the case, but also the safeguarding of environmental preconditions for societal well-being.

Finally, there is also a need to better clarify what is meant by implementation of SDGs as they are not being implemented in a vacuum. Levels of human development and environmental sustainability vary very much across countries, which is mirrored by very different challenges countries face in implementing SDGs. In terms of the current landscape, it will require new institutions to achieve a deeper and less harmful connection between socio-economic and biophysical dynamics (institutions here is broadly interpreted to include laws, values, governance, as well as foresighting).

Research questions identified in relation to the SDG framework

Science can contribute in many different ways to finding an answer to the main issue regarding the conditions for the emergence of a sustainable economy supportive of SDGs. However, SDGs do not have easily definable boundaries or unambiguously quantifiable targets. Therefore, the following four suggested research priority areas will need context-specific space and time analysis:

(a) Co-designing development pathways between science and stakeholders that encompass the dynamics of biophysical and social systems

- What is the current state of SDG implementation and development in different countries? What are the progress indicators

for different countries, what does progress mean and how can measurement barriers (e.g. disaggregated indicators) be overcome?

- What are the institutional gaps in implementation of SDGs? How can the creation of new institutions that will help achieve the SDGs be triggered? How can SDG implementation be coherent in relation to existing and new policies?

- What are the lessons learned on the issue of transferability, key drivers and variables of transformative change? What are the tools/approaches for best practices of SDG implementation in which region (e.g. hot-spot mapping), how can they be adapted to other regions and/or how can experiences be transferred across countries?

- How can the effectiveness of SDGs be assessed in terms of biophysical and social outcomes?

(b) Harnessing the power of business and providing SDG-compatible business model designs

- How can planetary boundaries be translated to the micro level of corporations, as in many societies corporations are one of the main engines for wealth creation?

- How can globally allocated biophysical limits for companies (especially global corporations) be defined in a legitimate, socially acceptable way?

- How can business data and tools be used to progress scientific agendas?

(c) Adopting a systematic approach to assessing the implications of public policies and business strategies for achieving SDGs

- Assessing potentials and how they interact (e.g. exploiting the full potential for bioenergy might reduce realizing the full potential for biodiversity conservation):
  - How much food is needed to eliminate hunger?
  - How much energy is needed to meet the energy goal? How many schools are needed to meet the education target?
  - How many hospitals/doctors are needed to meet the health target?

- What are the consequences of socio-political and economic developments produced by SDG implementation, in comparison to business-as-usual cases?

- What material accounting systems are needed?

- What is required of the economic system, and, recognising the very diverse nature of national economies, how might the system be restructured to internalise social and environmental imperatives and how might this transformational change be achieved?

- How can biophysical models integrate social dynamics on regional and global scales?

- What are the internal contradictions in the SDG targets?

- What are the distributional impacts (both as outcome or impediment to implementation) of implementing SDGs?

Answering these questions will require thinking out-of-the-box, as humanity-nature nexus challenges will also require integrated "nexus models" at a time when current thinking is often disciplinary, sectoral and based on efficiency and optimisation rather than resilience. The concept of resilience as well as flexibility thinking and complexity science all have to become a part of the methods toolbox for research.

(d) Decision-making under uncertain conditions

- Reduction of uncertainty:
  - How can the understanding of potential positive or negative interactions between the goals be improved?
  - What is the best way to assess them to understand and operate within a bio-geo-physically safe and fair operating space for humanity?
  - What new decision-making tools co-designed with stakeholders are needed?
  - What tools are required in order to include the biophysical and metabolic implications of decisive dynamics within the socio-economic domain to explore feasible spaces and transformational pathways for sustainability?

- Acting under uncertainty:
  - How to provide aid for decision-making when uncertainty cannot be resolved before (irreversible) action has to be taken?

3.3 Food security & sustainable production and consumption – ocean and land

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In the 2030 Agenda, food security is at the heart of goal 2, and sustainable consumption and production are addressed in goal 12 in terms of economic competitiveness and poverty. The ecological dimension relating to climate is enshrined in goal 13, goal 14 covers the oceans and goal 15, terrestrial biodiversity. Society's greatest challenge will be ensuring a well-balanced and healthy diet for the future world population while avoiding significant ecosystem pollution, keeping remaining forests and wetlands intact, and without overexploiting land and ocean resources.

