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Contents

Barbara Hendricks, German Federal Enviroment Minister, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

1. EXECUTIVE SUMMARY

The international conference „Making the planetary boundaries concept work", held April 24-25, 2017 in Berlin, Germany, followed on from conferences on planetary boundaries held in Geneva[1] in 2013 and Brussels[2] in 2015, and reflected on the progress made since then. The main aim of the conference was to bring together two groups of individuals: scientists engaged in developing and refining the concept of „planetary boundaries", and policymakers and practitioners from all sectors of society who apply the concept in their activities („making the concept work"). From that encounter, new ideas, agendas and networks were to be formed.

The conference achieved these goals in a number of ways. It highlighted the need to mainstream planetary boundaries into existing frameworks and initiatives, in particular those related to sustainable development and the implementation of the Sustainable Development Goals (SDGs). Several entry points were identified in terms of political strategies and action plans at the national and regional level, to which planetary boundaries could add a global environmental perspective. In the business sector, opportunities were identified where planetary boundaries could add value, for example in assessing new risks, scrutinizing international supply chains and making investments more sustainable. Communicators and media began to formulate new narratives around a safe operating space and opportunities for sustainability transitions that invite all relevant actors to make planetary boundaries work.

Several follow-up activities are now underway that draw on the ideas and momentum generated at the conference. For example, the DBU (German Federal Environmental Foundation) is now mainstreaming planetary boundaries into their visions and goals, project portfolio and environmental communication. Initial explorations are underway on how to mainstream planetary boundaries into the new Science Platform Sustainability 2030 (SDG Platform). A group of forerunner countries has begun to

[1] Workshop in Geneva, November 3-5, 2013 on „Planetary boundaries and environmental tipping points: What do they mean for sustainable development and the global agenda?"

[2] Workshop in Brussels, January 23-24, 2015 on „Safe operating space – Current state of debate and considerations for national policies".

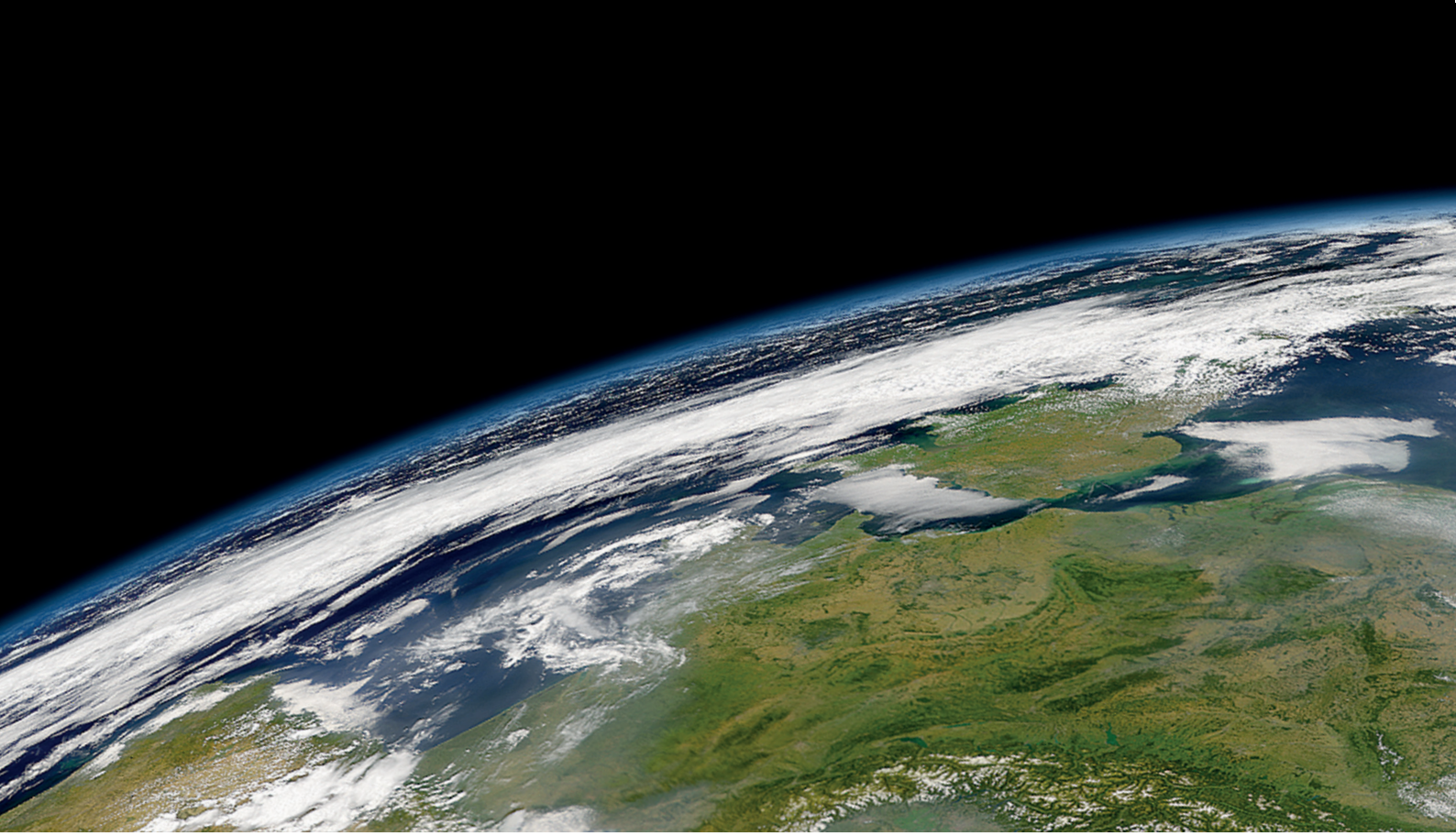
exchange experiences and lessons learned on the „operationalization" of planetary boundaries in the context of ongoing footprint work and integrated SDG implementation. All of these activities will have to contextualize planetary boundaries, integrating the top-down scientific concept with bottom-up sustainability criteria and other constraints.

For the political sector, next steps include continuing the dialogue process internationally and within the EU, focusing on a potential EU sustainability strategy and the 2030 Agenda (Transforming Our World: The 2030 Agenda for Sustainable Development; resolution adopted by the UN General Assembly in 2015). Other entry points are a potential 8th European Environment Action Programme, the German National Sustainable Development Strategy and SDG implementation, as well as sustainable development strategies in other EU Member States, such as the Netherlands, and other forerunner countries, such as Switzerland. Including the concept in the UN Global Sustainable Development Report and the Global Risks Report of the World Economic Forum is also crucial.

In the scientific world, action should focus on key areas of research such as „planetary boundaries simulation", „SDG pathways", socio-ecological complexity, implementation research (governance challenges) and implications for political order and communication. Follow-up activities could focus on pb-net.org, The World in 2050 process, and German and EU science funding agencies.

In the private sector, key next steps include further developing methodologies for companies, supporting companies in implementing the planetary boundaries concept, and further disseminating the concept's main messages. Potential entry points are the World Business Council for Sustainable Development (WBCSD), Econsense, the Science-Based Targets initiative and One Planet Thinking, as well as trade organizations, sustainability standards organizations and sustainability rating organizations.

From left to right: Johan Rockström, Director, Stockholm Resilience Centre; Heinrich Bottermann, General Secretary, German Federal Environmental Foundation; Harry Lehmann, Head of Division Environmental Planning and Sustainability Strategies, German Environment Agency



Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE

2. ROADMAPS

2.1 Next steps for the political sector

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2.1.1 Objectives

The concept of „planetary boundaries" forms an implicit – and increasingly also explicit – part of sustainability strategies and environmental policies (for example, in Germany, Finland and Switzerland). The concept has great potential for sustainability and risk governance in the public and private sphere, in particular for increasing policy and strategy coherence, communicating with expert groups, stakeholder groups and the broader public, supporting negotiations on global-scale targets for various environmental processes and influencing sub-global targets, as well as for mapping externalized environmental impacts. This potential needs to be further developed in a broad variety of conceptual, communicative and cooperative processes supported by policy to make the concept known and accepted, and to make it work.

Careful, contextualized, sophisticated communication and „operationalization" of the concept needs to be a key objective in the political arena.

The concept should be linked to (and embedded within) existing social and economic discourses. This can be done in particular by building a coherent narrative around the concept, that frames the integrity of planetary systems and processes as necessary conditions for human dignity, livelihoods, economic prosperity and global peace. The relationship between planetary boundaries and the Anthropocene could also be further highlighted in order to create context.

The most comprehensive, global-scale sustainability process – the 2030 Agenda – does not explicitly take the concept of planetary boundaries into account. This is reflected in the difficulties that arise when implementing, operationalizing and downscaling the planetary boundaries concept for benchmarking and mainstreaming beyond communication purposes. Yet the concept reinforces the idea and purpose of the Sustainable Development Goals (SDGs) by emphasizing that a safe operating space is an indispensable condition for human wellbeing, a healthy planet and a steady economy.

Politically, the implications of a transition from the Holocene to the Anthropocene should be brought to the fore, in particular its consequences for security, justice, inclusiveness and prosperity, and for safe and just spaces on a global and local level. The planetary boundaries concept should be stressed as a complementary and supportive approach, in particular for the implementation of the SDGs.

The concept is still evolving and, as a set of environmental quality and risk norms, not yet fully quantified. „Operationalization research" is evolving, and applications for sub-global contexts are growing, but there is not yet a „ready-to-go kit" for applying the concept in the political realm. Thus, there is a need for flexible interpretation within the planetary boundary framework of the parameters most relevant for different geographical scales and governance realities, in order to encourage the active engagement of policymakers.

For example, combining and linking the concept with bottom-up footprint work along global value chains, concepts of driving forces and environmental pressures, regionally and locally specified definitions of boundary systems and safe spaces is currently underway. This would appear to be as necessary as enhancing the link to concepts of social needs, distributional equity and economic prosperity. The risks that could arise when crossing planetary boundaries, and the associated dynamics and reversibility, should be further investigated and highlighted, and the insecurities involved should be described in a transparent manner.

2.1.2 Next steps

Dialogue

The dialogue process around planetary boundaries should be continued in a sophisticated manner, focusing on scientific, communicative, educational, political and societal issues. This dialogue can build on previous conferences and workshops such as those held in Geneva (2013)[1] and Brussels (2014)[2] and especially on the conference in Berlin in 2017. The dialogue process should be supported by policymakers.

In the political sector, especially within Europe, a dialogue should be initiated (or stepped up) between European, national and regional governments with the objective of elaborating on the political dimensions and potentials of the concept and how it can be integrated and operationalized. The idea of an exchange between European Union member states concerning the design of national policies and a potential 8th EU Environmental Action Programme, possible contributions to a renewed European Sustainability Strategy, and the implementation of the 2030 Agenda could be taken up within the EU, the European Sustainable Development Network (ESDN) and the European Environmental Agency (EEA).

Dialogues in the academic, business and civil realms could be supported by policy, national foundations and asso-

[1] Workshop in Geneva, November 3-5, 2013 on „Planetary boundaries and environmental tipping points: What do they mean for sustainable development and the global agenda?"

[2] Workshop in Brussels, January 23-24, 2014 on „Safe operating space – Current state of the debate and considerations for national policies".

ciations. Focus issues might include, for example: emergent planetary systems risks for the insurance, business and financial sector; the innovative and cooperative potential of the enhancement of safe and just spaces, both globally and locally; and the communicative and educative potential of planetary systems thinking.

Political action

Integration of the planetary systems („Earth as a complex system") idea into the 2030 Agenda could greatly advance the implementation of the SDGs at a national, European and UN level. The notion of a „safe and just space" could represent a politically sound path for connecting planetary boundaries with the 2030 Agenda. A scientifically informed political process should evaluate and inform the Agenda 2030 and its sub-global sustainability strategies referring to the concept of safe and just spaces; the Global Sustainability Report of the UN, relevant reports by UN Environment and related projects such as the Global Risks Report of the World Economic Forum (and the World Business Council for Sustainable Development) could begin connecting planetary boundaries with the 2030 Agenda. Further negotiations and development of sustainability targets and indicators on an international, national and regional level should form part of this process.

Policymakers should strive for operationalizing policy instruments that bend back the „hockey stick" trends that have emerged since the onset in the 1950s of the Great Acceleration phase of drivers and pressures impacting the integrity of the planetary systems. We need a politically initiated societal debate about a socio-ecological market economy, welfare models and new measuring approaches, taking into account the Anthropocene, planetary systems, global footprint and safe and just space approaches.

Research and education

Increased research efforts are needed into the governance challenge arising from the planetary boundaries concept and the strategies and policies needed to stay within the safe operating space. More research is also needed into how to effectively implement these strategies and policies from a global perspective, including suitable formats for dialog on scientific policy and identifying options for reforms to curricula (for example, in the field of political and business economics).

2.2 Next steps for the scientific community

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The planetary boundaries framework has become increasingly important in environmental policymaking on both a national and an international level. It underpins the UN's Sustainable Development Goals (SDG) process (2015), as well as some national policy agendas such as Germany's Integrated Environment Programme and Germany's National Sustainability Strategy (both 2016).