Research has contributed in many ways to enhancing knowledge about food production and interlinked areas on different scales. As food security is a global issue in terms of markets and international trade, there is a global responsibility to reduce hunger and increase knowledge about trade-offs in food production, as well as to deal with distribution challenges, ecosystem services, new technologies and food waste. Policy and legal frameworks are central for economic and political interactions between states and the capacity and resources of states. Internationally relevant resources and global commons such as biodiversity, oceans and climate stability must be dealt with on an international level. However, current policy and legal frameworks that provide instruments for managing ecosystem services (e.g., REDD+ payments to a country, as well as trust funds and other financial instruments) still lack a nested governance system with responsibilities divided across different levels of decision-making. Alternative governance frameworks for innovation and technology are also of particular relevance, both with respect to the deployment of existing technologies and research and development of new technologies (e.g. alternative intellectual property rights regimes). This should be adapted to the specific needs of regions where food security is an issue of particular relevance. Additionally, reforms in credit and risk markets (e.g. indexable risks not exclusively linked to weather) could influence individual decisions and take global food production to a more sustainable level. But the scale of regulatory spaces has to be better clarified in order to assign appropriate political responsibility. In the case of ecosystems, for example, political jurisdiction can cover multiple levels.

In contrast to the well-known evidence about ecosystem changes, there is a lack of knowledge about quantifying the links between changes in ecosystem conditions and services and their implications for food security, as well as the effects of increasing and intensified food production on ecosystem services and biodiversity. Furthermore, achieving sustainable food production systems will require an integrated understanding of technologies including new technologies and modern supply chain systems. There is also a need to better understand the impacts of new technologies on ecosystems and on the social-ecological systems. As farmers, for instance, decide on

whether and which technology to use, the adoption of new technologies may lead to unintended consequences such as harmful impacts on ecological systems and biodiversity, human health, and a greater possibility of systemic failures (such as large-scale crop failure).

In the context of sustainability, food waste does not come without an environmental cost. Food waste affects, for example, ecosystem services by altering nutrient cycles and metabolisms in certain places and generating greenhouse gas emissions. On the one hand, reducing food waste through improved food distribution could contribute to satisfying global food requirements without further (sustainable) intensification of agricultural production but could also involve trade-offs regarding transportation (and related environmental) costs. On the other hand, improved storage of food in e.g. Sub-Saharan Africa could contribute to increasing farmers' ability to deal with varying weather conditions and yield gaps. Reducing food waste provides not only direct benefits for the environment but also indirect benefits by stipulating the behavioural and lifestyle changes required to achieve sustainable development.

Research questions identified in relation to SDG framework

(a) Reforming global regulatory framework

- Can SDG 2c "Ensure proper functioning of food commodity markets and their derivatives" be reproduced in the current global governance structure regarding food security?
- What is involved in taking SDG 2 "Zero hunger" together with other relevant goals such as 1, 12, 14 and 15 as guiding principles?
- What considerations should be taken into account for the long-term perspective and what are realisable short-term options?
- What actions should be taken on what level (global, national, local; private - public; new approaches to property rights or derivatives)?

(b) Measuring risk and introducing insurance on different scales

How can credit and risk mechanisms be aligned to reduce systemic risk along with private risk? Do private risk management mechanisms (e.g. microfinance) create risk exposure for other SDGs? If so, for whom? How are risks currently allocated and pooled? Does this create unexpected interconnections among SDGs?

(c) Integrating environmental and ecosystem services into decision-making on farming

- What are the changes in ecosystem conditions and consequent changes in household agricultural production or revenues?
- What examinations of the ability of regulatory and market instruments to conserve ecosystem services under differing local contexts do we need?
- How can services be regulated at varied temporal and spatial scales?
- How can the costs of conserving ecosystem services and interactions related to other SDGs be evaluated?

(d) Elaborating technological approaches towards sustainable intensification of agricultural production

- What scope do new technologies, including genetically modified organisms (GMOs), precision agriculture, and information and communication systems, have to benefit and ensure food security?
- How can an a priori risk assessment of new technological interventions (individual technologies and groups of technologies) be conducted?
- What governance and regulation frameworks would be needed for new technology innovation and use?

(e) Reducing food waste and improving food security

- What trade flows and institutions contribute to sustainable food consumption?

3.4 Foresight as an approach for dealing with complexity in SDG implementation

Sustainable development and foresight have been closely linked for many decades (Destatte, 2010). With regard to SDGs, foresight could be a useful approach for exchanging the knowledge needed to deal with highly interlinked SDGs, as well as for identifying knowledge gaps. Workshop participants used an approach aimed at supporting decision-making by generating information about possible future stakes to develop a foresighted research framework for three nexus topics. A concrete tool to map SDG interactions was also discussed at the workshop.

In general, strategic foresight is a reflective process strongly connected to the (organisational) learning that precedes strategic decision-making. Foresight could include reflection on strategic planning practices or more participatory processes (Bootz, 2010; Godet, 2013). At this, strategic planning considers the learning phenomenon essentially as an educational process for decision-makers (e.g. scenario planning). Participatory processes are used as a collective mobilisation tool (e.g. strategic foresight), where foresight is an information tool and a stimulus to action. According to Bootz (2010), four different foresight profiles exist in practice and differ in strategic impact ("Does foresight reflection lead to either direct or indirect strategic actions?") and mobilisation level ("Does foresight reflection require a small number of participants (...) or most members of an organisation?"). The approach used at the workshop is inspired by the "decision-making support" profile. A profile that involves indirect implications, a small number of (expert) group members and is aimed at "... generating information about future stakes to feed strategic reflections. The results of foresight reflection are used as elements of decision-making support in the same way as other tools (strategic surveillance and benchmarking). Therefore, they are just one of the components in the decision-making process."

EXAMPLE: **HUMAN UTILISATION OF BIOMASS & FORESIGHT (SDG 6, 7, 8, 12, 13, 15)**

The field of human utilisation of biomass, where conflicts between SDGs are likely to occur in the areas of biogeochemistry, biodiversity protection and supporting human populations in a renewable/sustainable manner, could benefit from foresight processes. Biomass is an essential element of biosphere functioning, feeding all trophic chains of life, and being subject to targeted utilisation by humans in agriculture and forestry. It is facing very substantial pressures from processes related to SDG implementation that, in sum, are likely to lead to substantial degradation of the biosphere if not governed with foresight. Biomass is expected to feed two to three billion additional human beings; it is a crucial contributor in nearly all scenarios of achieving ambitious climate protection targets (through BECCS - Bioenergy with Carbon Capture and Storage); it is being discussed as perhaps the only feasible negative emission technology at scale for addressing problems of climate overshoot (i.e. removing CO_2 from the atmosphere after it has been emitted). It is central to far-reaching plans for establishing a bio-economy that uses biomass-derived materials for plastics, building materials and other products, most of which are envisaged to contribute to a sustainable economy. Furthermore, the already intensive use of biomass in agriculture and forestry will continue, and this includes widespread traditional uses by poor populations. Since global biomass contains nearly as much carbon as the atmosphere, and several times as much if soil carbon stocks are included, and transpires as much water as flows off in rivers, modifying its production and use has a severe impact not just on biodiversity, but also on biogeochemical flows and energy balances on the planetary scale. Here, scientific foresight on interactions between SDG objectives can substantially diminish serious risks of well-intended but detrimental outcomes of approaches with a narrow sector focus.

All foresight profiles are sources of knowledge-creation by (often) different communities. However, they effect organisational learning in different ways (e.g. information oriented knowledge vs. action oriented knowledge), and strategic decision processes would therefore benefit most from interactions between the communities referred to in all four approaches. This indicates the need for a deeper understanding of foresight, particularly in the SDG context.

EXAMPLE: **MIGRATION - EMPLOYMENT AND SAFETY - & FORESIGHT (SDG 8, 10)**

Specific foresight exercises could be performed with a view to the two basic motivations of migration – employment and safety – and how these might develop in the next decades (i.e. 2030 and 2050). Such exercises could be linked to fragility studies, integrated assessments and shared socioeconomic pathways for scenario development (O'Neill et al., 2014). Relevant questions include: Where will future jobs in an economy characterised by digitalisation be? How will the segmentation between jobs where physical presence is necessary and jobs where it is not play out on labour markets? What influence will these questions have on the choice of living place and on migration flows? Where will the safe and attractive social and biophysical living environments be? How are biophysical and cultural preferences linked? Foresight could be helpful to improve the understanding of patterns, motives and directions of migration flows in the context of SDGs, in particular if the aim is to build a spatially explicit database. A complementary approach would be to identify indicators related to and describing migration (push/pull factors; countries of origin and destination) and include them in the set of essential indicators on climate change, biodiversity loss, interactions between them and social tipping points which science (and policy) would want to measure in order to look into the future.

A concrete tool for generating systematic knowledge with a focus on SDG interactions was introduced by *Måns Nilsson*, Research Director at the Stockholm Environment Institute. He stressed the need for comprehensive easy-to-apply tools to identify SDG interlinkages and suggested that interactions could be mapped on a seven-point scale (see Figure Goals Scoring). The seven-point scale, which has since been published in a paper written by Nilsson in collaboration with Dave Griggs, Chief Executive Officer of Climate Works Australia, and Martin Visbeck, member of the Sustainable Development Solutions Network Leadership Council, indicates the type of interaction with other goals and targets, and describes relationships as positive or negative. According to Nilsson et al. (2016) positive relationships can support strategy building across sectors (e.g different ministries), whereas negative relationships are subject to further actions, such as extra regulations that could possibly also provide new opportunities for public investment.

In the process of SDG implementation and with the goal to identify an optimal set of implementation strategies, this scoring tool could initially enable researchers and policymakers to organise existing knowledge on interactions between the SDGs and identify key gaps and national priorities.