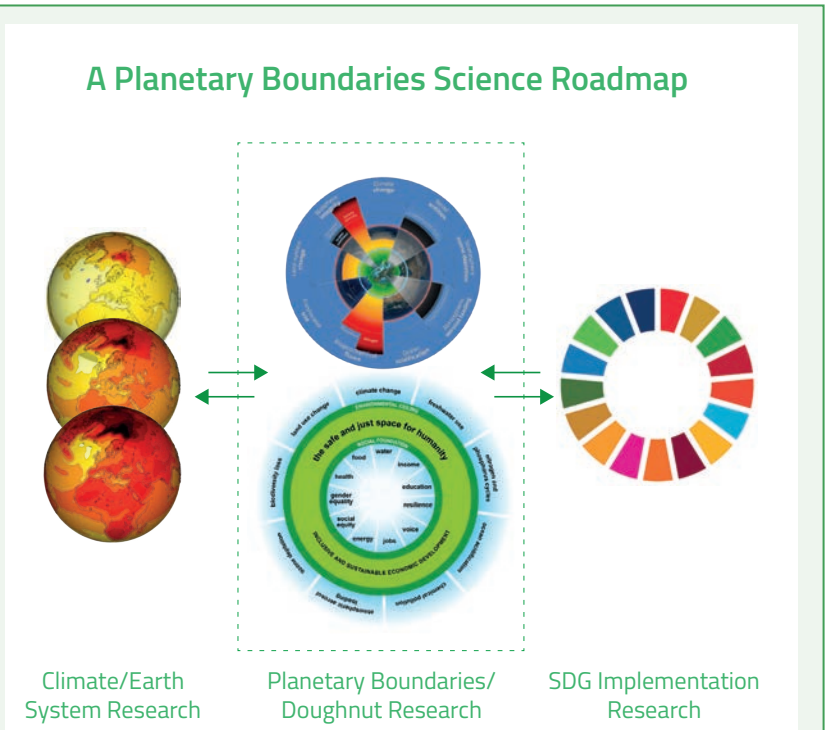

Figure 1: The position of planetary boundaries research between climate-oriented Earth system science and implementation-oriented sustainable development SDG research. The international research landscape at present features a gap in this central field.[3]

Nonetheless, the international landscape of research into planetary boundaries features some large gaps that are hampering the more advanced application, operationalization and communication of the framework in strategic policymaking, sustainability evaluation of business practices and the general public debate. The planetary boundaries research community, although expanding, is still relatively small. Available funding is not geared toward advancing the concept for operational applications. Efforts in modeling and data analysis require more focus on increasing the practical utility of the framework and its underlying challenges for economic theory, socio-metabolic governance and normative choice. This situation slows down the required strategic tie-ins between sustainable development and Earth system analysis in support of increased, targeted policy coherence.

Planetary boundaries research is situated between the more traditional climate-oriented Earth system sciences and implementation-oriented sustainability/SDG science. The scope of analysis is widened from a focus mainly on climate and its impacts to the whole of the Earth system, particularly the integrity of the biosphere. From the perspective of case-oriented socio-ecological SDG research, it elaborates the properties defining a safe operating space for social and economic development and the opportunities this space offers for implementation of the SDGs. Figure 1 illustrates the central position of planetary boundaries research between SDG research and climate-centered Earth system research.

The concept of planetary boundaries is characterized by several aspects:

- Multi-topical, systemic approaches
- Transformative implications of planetary boundary maintenance and transgression in the context of the SDG agenda
- Governance of socio-metabolic flows

Commonly asked questions include, for example: What are the dynamics of planetary boundary processes and how fast are we approaching the thresholds? What happens once we transgress boundaries? Why do we not see the effects of transgression yet? What are the synergies and tradeoffs for staying within planetary boundaries? How can a planetary quantity be applied to the evaluation of a region or a sustainable development strategy?

[3] Sources: MPI-M/DKRZ (left); Steffen et al. (2015): Planetary boundaries: Guiding human development on a changing planet. Science 347 (6223), S. 1259855 (middle); Raworth, Kate (2012): A Safe and Just Space for Humanity. Can we live within the doughnut? Oxfam Discussion Papers (middle); UN (2015): SDG colour wheel (right).

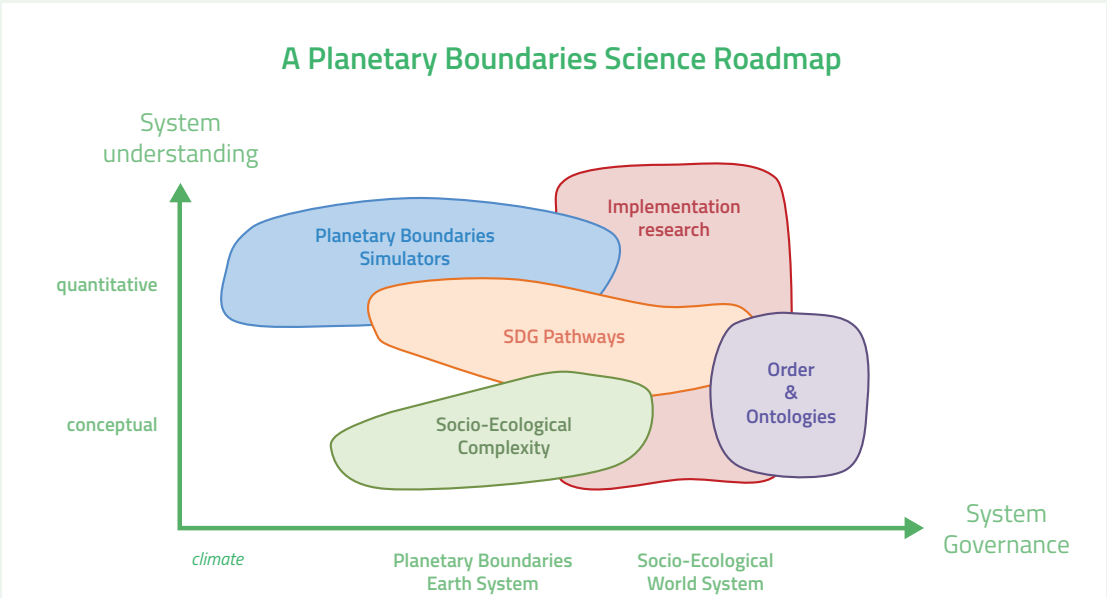

Figure 2

Figure 2 presents the outlines of a topical roadmap for planetary boundaries research, identifying the following key areas of research:

1) Realization of comprehensive planetary boundaries simulation models
2) Quantification of SDG pathways within planetary boundaries
3) Research on socio-ecological complexity under conditions of planetary boundaries
4) Research on the implementation of planetary boundaries concepts in environmental and sustainability policy, businesses, sectors and regions
5) Research on the implications of planetary boundaries for concepts of natural, social, economic and political order, and associated ontologies in discourse and communication

Additionally, a number of international procedural actions are suggested in support of operationalizing the planetary boundaries framework for the purpose of policymaking.

2.2.1 Planetary boundary simulators

The simulation of planetary boundaries and their dynamic interactions with the Earth system require adapted types of models, centered among other things on the marine and terrestrial biogeochemistry, biodiversity, the effects of agriculture and other land use, environmental pollution, and coupled to atmosphere-ocean models. Key new research areas are:

- A whole system approach in which biosphere integrity (not just climate) is central
- Treatment of human societies as dynamic biogeochemical components („anthropo-biogeochemistry")
- Planetary boundary interactions, hotspots and teleconnections
- Nexus research (land-ocean, land-water-energy-agriculture, and so on)
- Emphasis on tipping element interactions shaping the planetary boundaries framework

2.2.2 SDG pathways

Quantifying pathways that meet the socio-economic objectives of development while staying within planetary boundaries is an important task when evaluating sustainability strategies. With respect to a number of sectors (for example, water, food, energy), integrated assessment models have begun to simulate such SDG pathways (see, for example, the Sustainable Development Solutions Network's (SDSN) initiative The World in 2050 – TWI2050). Key new research areas are:

- The socio-economic feasibility of normative paths (including long term)
- Quantifying SSPs (shared socio-economic pathways; benchmarking against planetary boundaries)
- Economics of socio-metabolic and technological governance
- Non-monetary (social and environmental) metrics
- Synergies and tradeoffs between SDG objectives and maintaining and/or achieving safe and just operating spaces

2.2.3 Socio-ecological complexity

The co-evolving World-Earth system is a complex socio-ecological system expected to display properties such as bifurcations, tipping points, state transitions, limit cycles, and the emergence of macro-patterns and macro-dynamics. To a large extent, established Earth system and integrated assessment models fail to capture these properties due to their specific approaches. The preconditions under which a simultaneously safe and just operating space exists, from the viewpoint of complexity science, is a topic of critical importance. Key new research areas are:

- Preconditions for the existence and resilience of safe and just operating spaces
- Co-evolutionary planetary-scale socio-ecological dynamics and tipping points
- Topology and attainability of desirable states
- Resilience and interaction metrics, definitions and concepts
- Agency, networking, and complexity in socio-ecological dynamics

2.2.4 Implementation research

The interfaces of planetary boundaries research with policymaking, business and the broader public are decisive for their operationalization, and represent a topic of research in themselves. Such research also addresses the normative dimensions of the concept, such as concepts of risk, precaution and cultural preferences, as well as the challenges of policy coherence across sectors and spatial scales. Key new research areas are:

- Science-society interfaces, translation, and integration into decision-making cycles
- Global footprints: teleconnections and socio-metabolic externalities
- Environmental justice, security, legitimacy, cooperation and institutions
- Resolving up-scaling and downscaling dilemmas, systemic and cross-scale policy coherence, and actor, interest and institutional analyses
- Interlinkages with the circular economy, the green economy
- Learning and education, initiatives and social engagement

2.2.5 Orders and ontologies

If the concept of planetary boundaries is to become more prevalent in the public discourse, it is very important that its implications for the dimensions of socio-cultural discourse are considered. Also of central importance is the issue of language and images, their implications, associations, subtexts and opportunities. Key new research areas are:

- Planetary boundaries and new natural, social, cultural and political orders/mindsets

- Methods for advancing shared meaning through common language
- Reconnecting with the biosphere: ethical, spiritual, religious, philosophical, and moral aspects
- Risk discourse and precaution, opportunity and transformation narratives

2.2.6 Procedural actions

A number of international initiatives and actions supporting operationalization the concept of planetary boundaries in policymaking are recommended:

- Regular planetary boundary Assessments (including SDG evaluation), national/sectoral assessments
- Dialogue platforms with business/finance
- „Costs of inaction" reports and research gap analysis
- An international advisory group on concepts and definitions
- Cooperation on modeling, scenarios and data cube (Future Earth, TWI2050, SDSN, etc.)

2.3 Next steps for the private sector

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The planetary boundaries conference underlined both the challenges for private sector operationalization and the progress that has been made since the concept was first established in 2009. The main challenges comprise developing methodologies to downscale and translate the global concept to the scale of companies and to embed it in companies' operations so as to influence their performance on corporate sustainability – in a way that goes beyond merely referring to it in corporate responsibility reports.

Since 2009, several companies have embarked on the operationalization of planetary boundaries, relating their corporate activities to the concept. Overall, however, implementation is still in its infancy. This is despite important steps having been taken, especially under the Action 2020 plan formulated by the World Business Council for Sustainable Development.

2.3.1 Added value

The conference underlined that the planetary boundaries concept has added value for sustainable businesses. First, there is the communication side of the framework. The concept creates a narrative, a story, which puts sustainable business activity in a much larger context – that of safeguarding humanity. Companies can use the concept as a tool for raising awareness both internally and externally:

- Internally, they can use it to put the risks the concept highlights on the managing board's agenda (planetary boundaries as risk management)
- Externally, they can use it to showcase their commitment to sustainability and to build consumer trust by coupling references to the concept with credible steps aimed at implementing sustainability measures across the entire value chain.

Second, there is the content of the concept itself. The concept helps

determine the main sustainability dimensions that companies should take into account (a comprehensive sustainability dashboard), as well as highlighting their interlinkages (the systemic nature of the framework). For some planetary boundaries, the concept suggests a global budget and formulates global-scale performance indicators. Potentially, the concept can thus support the formulation of science-based targets for companies. As current methodologies for downscaling are still evolving and not yet fully functional, directly deriving targets from the concept on a larger scale is not yet feasible. Furthermore, it is crucial to take the company's context into account when relating the planetary boundaries concept to actual business activity (co-development).

2.3.2 Next steps

Several objectives are important for further operationalizing the concept. Scientifically, an initial objective would be to continue developing methodologies for downscaling, and to further strengthen the concept. It is also important to analyze existing corporate responsibility standards, such as the standards developed by the Global Reporting Initiative (GRI), the UN Global Compact, the European Commission (Eco-Management and Audit Scheme, EMAS), ISO 14001, and footprinting standards such as 14040, regarding their relationship to (and compatibility with) planetary boundaries. This is important because these standards are one of the main entry points for operationalization. To support such an analysis, it would be helpful to conduct interviews with standard organizations and companies. It is also crucial to discern where, and how, the planetary boundaries concept has already been applied in market overviews, and to develop further strategies for incorporating it into business operations.

A second objective would be to support companies in implementing the concept. In this regard it is important to develop argumentations and narratives focusing on the added value for businesses of incorporating the planetary boundaries concept – in other words, a business case. Furthermore, guidance as to how to implement the concept is crucial, for example through a planetary boundaries compass, by incorporating forerunners („flagships") for specific boundaries, and by translating the concept into concrete terms for the business world. When supporting companies it is especially important to relate the concept's core messages to the existing corporate language and corporate sustainability instruments. The planetary boundaries concept should be framed as complementary to existing standards.