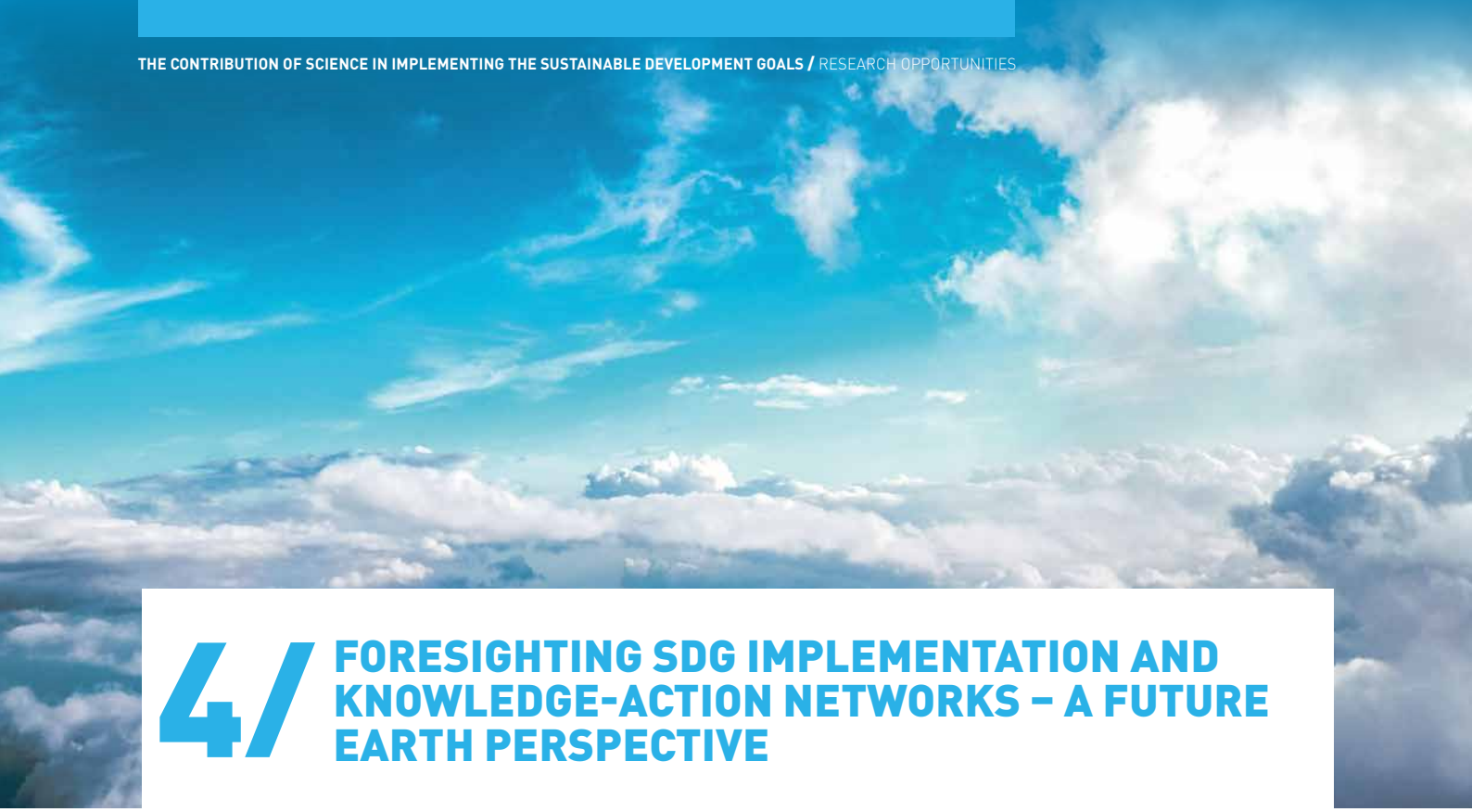
GOALS SCORING

The influence of one Sustainable Development Goal or target on another can be summarized with this simple scale.

Interaction	Name	Explanation	Example
+3	Indivisible	Inextricably linked to the achievement of another goal.	Ending all forms of discrimination against women and girls is indivisible from ensuring women's full and effective participation and equal opportunities for leadership.
+2	Reinforcing	Aids the achievement of another goal.	Providing access to electricity reinforces water-pumping and irrigation systems. Strengthening the capacity to adapt to climate-related hazards reduces losses caused by disasters.
+1	Enabling	Creates conditions that further another goal.	Providing electricity access in rural homes enables education, because it makes it possible to do homework at night with electric lighting.
0	Consistent	No significant positive or negative interactions.	Ensuring education for all does not interact significantly with infrastructure development or conservation of ocean ecosystems.
–1	Constraining	Limits options on another goal.	Improved water efficiency can constrain agricultural irrigation. Reducing climate change can constrain the options for energy access.
–2	Counteracting	Clashes with another goal.	Boosting consumption for growth can counteract waste reduction and climate mitigation.
–3	Cancelling	Makes it impossible to reach another goal.	Fully ensuring public transparency and democratic accountability cannot be combined with national-security goals. Full protection of natural reserves excludes public access for recreation.

FIGURE **GOALS SCORING**

"The scoring tool is globally applicable and rate interactions from the most positive (scoring +3) to the most negative (scoring -3). There are four main considerations when applying the scale. First, is the interaction reversible or not? For example, failing on education (goal 4) could irreversibly damage social inclusion (goal 8). Loss of species owing to lack of action on climate change (goal 13) is another irreversible interaction. Conversely, converting land use from agriculture to bioenergy production (goal 7) might counteract food security (goal 2) and poverty reduction (goal 1) but could be reversed. Second, does the interaction go in both directions? For instance, providing energy to people's homes benefits education, but improving education does not directly provide energy. A third consideration is the strength of the interaction: does an action on one goal have a large or small impact on another. Negative interactions can be tolerable if they are weak, such as the constraints that land resources might put on the development of transport infrastructure. Fourth, how certain or uncertain is the interaction: is there evidence that it will definitely happen or is it only possible?" (Nature News; Nilsson et al., 2016; ©2016)



4/ FORESIGHTING SDG IMPLEMENTATION AND KNOWLEDGE-ACTION NETWORKS – A FUTURE EARTH PERSPECTIVE

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Over the past two years, Future Earth has contributed scientific input to the development of the Sustainable Development Goals and the eventual signing of the 2030 Agenda. Even as SDGs were still being discussed and developed, we were eager to start thinking about the barriers to their implementation, especially since research on overcoming such barriers might require several years' lead time. The idea of foresighting the possible failure of any programme is simple. It is an "anticipatory" management strategy that allows people to be mindful of potential failures at the implementation stage. This enables decision-makers to take preemptive action to prevent failures, and any necessary research to be established in good time. Anticipation or foresighting needs to look five to ten years into the future to imagine and identify pathways to overcoming possible failure in order to be meaningful for decision-making in long-term global programmes.

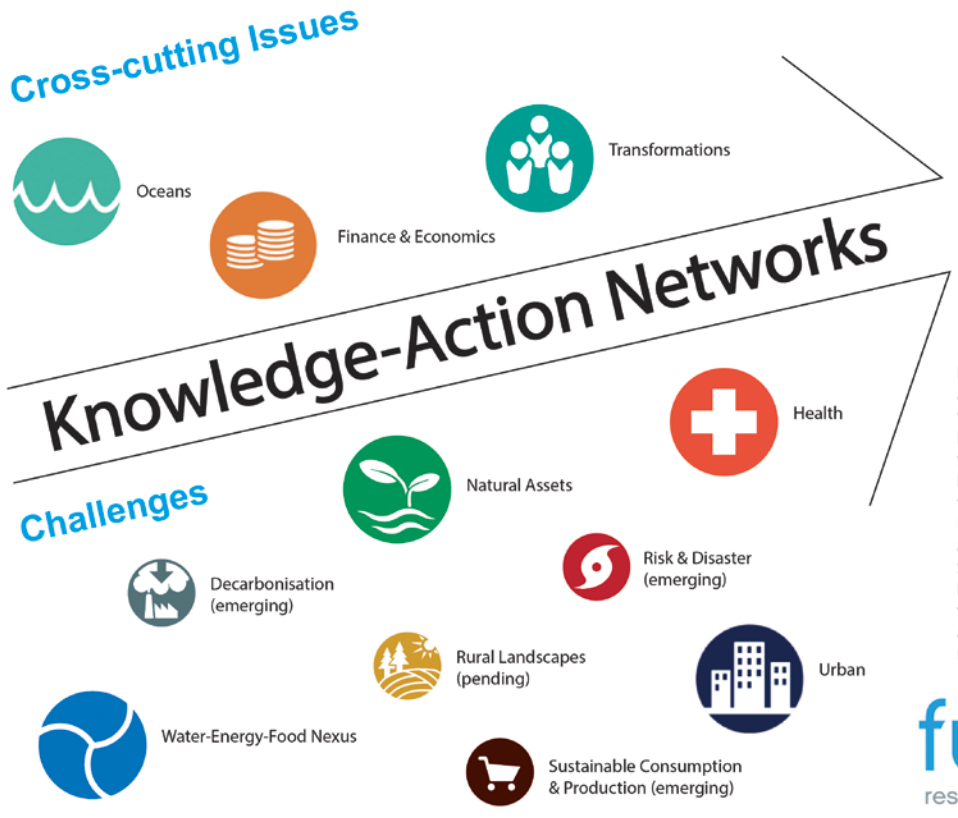
In our pursuit of foresighting capabilities, Future Earth were fortunate to work in partnership with DFG and the German Committee Future Earth to co-design and participate in the workshop on foresighting SDG implementation. Chapter three of this report presents an excellent summary of the workshop and we present in this section contextual information as to where the workshop themes are positioned in Future Earth's research agenda, and especially how they relate to our emerging Knowledge-Action Networks (KANs) supported by over 20 Future Earth global research projects.