To further incorporate the concept in small and medium-sized enterprises (SMEs), it would be very beneficial to relate the innovations already undertaken by SMEs to the overarching concept (for example, in the form of a „good practice guide"). Many companies, including SMEs, already implicitly promote the planetary boundaries concept by developing and using innovative technologies and production processes to improve their environmental performance. Such an analysis could also facilitate the exchange of innovative ideas between companies, or inspire those who want to take their engagement in environmental protection further.

A third objective would be to further disseminate the concept. For this, it is central to raise awareness among companies. In particular, the concept needs to be connected to other dialogue processes of relevance for the private sector, such as socially and environmentally sustainable procurement (Kompass) and „CSR made in Germany", as well as SEED and SDG implementation. It is also important to use existing communication channels to contact SMEs and larger companies. Continuous dialogue focusing on the further co-development of planetary boundaries is thus an important next step when working with chambers of industry and commerce, insurance companies and trade associations, for example, as well as with businesses, the scientific community and the political sector.

From left to right: Dietmar Horn, Head, Directorate General "General and Strategic Aspects of Environment, Building and Urban Development Policy", German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety; Loa Buchli, Head of Section „Economics", Federal Office for the Environment (FOEN), Switzerland; Jock Martin, Head of Integrated Environmental Assessments, European Environment Agency; Melissa Leach, Director, Institute of Development Studies, University of Sussex

3. INTRODUCTION

The international conference „Making the planetary boundaries concept work" took place on April 24-25, 2017 in Berlin, Germany. It was co-hosted by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, the German Environment Agency, and the German Federal Environmental Foundation. It was organized by adelphi, the Potsdam Institute for Climate Impact Research, and the Stockholm Environment Institute.

The conference focused on two main areas:

- Further scientific development of the planetary boundaries concept
- Further operationalization of the concept by translating it into national and regional policymaking, private-sector activities and investments, civil-society engagement, and media reports

The conference brought together more than 400 experts from policymaking, the scientific community, the private sector, civil society and the media. Keynote speakers included the German Federal Minister for the Environment Dr. Barbara Hendricks, Prof. Dr. Johan Rockström, Prof. Dr. Jacqueline McGlade, and Dr. Heinrich Bottermann of the DBU (German Federal Environmental Foundation).

The conference explored how far we have come since the planetary boundaries concept was first introduced nearly a decade ago. It looked at what has been achieved in terms of developing and consolidating the concept and taking initial steps to apply it in practice, transforming our economies and societies. It brought together scientists working on planetary boundaries and (actual and potential) users of the planetary boundaries concept, asking them what the main challenges have been to date and what lessons can be learned from this for embedding the concept in the policymaking process and the business sector.

Furthermore, the conference identified the key elements of an effective, consistent framework for operationalizing the planetary boundaries concept that facilitates policy coherence and coordinated action by all the stakeholders involved. It also explored opportunities for communication, awareness-raising and dissemination of information about the planetary boundaries concept among all stakeholders who need to be involved in operationalizing the concept. And it examined gaps in our knowledge and gaps in the scientific basis for the planetary boundaries concept.

The conference concluded by analyzing the key challenges that need to be addressed now and in the future. Mastering these challenges is essential in order to build on our progress to date in operationalizing the planetary boundaries concept, and to bring about the required transformation of our economies and societies.

Barbara Hendricks, German Federal Enviroment Minister, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

4. CONFERENCE DAY 1

4.1 Setting the scene: Opening session

The conference began with opening remarks and keynote speeches by the German Environment Minister Dr. Barbara Hendricks, Prof. Dr. Johan Rockström (Director of the Stockholm Resilience Centre) and Prof. Dr. Wolfgang Lucht (Co-Chair of „Earth System Analysis", Potsdam Institute for Climate Impact Research).

4.1.1 From German environmental policy…

Dr. Hendricks spoke on „German environmental policy for respecting planetary boundaries". She began by relating the conference and the planetary boundaries concept to the global „March for Science" that took place on April 22, 2017, in the run-up to the conference. She pointed out that it is vital to defend rational argument, enlightenment and the status of science while ensuring that scientific findings are accessible to the broader public. Planetary boundaries are an example of how scientific knowledge can be harnessed for public discourse. The concept highlights the interlinkages between different ecological processes, as well as the great pressure on the Earth system and the increasing risk of crossing tipping points. Focusing on the two core boundaries „climate change" and „biosphere integrity", the Minister pointed out how the concept underlines the need to stay within a two degree Celsius guardrail to avoid the risk of passing tipping points, and the need to stop irreversible biodiversity loss. Key next steps would be to sustainably transform the current agricultural system, to take into account environmental impact through consumption, and to realize that peace and prosperity are only possible within planetary boundaries. Dr. Hendricks concluded that it is vital to reduce Germany's global footprint and strengthen international cooperation.

4.1.2 …to maintaining the Holocene…

Professor Lucht began his speech by highlighting some worrying scientific findings, namely biodiversity loss, changing oceanic circulation, fossil fuel emissions, chemical pollution and the release of nanomaterials in the environment. These phenomena amount to geo-engineering and pose

a great risk to humanity's prosperity and security. In Professor Lucht's view, planetary boundaries formulate conditions for societal prosperity and define the challenge we face as a civilization. To prosper, we need to become a „homo geo-sapiens", fully aware of the planetary foundation of our civilization. The planetary boundaries provide us with guidance in the form of a set of numbers, but they also highlight the opportunities within boundaries and the need to reconnect to the biosphere. The concept can be understood as a deliberate strategy in the face of major complexity and uncertainty. This strategy implies the obligation on the state to follow the precautionary principle. The state needs to become an ecological welfare state. Key tasks are to apply systemic approaches in environmental policy-making, ensure vertical, horizontal and inter-temporal policy coherence (across scales, between environmental processes, and from short-term to long-term policies), to transform the economy to an economy of deliberate and internationally negotiated scarcity, and to form a Holocene-like, consciously managed Anthropocene.

4.1.3 ...and understanding the huge sustainable development challenge

Professor Rockström focused in his keynote speech on the status and application of the planetary boundaries concept in society. He argued that the most critical equation that academia can communicate to humanity is „Anthropocene + Holocene + tipping points = planetary boundaries." First, there is ample evidence that humanity has now entered the Anthropocene and that pressures on the Earth system are increasing exponentially (based on observation, not modeling or hypotheses). Second, there is scientific evidence that the Holocene is the only stable state in which humanity was able to thrive. Professor Rockström gave the example of our evolution from hunter-gatherers to farmers, which was only possible because of stable ecosystems. The challenge would now be to return to Holocene-like conditions and allow humanity to continue to thrive. Third, there is an increasing understanding that the Earth system has tipping points – not just in the climate change system but also in large-scale biomes. Furthermore, different components of the Earth system are interlinked, so that, for example, tipping points in Greenland (the melting of the Greenland ice sheet) impact on the thermohaline circulation in the ocean, which changes the amplitude and frequency of El Nino, which impacts on forest dieback in the Amazon rainforest and the Indian Monsoon. Not only are tipping points driven by climate change, the underlying resilience of systems also determines whether tipping points are crossed. For example, the likelihood of rainforests coping with stress depends upon fresh water and soil quality. As a result of global biophysical interlinkages, „geopolitical bombs" emerge, in other words, environmental changes in one part of the Earth that can lead to impacts in another part, contributing to conflict escalation. An example of this is that China depends for its rainfall on moisture feedback from functioning forests in Russia and Central Europe.

Professor Rockström highlighted the major challenge facing humanity, arguing that in 50 years we have moved from the 10,000-year Holocene to the Anthropocene. What we do in the next 50 years will determine the next 10,000 years. With current knowledge, we now need to lead the way toward a sustainability transformation.

With regard to the details of the planetary boundaries concept, Professor Rockström pointed out that the nine identified boundaries represent those environmental processes that regulate the stability and resilience of the Earth system. It is important to differentiate between two types of processes: nonlinear, global-scale processes with global tipping points, and linear processes with local-scale tipping points, which may undermine the global-scale climate boundary, for example. Furthermore, three clusters should be differentiated: (1) the „big three", namely climate change, ocean acidification and stratospheric ozone depletion; (2) the „slow variables", namely biogeochemical flows, global freshwater use, land system change and rate of biodiversity loss; and (3) the „Earth aliens", namely chemical pollution and atmospheric aerosol loading.

Professor Rockström pointed to the concept's acceptance and use by the scientific community (over 3,000 citations), the policy sector (operationalization in Switzerland, Germany and Sweden, as well as by regional and international organizations), the private sector (for example, by H&M and Unilever), and within civil society (for example, by WWF) and the media. Overall, the planetary boundaries concept tells a simple scientific story: Up until 1990, there was a small world on a large planet; today, there is a large world on a small planet. What is needed is a mind shift focusing on three principles: (1) the inclusivity principle, respecting every component of the Earth system as relevant for local prosperity; (2) the universality principle, sharing the remaining environmental space; and (3) the resilience principle, focusing no longer on efficiency and optimization but rather on building a buffer zone. The Sustainable Development Goals (SDGs) represent a great opportunity for transformation and for implementing these principles.

4.2 Putting planetary boundaries into practice

The discussion then moved on to concrete examples of operationalization, as well as the importance of a social equity dimension when putting the concept into practice. Contributions were made by Jock Martin (Head of Integrated Environmental Assess-

Johan Rockström, Director, Stockholm Resilience Centre

ments, EEA), Loa Buchli (Head of the Economic Section at the Federal Office for the Environment in Switzerland), Dietmar Horn (Head of the Directorate General „General and Strategic Aspects of Environment, Building and Urban Development Policy" at the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety) and Melissa Leach (Director of the Institute of Development Studies at the University of Sussex).

4.2.1 The European dimension

Jock Martin presented the EEA's approach to operationalizing the planetary boundaries. He pointed out that the EEA is at a very early stage regarding the implementation of the concept. The 2009 Rockström et al. article on planetary boundaries influenced the framing of the 7th EU Environmental Action Programme („Living well within the limits of our planet"), which is guiding EU environmental policy until 2020. Some of its objectives in particular reflect Rockström's article, such as the emphasis on natural capital and Priority Objective 5, which asks for „further research into planetary boundaries". Martin talked about the direction of the forthcoming 2020 SOER report on the state and outlook for the European environment, which will be focusing among other things on the relationship between global megatrends and planetary boundaries, and how European lifestyles impact on the planet and planetary boundaries. Within their network, there is an interest in downscaling global megatrends to the national level, as well as downscaling planetary boundaries to the national level. In response to the fifth objective of the current Environmental Action Programme, the Environmental Knowledge Community was formed; within this community the knowledge innovation project „Within the limits of our planet" was established with the aim of thinking about planetary boundary operationalization in the context of the EU.

Jock Martin, Head of Integrated Environmental Assessments, European Environment Agency

Martin said that the guiding questions for this project were: What is the safe operating space for the EU? (biophysical scaling of planetary boundaries at the EU scale and global interlinkages); is the EU living within the safe operating space? (measuring EU performance, internally and consumption- based; developing a dashboard across environmental goals); and how can the concept inform EU policy (identifying entry points for planetary boundary policy integration through systematic mapping and linking the concept to SDG implementation at EU regional level). He presented initial outcomes from this project, namely that Europe is largely externalizing its environmental footprint (that is, Europe's consumption-based performance is considerably worse than its production-based territorial performance). Also, transgressions of planetary boundaries' „tolerance levels" are generally higher in Europe than the global average. Martin raised the question of how it would be possible

to enhance understanding and utility between the growing body of scientific evidence on planetary boundaries and the increasing interest of policymakers in operationalizing planetary boundaries across different governance scales.

4.2.2 The Swiss experience

Loa Buchli argued that it was very important to operationalize the planetary boundaries concept at a business, national and individual level in order to create impact. She presented research undertaken in Switzerland on planetary boundaries and footprints. From a national boundaries perspective, Switzerland's environmental performance is assessed as positive. However, taking into account that Switzerland is an open economy, consumption-based footprints are very important (for example, imports of raw materials, manufactured products). For example, when looking at the greenhouse gas footprint indicator, domestic consumption-based use is declining, while consumption-based use abroad is rising. Similar patterns emerge for other environmental processes. To derive policy priorities, a project undertaken for the FOEN assessed the Swiss global footprint and compared it with the (assumed) Swiss share of the global limit, in order to identify overshoot. According to the study, the footprints for climate change, ocean acidification, biodiversity loss and nitrogen losses were clearly unsafe. To derive policy priorities from the findings, it is necessary to look at the drivers of environmental impacts. Nutrition, for example, is a major driver for climate change, biodiversity loss and nitrogen losses. Relevant economic sectors for „nutrition" are wholesale and retail trade, as well as the agriculture and food industry, information technology, financial services and commodity training. Relevant product groups include animal food, coffee, cocoa, palm oil, and so on.

Buchli further pointed out that the Swiss government has been formulating an action plan on consumption/production, waste and raw materials and cross-cutting issues such as sustainable finance, innovation and research. However, more ambitious policies have not been backed by the political sovereign so far: The Swiss popular initiative „for a sustainable and resource-efficient economy" was rejected by the population in 2016. There are, however, also positive examples: The Swiss sustainable development strategy has embed ded the planetary boundaries; also the Parliament in 2017 proposed an amendment to the Constitution on food security, acknowledging the need for sustainability in consumption and trade. Buchli argued that ways forward include assessing national/Europe's footprints against planetary boundaries and so demonstrating the urgent need for action, as well as stimulating the debate on countries' responsibilities to reduce their greenhouse gas footprint. Other next steps would be to develop a vision for critical systems, such as sustainable

Ioa Buchli, Head of Section „Economics", Federal Office for the Environment (FOEN), Switzerland

food, housing and transportation, align them with planetary boundaries, and provide analysis that facilitates target-setting at a business level („one planet" approaches for companies).

4.2.3 Operationalization in Germany

Dietmar Horn spoke on „Planetary boundaries and transformative policies in the German Integrated Environment Programme". Referring back to Rockström's keynote speech, he underlined the importance of Rockström's statement that we have already changed the planet massively in the last 50 years and that we now have responsibility for the next 10,000 years. He focused on the notion of transformation, which is also central to the 2030 Agenda. According to Horn, we appear to be currently in a period of worrying counter-transformation, where facts are altered if they do not suit a particular world view. This development endangers ecological as well as rational, democratic policymaking. While democratic deliberation is central and necessary, facts should be taken into account in order to formulate sound policies. The 2030 Agenda is also, Horn argued, the answer to the challenges raised by the planetary boundaries, and includes the necessity to transform. Horn highlighted the German approach to transformation, citing among other things the sustainability strategy formulated in 2002. The 2030 Agenda now creates a window of opportunity for including stronger sustainability policies. As a result, an update of the German sustainability strategy was established in 2016; within this strategy the planetary boundaries are included as absolute guardrails for policymaking. The German government hence recognizes the concept as guiding principle for policy.

The Integrated Environmental Programme 2030 represents an answer to the transformative challenge raised in the 2030 Agenda and the sustainability strategy, outlining how environmental policymaking would need to change. According to the Programme, living within the limits of the planet is possible. Horn highlighted that positive change has already taken place, for example, the Energiewende (transformation of the energy system in Germany). This shows that change is possible. But structural change would need to take place in order to contribute to the sustainability transformation. Horn concluded that it is crucial to reflect on the reasons for the widespread reluctance to embrace change, including examining whether the societal impacts of change are truly taken into account and whether we genuinely listen to those that are not yet convinced about sustainability transformation.

Dietmar Horn, Head, Directorate General "General and Strategic Aspects of Environment, Building and Urban Development Policy", German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

4.2.4 The importance of a social equity dimension

Melissa Leach spoke on „Global inequality and planetary boundaries: adding a social equity dimension to the safe operating space". She underlined that there are two defining challenges for this century: maintaining a stable and resilient planet, and addressing rising inequalities. The question of equality/equity needs much more attention now as it represents a global challenge deeply interlinked with the resilience dimension. While planetary boundaries help operationalize the resilience side, much more focus needs to be placed on equity. There are two reasons for this: First, from a moral perspective, equality and fairness have intrinsic values; second, from a pragmatic perspective, inequalities and their consequences threaten progress toward sustainable development. Leach called for a new integrated agenda, including conceptual frameworks, solutions-oriented research, policy and practice.

Leach further described the inequality challenge, which is high on the agenda of governments and civil society. She argued that perceived inequality in part helps explain the motivation for people voting for Trump and in favor of Brexit. She also gave the example of the number of world protests, which has been growing since 2006. The major grievances raised at these demonstrations relate to economic and social justice. The topic of inequality is also central to the 2030 Agenda, for example in SDG 10 and its pledge to leave no one behind. Social science has also taken up the topic of inequality, with research in this field challenging inequalities. Leach referred to the 2016 World Social Science Report, which examines the interactions between multiple dimensions of inequality, documents the trends in inequality in all world regions (especially within Africa and Asia), analyzes the consequences of inequality in different countries and regions, and identifies strategies to reduce inequalities and knowledge gaps.

Leach highlighted several findings of the Report. For example, economic and political power are now increasingly concentrated in the hands of a small number of people globally. While global economic inequality declined during the first decade of this century, largely driven by the reduction of poverty in countries such as China and India, inequalities are rising in long industrialized countries, in industrializing countries, and in the poorest countries alike. Those at the bottom of global inequality – the bottom 30 percent – are concentrated in the poorest countries of sub-Saharan Africa. Leach argued that inequalities should not be understood and addressed only in relation to income and wealth. Instead there are several dimensions of

Melissa Leach, Director, Institute of Development Studies, University of Sussex

inequality, as the Report highlighted:

- Economic inequality (for example, differences between income levels)
- Social inequality (differences between the social status of different population groups and imbalances in the functioning of education, health, justice and social protection systems)
- Cultural inequality (discrimination based on gender, ethnicity and race, religion, disability and other group identities)
- Political inequality (differences in the capacity of individuals and groups to influence political decision-making processes and to benefit from those decisions, and to enter into political action)
- Spatial inequality (spatial and regional disparities between centers and peripheries, urban and rural areas, and regions with more or less diverse resources)
- Environmental inequality (unevenness in access to natural resources and the benefits of their exploitation; exposure to pollution and risks; and differences in the agency needed to adapt to such threats)
- Knowledge-based inequality (differences in access and contribution to different sources and types of knowledge, as well as the consequences of these disparities)

Some of these dynamics are vertical, for example, rich versus poor, or class-based inequalities. Some are horizontal, between groups, for example, cultural inequalities. But most importantly, they can intersect. In other words, inequalities can be compounded; Leach gave the example of a woman who is part of a low-income, marginalized ethnic group living on the fringes of a city.

Leach further argued for the „safe and just operating space" concept, which views human-natural systems as coupled, and equality and sustainability as both arising from these coupled systems. This concept unpacks multiple dimensions of equality and sustainability and their interactions, and opens up an entirely new discussion. Leach highlighted several dynamics that should also be taken into account when operationalizing pathways:

- A market capitalism dynamic – dominant economic structures and processes produce both inequalities and environmental unsustainability
- A distributional dynamic – inequalities and unsustainabilities are coproduced through the uneven sharing of ecological space, and resources are not fairly distributed, for example, between countries and groups
- A marginalization dynamic – environmental shocks and stresses contribute to inequalities by driving and deepening marginalization, contributing to downward spirals of impoverishment and vulnerability, pushing those at the bottom into unsustainable practices
- An elite dynamic – those who hold power and wealth facilitate them to pollute and degrade the environment with impunity and influence economies and regulations in their favor
- A status and consumption dynamic – inequalities lead to „status anxiety" and concern about relative position in social hierarchies, which drive unsustainable forms of consumption
- A collective action dynamic – inequalities work against sustainability by making cooperation more difficult at different levels: locally, as regimes to manage common property resources are undermined by horizontal inequalities or class differences; globally, as inequalities between countries have compromised cooperation on challenges such as climate change and biodiversity; and nationally, as unequal societies are less able to form common commitments for change
- An environmental intervention dynamic – interventions in the name of sustainability can exclude people further, and policy and action in the name of sustainability

(in some versions) lead to exclusion and dispossession of rights, voice and livelihood. For example, investments in a green economy may reduce employment for some

Leach argued that, across these dynamics, several future scenarios are possible: (1) equality and sustainability worsen together (downward synergies); (2) equality and sustainability improve together (upward synergies); and (3) equality and sustainability move in different directions (tensions and trade-offs). However, positive change is possible. Operationalizing pathways in a safe and just space means identifying and supporting synergies, avoiding trade-offs and recognizing that how these trade-offs are assessed depends on the type and version of (in)equality and (un)sustainability at stake. Leach mentioned several factors as next steps, including learning from positive country experiences, social and political action from below, and addressing embedded histories and cultural practices.

The subsequent discussion focused on the empirical evidence for linkages between inequality and unsustainability. Comparing China with Germany, one participant highlighted that both countries are making progress on energy independence but have different track records regarding inequality. The debate also focused on trade-offs between global and intergenerational justice. Leach argued that if transformative pathways are chosen prudently, trade-offs do not necessarily have to occur. She raised the question of whether it is possible to deliver on the environmental SDGs and at the same time achieve the objectives of the social SDGs. It was also asked why lifecycle assessments are not fully taken into account in public spending.

Participants criticized the „obsession with economic growth", which in their eyes has led to humanity moving beyond the boundaries; they argued instead for the necessity of sufficiency and resource capping schemes. Dietmar Horn responded that it was not growth in general that was the problem, but the kind of growth happening (what grows, and what should not grow). Supply to a growing population could only be ensured by continuing to grow, Horn argued. It was also asked by the participants what strategies industrialized countries could take when facing the fact that developed countries' resource consumption is three times higher than would be replicable worldwide. Participants pointed out that in the EU there are four systems that contribute greatly to unsustainability: food, energy, mobility and the built environment. But behind these systems, according to Jock Martin, lie the (primarily private) financial and (public) fiscal systems.

The key next steps according to Leach, Martin, Buchli and Horn are as follows (respectively): to ensure that conceptual, empirical and action-oriented work takes equity into account; to focus on biosphere integrity and its relationship with other boundaries; to assess footprints against planetary boundaries (transparency); and to win over majorities for the planetary boundaries concept.

4.3 Conference panel: Transforming society and the economy

The subsequent conference panel focused on the transformation of society and economy, taking the planetary boundaries concept into account. The panel consisted of Harry Lehmann (Head of Division Environmental Planning and Sustainability Strategies at the German Environment Agency), Kate Raworth (Senior Visiting Research Associate at Oxford University), Gail Whiteman (Director of the Pentland Centre for Sustainability in Business at Lancaster University and Professor in Residence at WBCSD) and Johan Rockström.

4.3.1 Between optimism and pessimism

Harry Lehmann said that he was neither optimistic nor pessimistic when it comes to the question of how well we are doing from a sustainability perspective. Citing necessary fields of action, he argued that for the field of technology he is optimistic, as societies have learned to employ renewables and increase resource efficiency. However, when looking at the economy and the way the financial and fiscal systems are shaped, he is pessimistic, as poverty and wealth at the top are increasing and there appears to be little to change these structures. Looking at lifestyles, Lehmann said that he is even more pessimistic, as lifestyles are not changing even though – at least in

Kate Raworth, Senior Visiting Research Associate, Oxford University; Harry Lehmann, Head of Division Environmental Planning and Sustainability Strategies, German Environment Agency; Johan Rockström, Director, Stockholm Resilience Centre

Germany – citizens are more aware of their environmental responsibility. The next step would be to move from technology-based solutions to involving society, in order to change the underlying societal structures of unsustainability.

4.3.2 The power of pictures and words

Kate Raworth drew attention to the fact that planetary boundaries can be seen as a new paradigm for the twenty-first century, building on much earlier findings from ecological economics and a recognition that the economy is embedded within ecology. But this paradigm now comes with a powerful illustration, more specificity, and is supported by better data. She highlighted the power of pictures by talking about how she created the image of a doughnut, with an inner circle and an outer environmental circle (the planetary boundaries) – an image that has been used widely. The doughnut image has changed the conversation about planetary boundaries by highlighting the equity dimension and its relationship with planetary boundaries. Raworth also argued that every word we write amounts to a frame, and every picture that we draw could equal a paradigm. She said that scientists cannot simply argue that they are providing the science, and that storytelling would begin later. The current planetary boundaries illustration, for example, raises problems as it paints several environmental processes in yellow, not giving a clear signal to reduce pressures. She also mentioned the difference in wording between „growth within limits" and „prosperity within limits", which would translate into entirely different actions.

Raworth was very concerned about the current political situation, as the planetary boundaries story is not „winning" globally due to barriers and resistance. She cited a tweet that was published by US President Donald Trump during Earth Day, which read: „I am committed to keeping our air and water clean, but always remember that economic growth enhances environmental protection. Jobs matter!" Raworth argued that this tweet exemplifies a common paradigm: focusing on local, visible pollutants, economic growth as essential (environmental Kuznets curve), and the necessity of jobs (whereas in fact there are more jobs in the renewable sector than in mining). What we need now is a clearer scientific picture as the public, too, often reacts to scientific findings with an attitude of „Well, who knows?" Science needs to come out of its comfort zone.

4.3.3 The role of the WBCSD in moving planetary boundaries into the private sector

Gail Whiteman focused on the work of the WBCSD. She spoke about how Peter Bakker, the head of the WBCSD, had tweeted during the planetary boundaries conference in Berlin that business needs science-based targets, arguing that this exemplifies a major shift. Building on her work in moving the planetary boundaries concept into the WBCSD, she highlighted some of the challenges involved when addressing businesses with scientific concepts. To convince CEOs, scientists would only have a very limited amount of time in the boardroom (for example, five seconds). When pitching a scientific finding, including overly complex slides and illustrations would not convince decision-makers in the private sector. The image of the planetary boundaries is particularly helpful when translating it into business language, portraying it as a sustainability dashboard, measuring global performance through indicators for the planet (key performance indicators, collectively). Planetary boundaries could deliver collective science-based targets for the private sector.

Whiteman continued that moving the concept into the WBCSD was still very difficult, because science and business do not usually work together unless business owns science. Scientists are also usually preoccupied with their day jobs and are not easily moved to the „boardroom" when private sector demand for information arises. There are therefore different timeframes. There is also the problem of a common language. Whiteman talked about one occasion when, during a meeting, one of the private-sector representatives did not pay attention when a

scientist explained the underpinnings of the ocean acidification planetary boundary. Whiteman pointed out that this phenomenon is about the „death of the ocean". But the representative was not convinced, calling the discussion „boring". On the other hand, Whiteman argued that scientists generally do not know how to pitch in the boardroom, that is, how to condense their findings and arguments into highly concise messages (for example, three major points). From her perspective, while it is important to make scientific findings accessible, it is also crucial to go beyond storytelling and changing the „rules of the game", that is, the economic system and monetary system. She suggested putting a planetary risk report in place and creating a world resilience forum that could make these topics more visible.