The three workshop themes of (a) Socio-economic & biophysical dynamics of the humanity-nature nexus, (b) Food security & sustainable production and consumption – ocean and land, and (c) Migration and its impacts on or relevance for the implementation of the SDGs are all connected to Future Earth's KAN on Sustainable Development Goals, and can help to establish the direction of research in this case. Additionally, theme (a) also links to the Sustainable Finance-Economics KAN, and theme (b) links to three other Future Earth KANs - the Cities KAN, the Oceans KAN, and the Food-Water-Energy Nexus KAN. Theme (c) links to the Health KAN, Transformations KAN, Food-Water-Energy Nexus KAN, and also the Natural Assets KAN. To understand these connections, we will describe in the following section the Future Earth Knowledge-Action Network concept, summarise the objectives of the eight KANs and provide a tentative mapping of where they intersect with Sustainable Development Goals. The KANs have been launched in collaboration with Future Earth global research projects, researchers and stakeholders of the global community and are expected to co-evolve in interactive and interdependent, rather than siloed, ways.

Future Earth Knowledge-Action Networks

Both the opportunities and challenges inherent in working towards global sustainability require a new type of planetary research – one that not only expands our fundamental understanding of the planet we live on, but also meets the needs of societies as they strive to solve the problems facing them. Future Earth aims to generate a virtuous cycle of agenda setting, research coordination and solutions delivery. Its activities aim to bring researchers together with societal partners to identify critical research gaps in various areas; then to take the resulting agendas and publicise them to attract funding. Most research projects will usually be funded and undertaken on a national level. Future Earth aims to coordinate similar projects across the world and encourage synergies, for example by promoting common methods so that otherwise disparate projects can be compared and combined. Future Earth encourages co-production of knowledge to help produce syntheses and products that are useful to decision-makers regionally and globally. Future Earth seeks to co-disseminate results. This solution-oriented research followed by review and learning can lead to a new cycle of agenda-setting. This type of activity occurs at the level of Future Earth's whole agenda, but also in more focused domains through its international global research projects and Knowledge-Action Networks. Increasingly, projects help researchers and stakeholders to interact in order to produce solutions-oriented research. It is with this new type of research in mind that Future Earth has worked to develop eight initial Knowledge-Action Networks.

The challenges facing the planet and its inhabitants are complex and do not respect the boundaries of traditional scientific disciplines or nations. As a result, Future Earth's Knowledge-Action Networks need to bring together scientists from across disciplines – from soil ecologists to human pathologists – to work with one another as well as with policymakers and practitioners. Natural scientists will collaborate with social scientists and experts in the law and humanities, because fostering global sustainability requires an understanding of how human societies function and how behaviours can change. Crucially, researchers will design projects and driving questions in tandem with the people who will actually use the results of their research: leaders in the public and private sectors,



Knowledge-Action Networks evolve as part of a bottom-up process linked to the development of the Future Earth 2025 Vision. The Vision identified eight key societal challenges that Future Earth will focus its efforts on in the years to come. Knowledge-Action Networks also address issues that cut across several of these challenges. The Sustainable Development Goals Knowledge-Action Netowrk might focus on synthesis and integral aspects of the Sustainable Development Goals framework.