Harry Lehmann pointed out that while the endorsement by the WBCSD of the planetary boundaries concept is a good sign, the majority of the economy – the 90 percent – is still not moving toward transformation. Part of the problem lies in only talking to the 10 percent that is already convinced of the necessity of being more sustainable. Especially problematic is the fact that businesses very often have different timescales from scientists, focusing on short-term gains and not being concerned about future environmental impacts. Lehmann highlighted the risks of framing future impacts in apocalyptic scenarios, inducing fear among the audience; environmental communication should also, he argued, include alternatives or solutions so as to provide positive pathways.

4.3.4 The role of science in transformation and lessons learned

Johan Rockström argued that the biggest challenge today is cooperation. He highlighted the necessity for science to work independently, to come up with the „boring graphs and tables", and not to easily give in to private-sector demands. There is a large challenge in communicating/pitching, exemplified by the impossibility of convincing a broader audience of the RCP 2.6 scenario (the pathway to stay within 400 ppm). He argued that the challenge is not for science to change its way of storytelling, but for science to work together with politics, the private sector and other sectors. Science would therefore deliver the evidence base for further action. **Whiteman** agreed, and pointed out that business wants exactly this evidence base. There should be co-creation of business priorities for science, and science priorities for business – essentially an engagement question.

Rockström enumerated three lessons learned for the future of the planetary boundaries concept. The first is the continuous need to refine its quantification, especially with regards to the biosphere integrity boundary. The second is the equity challenge: planetary boundaries require sharing the remaining space globally. This forces countries and other actors to calculate their „share of the pie", a challenge that appears to be very demanding. The third lesson learned is that science needs to be transformed into an evidence-based story, where sustainability forms the entry point for development and progress, breaking the dogma of unsustainable development first, and sustainability second. This would also require scaling up existing transformative success stories.

4.3.5 The question of strategy and policy

The subsequent discussion centered around the practicalities of putting planetary boundaries into practice and moving globally toward a more sustainable society and economy. Plenary participants raised questions about which actions could be undertaken when boundaries are crossed, how to ensure that societies stay within boundaries, how the drivers of environmental pressures and the mechanisms of societal management and cultural values such as „the growth mania" could be simultaneously addressed from a political perspective, and how to include „voices from the South" in the planetary boundaries framework.

Lehmann highlighted the importance of laws in enforcing sustainable behavior, as well as creating alternative systems for people to choose from that are already in place and

reliable, so that citizens can actually be more sustainable. The solution lies in making better solutions affordable and creating the right incentives. According to Lehmann, sufficiency is another important aspect of policy. He also focused attention on bottom-up initiatives, as it would be futile to wait until global governance mechanisms are sufficiently established. **Rockström** focused on the urgency of the challenge that the planetary boundaries concept describes. This makes it necessary to strengthen global governance – for example, by creating a world resilience forum and by coupling the question of crossing boundaries with global governance. The result would be enforceable, global governance mechanisms for all nine boundaries, for example, at the UN level, which could then steer the transformation. **Whiteman** argued that rapid response governance mechanisms should be established, as there is not enough time to negotiate global policies for each boundary as was done for the climate change boundary. This also means that there is a great need for financial support and impact investment. **Raworth** highlighted the need to fight the existing paradigm of „endless growth" (for example, short-term financial return). Reflection needs to take place and current questions need to be reframed. For example, instead of asking „what can planetary boundaries do for finance?" the question would be „How does the financial system need to change to be within boundaries?" Raworth also highlighted the danger of activating a mechanism of greediness when speaking about sharing scarcity (for example, „fair shares"). A solution would lie in focusing on distribution and regeneration.

The panelists indicated the following priorities for the future: supporting the ongoing transformation of the energy

From left to right: Gail Whiteman, Director, Pentland Centre for Sustainability in Business, Lancaster University; Kate Raworth, Senior Visiting Research Associate, Oxford University; Harry Lehmann, Head of Division Environmental Planning and Sustainability Strategies, German Environment Agency; Johan Rockström, Director, Stockholm Resilience Centre; Jacki Davis, Moderator

system to address climate change; building a rapid response team for the planet; strengthening the science-private sector dialogue; changing current economic education; tipping the scales fast enough on all fronts; and building on minorities that are strong enough to change the system.

4.4 Building on practice: Stocktaking (workshops)

4.4.1 Building a coalition for operationalizing planetary boundaries: Starting points

Workshop 1 focused on how to build an effective coalition between science, policy- and decision-making, civil society, and the private sector. This should build on existing experiences and learn from previous champions of trans-disciplinary sustainability. The workshop discussed environment and sustainability governance across scales, and how to align different sectors of society and different levels of governance with planetary boundaries' science for cogeneration of action-oriented knowledge. It also looked at what the main fields of action and next steps for a global planetary boundary coalition are. The workshop was chaired by Sarah Cornell (SRC) and participants included Damien Friot (Shaping Environment Action and project member in the Bluedot project), Frank Sprenger (Sustainable Impact) and Vesa-Matti Lahti (from the Finnish innovation fund SITRA).

Sarah Cornell introduced the workshop by pointing out that there is arguably enough science to diagnose the problems but maybe not enough finesse to point us in the direction of the responses required. Indeed, these responses could be manifold and are linked to various levels of decisions, from households to corporation to policies.

Cornell explained that strategic collaboration and a more trans-disciplinary Earth science emanated from the Bretherton series in the late 1980s and resulted in the Future Earth research platform. Structures are in place for scientific coordination. However, science is clustered in separate knowledge communities (for example, climate change, biogeochemical change, biodiversity and chemical pollution), and these structures therefore operate differently and have different policy contexts to satisfy. Downscaling planetary boundaries is a challenge that forces us to interact across communities and comfort zones. For example, there is no single equation to determine variables such as equity or fairness.

Cornell raised the question of whether our structures for strategic coordination are sufficient, or whether we should consider a structure such as the IPCC to address planetary boundaries and global governance. The outline of a report building on such a structure could mirror the IPCC report outline and have the four following sections: 1) The science of the boundaries: the evidence base; 2) Impact: What kind of impacts will crossing the boundaries have? How can we use these impacts to communicate the urgency of action? What certainty do we have and where should we place the boundary when entering the political discussion and drawing up a political target? 3) Pathways: What are our options for maneuvering within this space? What kind of pathways are there? And what are the options? 4) Policy uptake.

Cornell argued that although the concept is about global target-setting, the next step at the national level would be to enquire which share of this global challenge should be addressed at the national level. Issues of equity and burden-sharing have been discussed at length by the climate change community. Cornell raised the question of whether it would be useful to cross-fertilize and bring the experience to other planetary boundaries.

Damien Friot outlined four core challenges for building a coalition. The first pertains to universality. While considering sharing the rest of the resources we have, there is no self-explanatory, practical way of allocating numbers. „Allocation" faces challenging questions such as who we

allocate to – people from today, yesterday, or the future – and until what point in the future. Also, what are we allocating: rights to use resources, a share of the possible use of resources, or access to resources? A coalition would be needed to discuss these possibilities and find a pragmatic way forward.

The second challenge refers to inclusivity, meaning the responsibility a country has in its resource use throughout the world. This means following the footprint of products across the entire value chain.

The third challenge pertains to biophysical indicators. He Friot argued that planetary boundaries indicators could build on a selection of existing indicators.

The fourth of Friot's challenges refers to verticality. Different „communities" are struggling to communicate with each other, and a coalition would need to link the different levels and scales of communication involved.

Frank Sprenger argued that the private sector would need the planetary boundaries concept to be presented in a different manner than it is at present. He gave the following pragmatic advice: To translate the concept into business thinking, first and foremost one should make businesses realize that they are part of society. We should not think that the private sector needs precision: The need for more data arises after we have convinced private-sector representatives that the issue is of relevance. We should also refrain from presenting different frameworks, as this leads to confusion. The SDGs are a good framework for engaging with the private sector, while the concept

of boundaries is opposed to the business mindset. Showing peer relevance is crucial. This could be achieved by examining the whole value chain and pointing out the risk of unsustainability in resource provision along the value chain. Actions for a possible coalition would entail using the media to create stakeholder pressure and push for planetary boundary footprints, transparency and competition. There are opportunities to engage with the private sector along the value chain. For example, a shift of mindsets could be achieved through education and by changing business studies. It is also necessary to shift from thinking in a linear, two-dimensional way more toward system thinking. Humanity needs a positive vision.

Vesa-Matti Lahti presented the NEXT ERA global initiative. The starting point of the initiative is that SITRA believes that we need to stay in the „donut" (a reference to the doughnut economy concept developed by Raworth). Lathi argued that we are at a crossroads, and that many things are threatening the old economic model. In response, SITRA started the NEXT ERA project on decoupling perceived wellbeing and economic growth from the consumption of natural resources. The guiding question is how to substitute the twentieth-century promise that growth leads to work, which leads to wellbeing. The project starts from the premise that digitization plays a key role in promoting a vision for sustainable wellbeing. It focuses on three research topics: 1) work and income (digitization, taxation and basic income); 2) democracy and participation; and 3) growth and progress.

The **plenary discussion** reflected on how to build a coalition for operationalizing planetary boundaries.

The question was raised of how, within a competition model, it is possible to shift the terminology to organize a discourse that is politically useful. In particular, how can we express the existential threat that we face in a world in which there is more movement of information, more people questioning the soundness of science, more opinions, and more competing visions based on competing value systems? The question was also raised of whether it would be better to focus on one of the boundaries rather than on all nine.

A related question was who, in building a coalition, would be the target audience for the private sector? For example, would it make sense to focus on senior executives in big enterprises or technical experts? WWF, for example, decided to focus on the 1 percent of companies that use 67 percent of the world's resources, targeting large players in the energy agriculture and food sectors.

The multiplicity of approaches and models was recommended as a sound way forward. There should not be one goal and one methodology, but rather research should focus on integrating different models (for example, planetary boundaries and SDGs), applying the models in real contexts. In a potential coalition it would be important to leave space for different people to use the model that they enjoy working with, while it would still be crucial to have clear roles.

4.4.2 Legitimizing the setting of planetary boundaries: Scientific findings and normative choices

Workshop 2 presented the current state of the discussion on the scientific and normative aspects of planetary boundaries. Furthermore, it proposed ways for co-designing the further development and operationalization of the concept. The workshop was chaired by Detlef van Vuuren (PBL), and participants included Katherine Richardson (Copenhagen University), Victor Galaz (SRC), and Åsa Persson (SEI).

Detlef van Vuuren introduced the workshop and highlighted that the planetary boundaries were initially mainly framed as a scientific concept. Still, clearly normative choices need to be made „in making the planetary boundaries concept work." These relate, for example, to the question of whether risks of transgression are deemed to be acceptable or not and for which time span and how the planetary boundaries relate to other societal goals, such as the goal to eradicate hunger. He pointed out that

in the negotiations. the 1.5 versus 2 degrees Celsius targets are discussed not only in the context of scientific arguments, but also in the context of political arguments and legitimacy questions. Other planetary boundaries raise even more questions of legitimacy. One of the challenges is translating planetary boundaries into targets for nations and non-state actors, taking into account the capabilities and responsibilities of these actors.

Katherine Richardson emphasized the importance of further communicating the concept, not only in the context of larger conferences but also regionally. She addressed the question of whether the planetary boundaries are normative or not. She said that, if she could redesign the concept, she would not call them „boundaries" in fact, as this gives the impression that you should never cross them. As the boundaries have already been transgressed and „doom" has not yet set in, this only leads to confusion. It would be more useful to consider the planetary boundaries more like „blood-pressure-related risks" or a „bank statement" for available global resources. One cannot continue to ignore a signal that the system is not sustainable. Richardson concluded that the concept is mainly descriptive, whereas the normative part pertains to the assumed necessity of staying within Holocene-like Earth system conditions.

Victor Galaz asked whether planetary boundaries science faces unique or greater legitimacy issues than other fields of global environmental research. He raised the question of whether planetary boundaries science is not just inheriting the challenges of global democratic governance, and whether there is a really a unique democratic legitimacy and

accountability problem involved. For Galaz, the key challenges include the non-existence of a clear international knowledge body or location where different global and diverse knowledge institutions meet. In that sense one can question the legitimacy of the planetary boundaries concept. A key next step, therefore, would be to move from a discourse of „limits" to a debate on opportunities and mobilizing the majority by presenting future possibilities. It would be dangerous to think that we cannot wait for the majority; there is an urgent need to develop a narrative for mobilization.

Åsa Persson argued that there are reasons for optimism regarding the legitimacy of planetary boundaries. Three boundaries have been incorporated into international environmental agreements, namely climate change, biosphere integrity, and stratospheric ozone depletion. Furthermore, most boundaries are being addressed politically. Agreeing and setting a boundary appears to be less controversial than actually enforcing it (here, Persson cited the Universal Declaration of Human Rights as an example). Planetary boundaries can be set in a democratically legitimate way, as there is a legitimate division of work between science and the public. The discourse around planetary boundaries could in itself be helpful even without international negotiations. This is because research on regulation shows that „shadow regulation" (the threat of regulation) can be just as effective as regulation itself.

The subsequent **plenary discussion** focused on how to translate the global concept into national action. It was pointed out that it would be beneficial to create a public discourse around the concept and to further include political actors, as they are the ones translating the concept into policies. Taking the academic concept to the public would be necessary in order to include voices from minorities that are not at the moment included in the planetary boundaries discourse, such as indigenous communities. Furthermore, the plenary emphasized that the planetary boundaries cannot and should not become the only narrative for sustainability, as many cultures are moving in the same direction of sustainability but would not use the planetary boundaries concept. It was pointed out that there is a conflict between legitimacy-building during a long political process (for example, the international climate change negotiations) and the need to act quickly.

The discussion also centered on the language of the concept. It was argued that the EU tried to get the concept into Rio+20 but that the US and G77 were against it, which could (in the case of the G77) partly be attributed to the fear that instead of „fair shares", the global allocation of resources would not be just. It was suggested that the concept should be reframed into pure risk language. However, the counterargument was made that risk language and reliance on the precautionary principle could undermine scientific inquiry by removing the need for clear evidence, and instead highlighting risks.

4.4.3 Building on experience: Lessons learned from initial operationalizations

Workshop 3 focused on lessons learned from initial experiences with operationalization: the barriers to and requirements for operationalization, improvements needed to the concept, and the benefits of using the concept. Different cases of application of the concept were discussed, focusing on Switzerland, South Africa, China and India. The workshop was chaired by Jörg Mayer-Ries (BMUB/IASS), and participants included Andreas Hauser (FOEN), Hy Dao (UNEP Grid), Megan Cole (Oxford University) and John Dearing (University of Southampton).

Jörg Mayer-Ries opened the workshop by highlighting the activities of the BMUB relating to the planetary boundaries concept. Mayer-Ries was head of a research project at the German Integrated Environment Programme on operationalizing the planetary boundaries concept in Germany. The current conference was part of this project.

The first example from Switzerland was presented by **Andreas Hauser** and **Hy Dao**. The underlying motivation for the project was Switzerland's growing external ecological footprint (for example, carbon dioxide emissions due to net imported goods

and services) and shrinking internal footprint (for example, carbon dioxide emissions due to domestically produced goods and services). This divergent pattern raised the question of how much resource-exhausting and polluting activity in Switzerland or due to consumption in Switzerland would be sustainable. This motivated the project on the planetary boundaries concept. A straightforward answer would have been absolute decoupling, which would have reduced the footprint by one percent. The project on the planetary boundaries concept was also motivated by the question of whether absolute decoupling suffices.

Hauser presented results from the operationalization of the planetary boundaries for Switzerland, in particular quantitative assessments for the planetary boundaries dimensions „climate" (where the limit is exceeded by approximately 2,100 percent) and „biodiversity" (100 percent). Overall, the planetary boundaries are exceeded in four dimensions. Overall, The project revealed that Switzerland is far from keeping its activities within its share of the planetary boundaries. Furthermore, the project revealed that a one percent reduction (absolute decoupling) of the footprint is not enough by far.

Hauser also presented lessons learned from the project for operationalizing the planetary boundaries concept. In the area of science, the presenters concluded that the traffic light planetary boundaries illustration can be very useful, indicating whether a country is in a „clearly unsafe", „unsafe" or „safe" position for a particular environmental process. Furthermore, it is important to account for trends over time and determine the confidence of the assessment, based on data quality and so on. In the area of policymaking, the presenters concluded that the planetary boundaries concept directs attention to the ecolo-

gical consequences of human activity aggregated along the whole production chain. The concept indicates the „system boundaries" of policymaking and indicates the need for change in a way that is different from other footprint assessments: in particular, it is more specific and more urgent.

In the second part of the presentation, Dao focused on the methodology of the operationalization of the planetary boundaries concept in Switzerland. He pointed to several methodological challenges when operationalizing the concept. First, there was a need to link each of the dimensions of the planetary boundaries to drivers, for example, the „climate change" dimension to the emission of greenhouse gases and land cover changes. To operationalize the planetary boundaries, each driver can be assigned one or several indicators. The values set as the limits for the specific dimension can then be used to derive limits for the indicators of the related drivers. Dao stated that a driver and an indicator for that driver do not logically follow for all dimensions of the planetary boundaries concept. He cited the example of the dimension „(loss of) biodiversity".

Another critical challenge is demographics. Dao referred to the famous IPAT equation, according to which the footprint of a country is proportional (in a first approximation) to its population. In the Swiss project each country was assigned a „slice of the planetary boundaries cake" at a set date, without accounting for subsequent population changes, which were seen as the responsibility of the country in question.

Dao also spoke about the challenge of data availability. In the case of Switzerland, data availability and data quality at the national level was very good. The planetary boundaries concept was also operationalized for other countries within the same project, for which global databases with lower quality (less detail) needed to be used. The assessment of the planetary boundaries was done by deriving indicators of drivers for each dimension and then calculating (1) the current value of the indicator, and (2) the limit for the nationally operationalized indicator to remain within the planetary boundaries. By dividing (1) by (2), the current state could be assessed with respect to whether it was above or below a sustainable level.

Dao also presented the example of climate change. Here, the remaining global carbon budget to stay within the IPCC limit for global warming was calculated for the year 1990. This budget was distributed to countries for that year according to the „equal share" principle. For Switzerland, the current score in this dimension on the basis of these calculations is 22.7. That is, the sustainable level of emissions is exceeded by more than 2,100 percent.

A number of points were raised in the subsequent discussion. The distribution of the planetary boundaries share is critical for operationalization at the national level. The „equal share" principle would be one option. Ideally, IPCC-like assessments and UNFCCC-like conventions would be required for each dimension of the planetary boundaries concept. Related to the previous point, the imposition of limits to a country's activities in certain fields must be regarded as difficult. As an example, it was mentioned that resource-rich countries already tend to block such attempts. To overcome the issue of defining limits, a local perspective could be useful. This could be the perspective of a „steward of local resources" who manages these resources. The relationship between the planetary boundaries concept and the SDGs was also discussed; this relationship remained unclear. It was mentioned that some footprints are included in the SDGs, but that a fulfillment of the SDGs does not keep the world within the planetary boundaries.

In the second presentation, **Megan Cole** talked about her work on South Africa. She tried to operationalize the planetary boundaries concept under a number of constraints, namely: keeping the visual design; defining dimensions of the planetary boundaries for which threshold values can be defined; generating results that are relevant to policymaking in the specific national context; and taking sub-national variability into account.

For her research, Cole interviewed several experts in South Africa. When

it came to the operationalization, she changed the original concept, replacing some dimensions with related but different dimensions, for example, replacing „aerosol loading" with „air pollution".

Regarding threshold values, Cole found that for all dimensions there were already limits defined by the national government or administration, for example, in national development plans. These limits were used. At the sub-national level, Cole produced nine figures of the operationalized planetary boundaries concept. Furthermore, she calculated trends for each dimension at the national and sub-national level.

According to Cole, the main achievements of her operationalization of the planetary boundaries concept for South Africa were as follows: to bring different environmental issues together in a single illustration; to bring stakeholders and experts from different environmental fields together at one table; to enable comparison of the achievements of different provinces; and to identify policy priorities.

One lesson learned from her work was that it was very important to account for narratives (including context-dependent narratives) when planetary boundaries are operationalized at the national level. Defining planetary boundaries and their limits provides new meaning to the reporting of sustainability indicators, because some benchmark exists in this context. Assessing trends over time is also useful for determining the current status, and sub-national operationalization can be helpful for identifying priorities at a sub-national level. To nest operationalizations of the planetary boundaries concept at

the national level in the global context, regional and global cooperation is required. For example, the SDGs could be useful in bringing planetary boundaries into national policymaking by integrating them into the national development plan.

In the subsequent debate, Cole explained that a top-down approach that uses global limits for planetary boundaries and distributes the global budget to individual countries according to the „equal share" principle results in completely different numbers for the limits of planetary boundaries for South Africa. From her point of view, operationalizations of planetary boundaries at a national level cannot be done without accounting for social issues, such as poverty.

John Dearing presented the results of a number of case studies in China and India. These case studies reflected a bottom-up approach, focusing on social and ecological systems at the local and regional scale, and investigating the sub-global dynamics of these systems.

Some of the key insights from the work were that time-series analysis is useful for defining boundaries, and that boundaries at the local level can be defined by transitions from one state to another with different mean values for state variables, or by comparisons of inter-temporal variability. Dearing argued that proxy data such as lake sediments can be useful to put current and future developments in their historic perspective, and to define sustainable limits (such as the maximum sustainable yield of an ecosystem). Also, Monte-Carlo simulations could be useful for studying the dynamics of social-ecological systems, assessing future management strategies, and studying the local environment of the planetary boundaries limit. This may make it possible to choose strategies that are not the „safest of the safe" but the „riskiest of the safe".

In the subsequent discussion, it was pointed out that all three of the approaches presented were complementary: knowledge about local dynamics is needed, national strategies and policies are needed, and global boundaries need to be respected. However, this can pose a challenge for communicating the planetary boundaries concept – for example, if several operationalizations exist in parallel. Some participants said that what can be helpful here is to focus on the relevance of the concept, not the underlying methodology.

Participants agreed that one of the key merits of the planetary boundaries concept is that it highlights the need for action and provides a global narrative. This can support effective global governance. However, the limits are more of a signal and cannot be used to allocate emissions.

In the national context, especially in developing countries, planetary boundaries do not have many sympathizers. To reach this audience, participants said that it would be useful to define global goals, set a common vision, and use the concept as a communication and advocacy tool.

The operationalization of the planetary boundaries concept in different national contexts also differs because of the different objectives, according to Cole. During Cole's research in South Africa, the National Development Plan was at the center of all related policy activities. The discussions all focused on social issues. The same challenge arises when the planetary boundaries concept is used in local contexts. Here, a key issue is that some environmental issues – noise, for example – are excluded. This implies that the planetary boundaries concept cannot be used as a substitute for existing concepts in all fields of environmental policy.

4.4.4 Planetary boundaries for SMEs: Starting points and added value

Chaired by Prof. Dr. Markus Große Ophoff, Director of Environmental Communications at the German Federal Environmental Foundation, Workshop 4 assessed the implications of the planetary boundaries concept for small and medium-sized enterprises (SMEs). Different perspectives on this topic were provided by Daniel Weiss (Senior Project Manager at Adelphi), Dr. Thomas Maier-Eschenlohr (Managing Director and Founder

of Landpack) and Donald Müller-Judex (Managing Director and Founder of Solmove).

The workshop commenced with Daniel Weiss highlighting three leading questions for SMEs in relation to planetary boundaries, namely: How can SMEs use the planetary boundary concept? What are the main areas of action and next steps? And how it is possible to disseminate the concept to SMEs? These questions served to frame the direction of the workshop.

Dr. Thomas Maier-Eschenlohr introduced the work of Landpack. The goal of Landpack is to make the international packaging and shipping market eco-friendly by substituting Styrofoam with an alternative – straw – that can be used for insulation packaging. From an industry perspective, Maier-Eschenlohr noted that the planetary boundaries concept serves as a useful scientific foundation for building consumer trust. In business terms, it is vital for communicating the company's aims and, importantly, differentiating the company from its competitors, especially where there are claims of greenwashing. The planetary boundaries concept has to be made visible, however, and needs to be communicated and understood by both employees and consumers.

Donald-Müller Judex introduced the company Solmove and its approach of putting solar panels on streets in order to generate electricity for households and industry. He pointed out that installing such panels implies using less land and potentially increasing income for communities, while producing energy for electric vehicles. This would reduce pressure on planetary boundaries.

The panelists agreed that the planetary boundaries concept serves as a stimulating concept to set against

existing business models at various levels of operation. However, questions were raised during the discussions as to how the planetary boundaries concept could be developed into a much broader concept in the future. In terms of environmental management and reporting, the audience asked how the concept could be integrated into this framework, and, in particular, which planetary boundaries were of most relevance for SMEs.

The panelists agreed that different business target groups should be included, ranging from SMEs to even smaller scale crafts and tradesmen. They argued that this is a factor currently missing from the discussion. In terms of communication, the planetary boundaries concept should be disseminated through a variety of platforms, thus scaling the concept over time and creating new networks. Some audience participants questioned whether all SMEs, especially the smaller ones, had the capacity to use the planetary boundaries concept to its fullest extent. Supply chains also exist as an important factor, and there was doubt as to how internationalized SMEs were with this topic – that is, how SMEs can stay up to date with current trends and new sustainability concepts.

In general the panelists agreed that trading sustainably was a key topic, but an important step toward this goal was to create a receptive culture and society which understands why this is the preferred mode of business.

Dr. Maier-Eschenlohr noted that it would be a positive step forward if the larger online retailers such as Amazon put greater emphasis on sustainable packaging in their delivery operations, as this would raise consumer awareness.

4.4.5 Implications of the planetary boundaries concept for new models of wealth

Workshop 5 was chaired by Hans Diefenbacher (FEST/Universität Heidelberg). There was input from Joachim Spangenberg (Sustainable Europe Research Institute SERI), Kate Raworth (Oxford University) and Diefenbacher. The workshop focused on how the planetary boundaries concept could inform new models of wealth and the discourse on wellbeing, what implications the concept has for de-growth, eco-sufficiency and an inclusive green economy, and which barriers exist when using the concept for new models of wealth.