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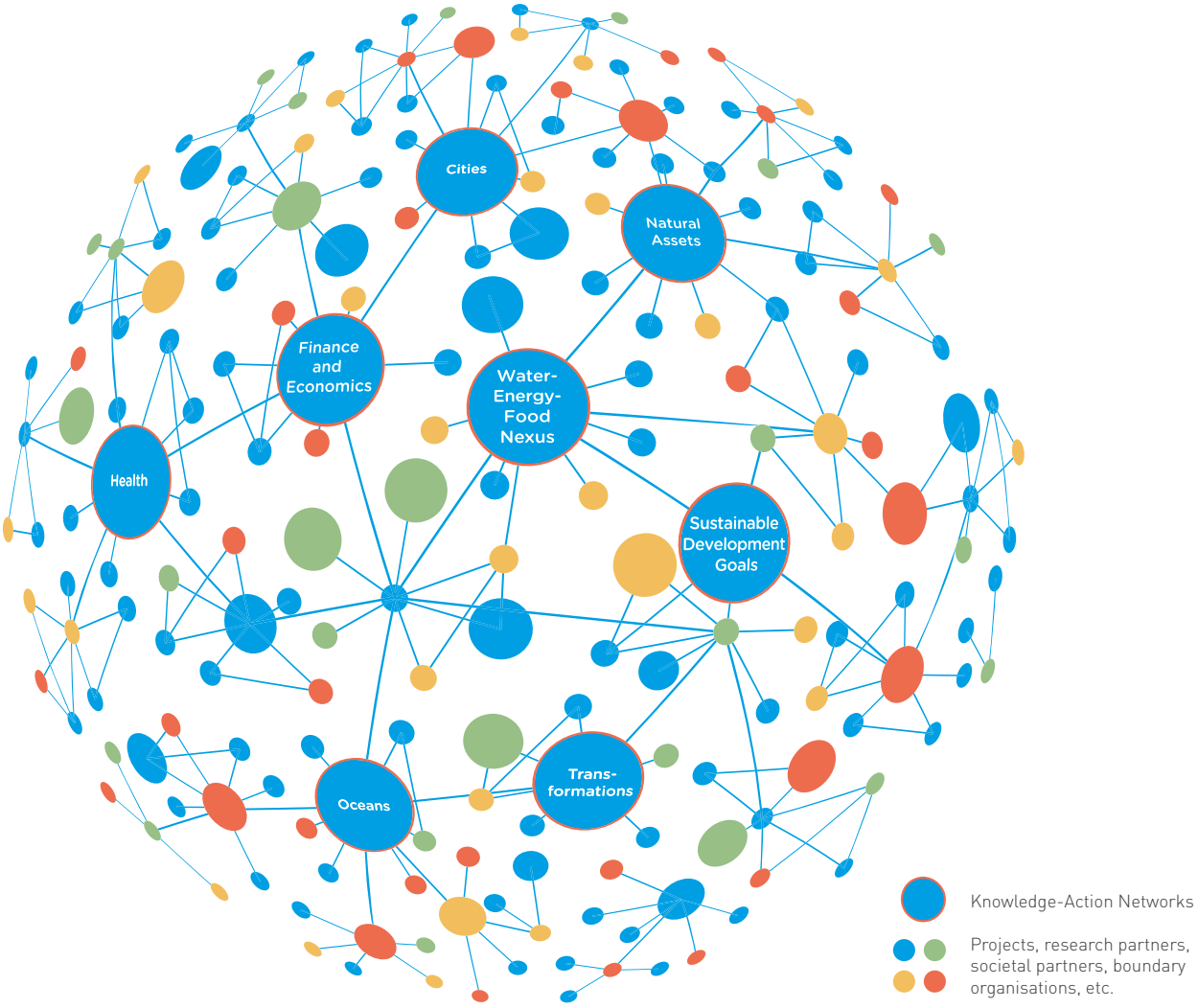
research for global sustainability



the technology industry, non-governmental organisations, funding groups, or also journalists, artists and many others. Through these collaborations in Knowledge-Action Networks, scientific knowledge will be able to be produced as solutions for achieving sustainability (Shrivastava et al., 2013).

Knowledge-Action Networks are collaborative communities in which the best minds in research, policy, business, civil society, the arts and others can develop research for themes critical to global sustainability. Research in KANs will address safeguarding natural assets, fostering biodiverse oceans which support thriving economies and cultures, developing financial and economic systems to bolster sustainability, maintaining the nexus of water, energy and food that is critical to the stability of human societies, understanding the connections between planetary and human health, building cities where people can live sustainably and equitably, informing people about the implementation of the Sustainable Development Goals and bringing about societal transformations to achieve sustainability (see Figure on Knowledge-Action Networks).

Integration and relationship between SDGs and KANs

The implementation of SDGs can only be achieved through deep integration and we concomitantly need to ensure that the Knowledge-Action Networks evolve in integrated ways as well, thereby developing unified science-based solutions in support of these global goals.

There are many forms and types of interlinkages among the SDGs as well as between SDGs and KANs. Interlinkages in the following three areas are particularly important: interlinkages between different sectors (e.g. agriculture, energy, finance and transportation), interlinkages between societal stakeholders (e.g. private sector, civil society or local authorities) and interlinkages between and within rich and poor countries. With regard to the KAN on Sustainable Finance and Economic Systems the different types of interlinkages can be made visible by bringing together stakeholders and the research community to facilitate the implementation of SDGs in lower-income countries through financial interlinkages between different sectors. This will then help to incentivise long-term investments in the early-stage market development of sustainable products and services (Stafford-Smith et al., 2016).

KANs can serve as a broad Agenda-setting tool, and also bring attention to targeted gaps in understanding and the need for synthesis. For example, KANs can be a good vehicle for responding to the challenges associated with the implementation of the SDGs that emerge from foresighting in the SDG KAN. KANs can bring together multiple communities and knowledge bases and thus have an all-encompassing view of potential barriers in SDG implementation. The systemic view taken by KANs can offer insights into how problems may travel through interconnected parts of the entire system. At this, Future Earth is also contributing to specific studies, such as The World in 2050 project, designed to foresight future pathways via forecasting and backcasting methodologies. The World in 2050 project, supported by Future Earth, SDSN, IIASA and SRC, will use modelling and backcasting in an attempt to understand how SDGs can be achieved in a time-bound manner. The SDG KAN might focus on synthesises of the eight Future Earth challenges and integral aspects of the SDG framework (with regard to policy coherence and indicators), whereas the Finance and Economics KAN as well as the KANs on Oceans and Transformations, address cross-cutting issues or domains that are identical for many of the eight challenges. Some other KANs directly address specific challenges such as the water-energy-food nexus, natural assets, cities and health (see Figure on Knowledge-Action Networks) and we hope that at some stage KANs will be created for each of the eight societal challenges identified in the Future Earth 2025 Vision.

Most importantly, the Knowledge-Action Networks are being built from the bottom up. Future Earth is focused on encouraging professionals around the world to join these KAN communities. Through the global research initiatives and core projects of Future Earth, which have generated new insights in numerous areas, Future Earth is already connected with networks of over fifty thousand scientific experts who will play a major role in driving forward the development of the Knowledge-Action Networks. Future Earth is also interested in bringing new partners on board, particularly from the Global South. Future Earth's five Global Hubs, four Regional Centres, four emerging Regional Offices and numerous national networks play a crucial role in this worldwide coverage. We are encouraging these networks to work with funding institutions and research communities at a regional and national level to develop the next generation of global sustainability research.

To support these communities the Future Earth Secretariat has set up a basic architecture and provides a broad range of support. For example, the Future Earth Open Network, an online platform where people involved in global sustainability can meet and collaborate, connects communities and projects in ways that can be used to support the implementation of SDGs and solve challenges by promoting cross-fertilisation between KAN communities and projects, and enable interactions among their domains.

Scientists, researchers, policymakers, civil society and businesses all over the world are invited to contribute to KANs, to help focus on how they work and what they hope to accomplish.

IV. OUTLOOK

In the coming years, science will need to play an important role in the provision of the data, information and knowledge that is required to facilitate the successful implementation of the 2030 Agenda for Sustainable Development and the associated SDGs. The 2030 Agenda explicitly recognises that sustainability challenges are fundamentally interrelated. Focusing exclusively on single goals will therefore not be effective. All actions need to be assessed for policy coherence across the goals. This means that science and society need to be aware of the broad SDG spectrum to find the best pathway to progress towards all the goals.

Reflective thinking and its power to facilitate holistic scientific approaches will be a key element in the SDG implementation process. For example, science can contribute regular scientific assessments that review the comprehensive knowledge base across the natural sciences, social sciences and humanities to better understand, analyse and cope with different types of potential conflicts in SDG implementation. In this way, solution-oriented research along with cutting-edge, globally coordinated upstream fundamental research will be able to create the critical knowledge base required to articulate efficient and coherent sustainable development pathways. Moreover, science will be able to contribute to facilitating the much-needed free and open sharing of data between all stakeholders.

Implementing the 2030 Agenda will be a continuous learning process that builds on knowledge exchange and close collaboration between different knowledge domains. Strategic foresight can be of invaluable help in addressing the complexity (and time pressures) in the SDG implementation processes. As an independent broker, the scientific community can facilitate discussions between different knowledge domains in order to build trust, reduce uncertainties, develop more robust pathways of global sustainable development, and better understand the challenges of implementation (success and failures) and value schemes. However, in order to better evaluate foresighting in the context of SDGs, a deeper understanding is required to pinpoint particular foresight mechanisms and adapt their respective processes to SDGs and the implementation of SDGs.

Finally, strong knowledge partnerships where equal weight is given to academics, decision-makers, practitioners, business leaders, civil society and/or others might be the most efficient way to inform people about SDG implementation on a regional and global level. Future Earth and WCRP anticipate working in partnership with SDSN, UN-SAB and other players to ensure that the best scientific knowledge is rapidly and freely available to decision-makers around the world, as well as to connect regional/national activities with international activities in order to ensure global policy consistency, and deliver innovative international research in support of global sustainability. In addition, these networks provide an ideal platform for (scientific) capacity building and knowledge exchange across regions/international borders.

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