Kate Raworth presented her views on the necessity of a new economic model for the twenty-first century – the „doughnut economy". She argued for a new model as this would be a necessary step to change the existing reality, which is in her eyes very much centered around growth. By contrast, the doughnut economy – a concept she herself developed – includes both an inner ring (critical human deprivations such as hunger and illiteracy) and an outer ring (the ecological ceiling, where planetary degradation such climate change and biodiversity loss are situated). In between the rings lies the doughnut, the space in which we can meet the needs of all within the means of the planet.

Raworth presented core ideas from her recent publication „Seven ways to think like a 21st-century economist." These are changing economic goals from the GDP to the doughnut, changing societal assumptions from a perspective of self-contained markets to embedded economy, moving from a perspective of „rational economic man" to social adaptable humans, transition from mechanic equilibrium assumptions to dynamic complexity, taking on distribution from the very beginning when designing economies, creating products that contribute to the circular economy, and focusing on „thriving" without growing.

Spangenberg began his input by stating that wealth is not a model. Rather, wealth is a stock of goods that is owned, and „standard of living" is access to a flow of goods and services. In the twenty-first century, sharing qualities (networking) is central, not increasing wealth in a different fashion. He also talked about the notion of „social capital", which he understands as „all the networks and connections" that individuals have in society. This would mean that organized crime is an important element of social capital in any society, making the concept deeply problematic. But withdrawing these instances as

„negative capital" would not work because the notion of capital does not allow for „negative capital". Spangenberg gave the example of invasive species (which are often perceived as negative from an ecological perspective) which add to natural capital and do not subtract from it. Hence, the concept of social capital should be avoided. Focusing on the environmental Kuznet curve, Spangenberg highlighted the onset of the concept prior to the 1992 Rio Conference, in the midst of a discussion on reducing pressures. Economists were arguing at that time that the best way to reduce pressures is through economic growth. Thus, economics functioned as a sort of „legitimizing science" for political interests. Spangenberg also spoke about demographics and the perception that population growth is not talked about. Looking at current projections, he pointed out that by 2050 there will be a 20 percent increase in population size, but also a 400 percent increase in GDP. Therefore, in his opinion, GDP is the most important driver for environmental pressures.

Spangenberg developed the notion of „environmental space". The concept holds that life cannot be sustainable if it is either in „environmental overshoot" or „social undersupply". He argued that planetary boundaries specify the „upper limit" of the space, and the social side of the doughnut specify the lower level. He explained what he means by „economy" in his analysis, namely the physical economy, that is, resource flows and energy consumption (not financial economy or the real economy of production). Taking the DPSIR model as a starting point, it is especially important to change the governance structure (the response side) to induce more sustainable behavior. Planetary boundaries refer to the state and impact dimension of the DPSIR model, but they do not refer

to the driving forces and pressures, nor to the institutional setting (similarly to the SDGs). Hence, planetary boundaries should be complemented with other elements. Directly responding to planetary boundaries (state or impact) does not solve the problem: for impacts, a policy choice would be to adapt, and for state, to restore. Both are helpful, for example, when safeguarding species. But adapting or restoring will not reduce pressures. Mitigation requires addressing the pressures, and prevention needs to address the driving forces.

To respect the planetary boundaries, Spangenberg argued that the physical economy would need to shrink. Relative decoupling („green growth") is an unsustainable pathway, like the „Green New Deal". Only absolute de-growth or a steady-state economy would be potentially sustainable. This task would be very challenging, building on the assumed energy and material consumption of hunter-gatherer societies and agrarian societies. To be sustainable, societies would need to move back to the energy and material consumption of somewhere between agrarian and industrial societies. Efficiency, a circular economy and renewable resources offer an estimated reduction by a factor of four to five, however this is the same amount as what three percent growth would eliminate within 50 years (efficiency achievements would be compensated when following the three percent growth paradigm). Economic growth cannot, therefore, go on forever. Using the example of reducing biodiversity pressures, changing course would also imply addressing the primary drivers (for example, interventions), secondary drivers (policies, governance, economy) and tertiary drivers (structures of society, ideologies). Focusing on household consumption, Spangenberg argued that the fields of „nutrition", „construction/housing" and „transportation/mobility" are those where households can make an environmental difference and have some influence. He argued that sustainability would require convergent development, giving everyone a fair share of the environmental space.

The discussion of Spangenberg's input focused on the demographics question. Some participants argued that demographics are often not talked about. Yet they matter because the number of people who would have a right to a fair share would increase. As a counterargument, Spangenberg pointed out that while demographics matter, understanding what prosperity means matters even more. However, „going virtual" would not be a real alternative to the current economy as it would imply very high energy consumption. The current discourse on progress (self-driving cars, the Internet of Things, and so on) is completely delinked from the social dimension (North-South) and from the resource limitation dimension that we would need to take into account. Asked about the technological side of de-coupling, Spangenberg argued that, in some fields, technologies exist to bring the economy close to being below the boundary, but not in other fields. Hence, it would be necessary to change consumption behavior for these fields; investments would need to focus on sustainable consumption.

Hans Diefenbacher looked at the implications of planetary boundaries for „new models of wealth". Diefenbacher argued that planetary boundaries serve as a new concept of strong sustainability, fighting projections of a „false harmony" between ecology and economy. The concept hence puts ecology in the center. The planetary ecosystem is the foundation for the social and economic sphere. To measure wealth, welfare and wellbeing, a complement to the GDP would be necessary. Looking at GDP alone would mean leaving out the consequences for the economy. For Diefenbacher, the concept of GDP is not a measure of welfare or wealth. In particular, GDP leaves out resource depletion and consumption of natural capital, environmental damage (reparation, adaptation, mitigation), future costs for present inaction, immaterial damage to nature and landscape, unequal income distribution, the value of housework and voluntary work, and public debts. The GDP in essence only looks at flows, not at stocks (wealth/welfare/wellbeing). When looking at the process of revising GDP, Diefenbacher stated that weapons are now defined as investment, not state consumption in Germany. The last five revisions of GDP in Germany each time resulted in an increase in GDP by

changing the methods of calculation. This is also related to the fact that, in the EU, GDP growth is defined as a reference point in the Maastricht criteria.

Diefenbacher also showed that a variety of efforts exist to measure new models of wealth. These efforts involve including additional indicators and/or indicator systems, creating composite indicators such as the Human Development Index or the Gross National Happiness Product, and creating new accounting systems such as the National Welfare Index (NWI). The NWI is constructed on the basis of different principles: weighing private consumption with income distribution; adding welfare-creating components not included in GDP, for example, housework and voluntary work; adding/deducting adjustments due to the temporal divergence of expenses and benefits; and deducting welfare-reducing components such as environmental impacts, traffic accidents, and the consumption of non-renewable resources. Comparing the German NWI with German GDP, Diefenbacher showed that the NWI went down or stagnated after the year 2000, while GDP increased, a consequence of highly unequal income distribution. During the economic crisis, GDP went down, but NWI was unaffected. Diefenbacher detailed some prospects for the NWI. From his perspective, it can complement the German sustainability indicators. International comparisons would also be beneficial. He concluded that the welfare of nations, not economic growth, is the better target for the economy. In the context of sustainable development, planetary boundaries are the relevant guidelines for strong sustainability. De-growth is not important, but presumably inevitable under the current GDP paradigm; when switching to a new measure-

ment system, de-growth would not be relevant. Green growth is inevitable, but sufficiency is at least as important. Translating the concept of planetary boundaries into new models of wealth is difficult.

The discussion of Diefenbacher's presentation focused on a number of areas: inter-temporal effects that are not included in the NWI; international effects that could be integrated if there were sufficient data; the decrease in the NWI after 2000 and the increase in 2014, which could be explained by the move toward renewable energies; and the increase in private consumption and happiness, which was not included as a dimension because, according to Diefenbacher, it is too subjective.

The overall discussion focused on whether governments can test new models such as the NWI in a safe environment. It was pointed out that governments are very often forced to oppose resource consumption limits, while secretly asking precisely for such limits. It was also underlined that a sustainability transformation would offer more benefits than costs. Politically, what is needed is forerunners who can demonstrate the economic opportunities of transformation and encourage the „laggards" to follow them.

4.4.6 Public understanding of planetary boundaries: Experience and challenges for communicators and educators

Workshop 6 was led by Kai Niebert, Professor of Science and Sustainability Education at the Anthropocene Learning Lab at the University of Zurich, and Sofia Getzin, a PhD candidate working on incorporating the concepts of planetary boundaries and de-growth into education. The workshop focused on how the planetary boundaries concept can be communicated and implemented in formal and informal educational settings. It aimed to identify areas of action for further improving the concept's reach.

Reinhold Leinfelder (Freie Universität Berlin) shared four key insights from his work on developing the comic books „The Great Transformation" and „Anthropocene Kitchen". First, he said it was important to encourage rather than threaten people when speaking about the future. He underlined that people were more likely to act on messages that were framed in a positive way – those that emphasized the „desirabilities" of climate change action (for example, improving social justice or health) rather than the negative possibilities (for example, rising sea levels, biodiversity loss). Second, and most importantly, he pointed out that relating scientific findings to everyday situations was a useful way of helping people to understand complex topics without oversimplifying them. In this context, he showed several cartoon images related to the topic of food. He also argued that it was important to support the understanding that multiple futures were possible, and to develop open, creative spaces where these futures could be discussed and negotiated, and where experimentation was possible.

Jose Alcaraz showed a wide variety of images from videos created by his MBA students on the topic of planetary boundaries. The ten-minute videos were produced for one of the main assignments of the degree program, and represented a form of creative and interactive learning that encouraged students to engage as non-experts with other non-experts.

Antje Brock (Freie Universität Berlin) shared some insights from her work on how the social sciences can play an important and empowering role in shaping the response to seemingly overwhelming tasks, such as tackling climate change. She spoke about how education on planetary boundaries should not only focus on scientific content but also aim to develop learners' „shaping competencies" (Gestaltungskompetenzen), such as the ability to work with other disciplines, to act ethically, to handle incomplete or complex information, to deal with conflict, to reflect on individual and cultural models, and to self-motivate and motivate others. She also noted that a deep, interdisciplinary approach was required, and when considering how and where to best leverage knowledge and skills, it was import-

ant to consider how responsibility for the nine planetary boundaries related to different spheres of influence and scales for action (from individuals to large organizations).

Kai Niebert highlighted the finding that that there was either no correlation or a negative correlation between pro-environmental attitudes and pro-environmental behavior. In light of this he asked whether the goal of education on planetary boundaries should really be to encourage pro-environmental attitudes. Instead, he suggested that the goal should be to enable schoolchildren and students to engage in political decision-making on sustainable development. He then went on to argue, based on the work of educational scientist John Hattie, that the most effective way of improving education on sustainable education was to better train teachers and provide them with better materials for communicating these topics. He said that his team had carried out an analysis of science curricula in the United States and Germany, and found that many cross-cutting topics, such as energy, could be connected to both science and society.

The participants then split into groups to discuss the presenters' statements further. Important themes from the discussions included:

- The need to create deep learning experiences that transformed knowledge, skills and emotions. This group discussed how interactive teaching methods and the use of images and examples related to everyday life could help engage learners and make them feel personally connected to an issue and therefore more passionate about it. One partici-

pant mentioned that this was also important for educators as they would be able to more effectively communicate the importance of a topic if they could identify with it

- The importance of educators and communicators appearing credible and authentic. It was mentioned that children and adolescents, as well as artists, could have an impact on political debates as they were unlikely to be seen to have a hidden agenda. In this context one participant mentioned the importance of museums and galleries as neutral spaces where people could approach and reflect on topics related to planetary boundaries

- The importance of cultural knowledge alongside scientific knowledge. It was noted that cultural awareness was often crucial for communicating effectively, and particularly when seeking to engage with groups and individuals in the Global South. Being culturally aware could lead to more equitable exchanges and greater mutual understanding

- The need to enable learners to engage in political debates on sustainability. Many of the actions that need to be taken to stay within the planetary boundaries have to be taken collectively rather than individually. It is therefore important that education on sustainable development allows people to participate in political debates on related issues, and to be able to distinguish between more and less effective actions

- The challenge of communicating clearly without reducing complexity. It was noted that educators could use real-life examples to illustrate how different processes and issues were interconnected, and that there were often no silver-bullet solutions

4.4.7 Planetary boundaries: Interpretations, metrics and quantification for regional applications

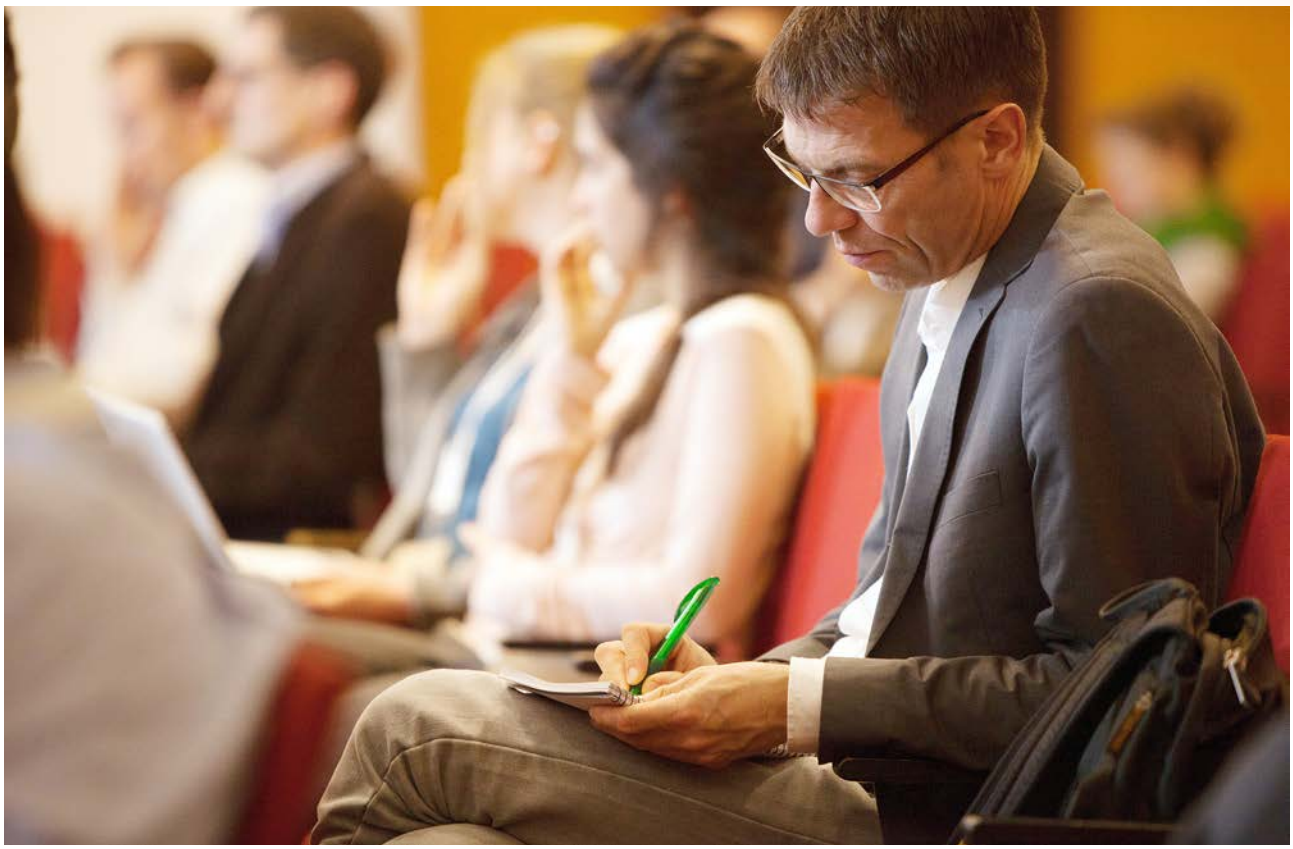
Workshop 7 was introduced by Dieter Gerten. Participants included Ingo Fetzer (SRC), Benjamin Bodirsky (PIK), Georgina Mace (UCL) and Michael McLachlan (Stockholm University).

The objective of the workshop was framed as follows: to revisit the Earth-systemic foundation of the planetary boundaries concept, in particular the current situation for selected planetary boundaries; to identify challenges and gaps; and to discuss improvements as preconditions for the further operationalization and co-development of planetary boundaries. Dieter Gerten drew attention to the fact that the conceptualization and quantification of some planetary boundaries is still ongoing, especially regarding the stringency of control variables, the planetary dimension of underlying regional processes, the nature and scale of impacts in the case of planetary boundary transgression, and planetary boundary interactions and the resulting Earth-system dynamics.

Gerten then discussed the planetary boundary for human freshwater use and ways to improve its quantification. Within Rockström et al.'s initial conceptualization (Rockström et al. 2009), a water-use boundary was set in order to safely sustain enough water flows for maintaining aquatic ecosystems, terrestrial ecosystem functioning and services (C sequestration, biomass growth, food production, biodiversity) and moisture feedback (to regenerate precipitation). Gerten stated that close interactions between land and the diverse water fluxes make it difficult to define an appropriate planetary boundary. A first attempt to define a boundary was made with runoff depletion („blue" water consumption) as a proxy (control variable) for capturing the full complexity. In the original calculation, global discharge (maximum available freshwater) was set at 40,700 km3 yr-1. From this value, inaccessible flow (69 percent) was subtracted, arriving at 12,500 km3 yr-1, as well as environmental flow requirements (9 percent) and volumes to avoid water stress (9 percent), ending at a value of 5,000 km3 yr-1. The lower end of the uncertainty range was set at ±1,000 km3 yr-1 and hence the planetary boundary at 4,000 km3 yr-1. In a follow-up article,

Gerten et al. employed a bottom-up calculation based on spatially detailed estimation of environmental flow requirements, using five estimation methods with a global process model (LPJmL) to cover the scientific uncertainty range (Gerten et al. 2013). The researchers concluded that the freshwater planetary boundary may indeed be lower than the original planetary boundary, at 1,100–4,500 km3 yr–1 (average 2,800 km3 yr–1). They found that the regional boundaries have been crossed in many places. Gerten argued that the next steps for quantifying the water boundary would be as follows: to integrate further aspects of human interference with the global water system (terrestrial ecosystem water needs, moisture feedbacks, freshwater influx to deltas and seas, and so on); to incorporate spatial patterns of the transgression of local boundaries; to quantify the cumulative or cascading impacts of local interferences; and to refine the control variable, accounting for interactions with other planetary boundaries.

Ingo Fetzer presented the current definition of the planetary boundary for land-system change. This is based on the extent of original (potential) forest cover that should be preserved per continent and forest biome. The planetary boundary for tropical and boreal forests is set at 50 percent, and for temperate forests at least 30 percent. These values have already been transgressed for some biomes due to forest conversion to croplands, pastures and cities, as presented in Steffen et al. 2015. After discussing the current situation and the criteria chosen to define the planetary boundary, Fetzer presented the results of an unpublished study (a Master's thesis conducted at PIK by C. Werner). This explored a new, multi-criterial approach to defining a planetary boundary for land-system change. The



new index comprises seven indicators of land-system change at regional and global levels, which, if analyzed altogether, provide information on the severity of interference by humans on several aspects, not only on the areal forest extent. This then also allows for the identification of regional hotspots, that is to say, where different indicators are transgressed concurrently, as shown on a map. This new approach also provides more options for operationalization policies, as some hotspots are easier to relate to policy processes than forest areas.

In the discussion it was pointed out, among other things, that the current status of the planetary boundary, if computed as in the original approach, may deviate considerably from the assessment in Steffen et al. 2015 if different land-use datasets are used. It was also more generally discussed why the focus is only on forests, given that the loss of shrub lands is also important, for example. The main argument for forests is that they are: (a) quite biodiversity-rich compared to other terrestrial systems, and even more significantly (b) fulfill important climate functions. This led to a short discussion of interactions between planetary boundaries and ways to define them anew, explicitly considering such interactions (such as how the water planetary boundary interacts with climate and land use, for example).

Benjamin Bodirsky spoke on the nitrogen boundary. He focused on two points: the current state and future projections for the global nitrogen cycle, and a critique on the current indicator for the nitrogen boundary. He argued that the central problem for understanding the global nitrogen cycle is that not enough data is available; at the moment nitrogen only appears within fertilizer statistics. In order to remedy this problem, he and his colleagues created an open-source global inventory to estimate the major flows of nitrogen from 1965 to the present day. Bodirsky detailed the findings of the unpublished paper, explaining the global nitrogen cycle and human interference, and highlighting where the proteins in our food come from – about one-third from animal products and two-thirds from plants. In their unpublished research, Bodirsky et al. create a nutrient budget for croplands, pastures and non-agricultural lands, analyzing how plants get their nutrients and examining major flows (fertilization and biological fixation, but also soil depletion). One of their major findings is that nitrogen flows have increased over time, not only on croplands/pasture but also on non-agricultural land, because nitrogen gets re-deposited through air. In the 1960s the magnitude of nitrogen fixation was roughly twice as high as original terrestrial fixation, while it is now five times higher. However, there are still options for mitigating nitrogen-related environmental impacts, such as changing our food diet, minimizing food waste and implementing more efficient fertilization in order to move closer to the boundary.

Bodirsky then criticized the current indicator for the nitrogen boundary. His first point was that non-agricultural sources of nitrogen emissions are currently excluded in the indicator used as a control variable for the planetary boundary. The boundary could be improved by taking into account nitrogen emitted through industry and mobility, too. Furthermore, the depletion of soils should be included in the indicator. Second, Bodirsky pointed out that other boundaries should be considered when estimating the boundary for nitrogen, as the impacts of nitrogen are captured by other boundaries – the global cooling effect through nitrogen-related pollution and global warming effect are captured by the climate boundary, and the ozone depletion and biodiversity loss boundaries also relate to nitrogen emissions. Third, he pointed out that the current boundary is exceeded by design, as the current conceptualization includes both a threshold for nitrogen and the assumption that we should not pollute more than current values (due to the precautionary principle). Even if current nitrogen emissions are very low, there is no possibility of increasing nitrogen emissions and staying within the nitrogen boundary. Improvements could focus on increasing flexibility, local conditions and other boundaries.

Georgina Mace focused on biosphere integrity and associated metrics and quantification. She started out by characterizing the original biodiversity boundary as conceptualized in Rockström et al. (2009). In Rockström

et al. (2009) the control variable for biodiversity loss is the extinction rate, measured as extinctions per million species per year (E/MSY). The boundary is set at <10 E/MSY. According to Mace, the rationale for this definition centered on the functional importance of diversity, building on biodiversity science, which shows that when diversity increases, ecosystem functions also increase. However, the conceptualization has been criticized as the diversity argument is built on field experiments and so is difficult to translate to a global scale. In particular, criticism has centered on the following: (1) Using extinction rates measured at global scale; (2) focusing on species richness („counting the number of species") and not on composition, and (3) leaving out the long-term impacts of diversity, in particular genetic impacts. Instead, Mace et al. (2014) suggest focusing on the „genetic library of life", „functional type diversity" and „biome condition" as alternative approaches. The 2015 update by Steffen et al. includes the „Biodiversity Intactness Index" in addition to the genetic diversity measure (extinction rate; E/MSY). Finally, Mace outlined next steps. These included focusing research on the as yet unquantified functional diversity boundary (Mace 2014), furthering research interactions between boundaries, identifying thresholds/ non-linear changes for biodiversity change, and refining local, regional biodiversity metrics for biodiversity.

Michael McLachlan focused on the „novel entities" boundary. He pointed out that, in contrast to other planetary boundaries, novel entities are a placeholder for pollution-related planetary boundary problems that we are currently ignorant about. The novel entities boundary is therefore by definition very difficult to quantify. In the original journal article by Rockström et al.,

the chemical pollution boundary (as it was framed) was classified as „not yet quantified". In the 2015 update, the planetary boundary was re-conceptualized as the „novel entities" boundary. The 2009 definition covers „chemicals and other new types of engineered materials or organisms [...] not previously known to the Earth System, as well as naturally occurring elements mobilized by anthropogenic activities." However, McLachlan pointed out that other planetary boundaries already fit this definition, such as climate change (CO_2, CH_4 and others), ocean acidification (CO_2), nitrogen and phosphorus cycles, and stratospheric ozone depletion (halocarbons). It is therefore still necessary to develop a planetary boundary for novel entities, as past experience and intuition tells us that there will be more planetary boundary problems than we are currently unaware of. Of course, as we are not yet aware of what these problems will be, we cannot quantify them. The challenge therefore lies in confronting our ignorance and prioritizing planetary boundary issues that could seriously threaten the planet – in other words, „planetary boundary threats".

McLachlan then set out to define what is meant by „planetary boundary threats". A planetary boundary threat exists when societies are ignorant of the existence of a boundary and humanity cannot easily „un-cross" the boundary. There are then three conditions for a „novel entity threat", according to McLachlan: (1) The novel entity has a disruptive effect on a vital Earth-system process; (2) the disruptive effect is not discovered until it is, or inevitably will become, a problem at a planetary scale; (3) the effect of the novel entity cannot be readily reversed. The next steps for the novel entities boundary include proactively identifying and managing planetary boundary threats, monitoring and studying vital Earth-system processes, and avoiding creating new planetary boundary problems when dealing with known planetary boundaries concerns.

The general workshop discussion focused mainly on the following areas: regional differences in freshwater supply; the reasons for not integrating freshwater scarcity (as the planetary boundary is concerned with the environmental situation to be preserved, not the status relative to that); and the reasons for basing the freshwater planetary boundary on watersheds and not rivers (as it is not easy to aggregate and scale it up, various scales should be considered and/or the appropriate scale found). It was also discussed whether marine biodiversity should be covered in the biosphere integrity planetary boundary; freshwater biodiversity could also be considered in the water planetary boundary, as per their environmental flow requirements.

The next steps for quantification are as follows: a systematic analysis of planetary boundary transgressions, including better constraining the planetary boundary position, uncertainty zone and cross-scale effects; improving the definition of control variables (at appropriate scales); and integrating the spatial pattern of the impact of transgression and analyzing the Earth system as a whole (planetary boundary interactions). The operationalization should focus on developing local/global calculation schemes for policy purposes and the business world, trans-disciplinary co-creation/co-development of planetary boundaries, assessing the status of planetary boundaries, examining trends and potential future trajectories, and defining societies' options for remaining within planetary boundaries.

4.4.8 Systemic views on planetary boundaries: Interactions across boundaries, scales and SDGs

Holger Hoff introduced Workshop 8. The participants were Detlef van Vuuren (PBL), Sander van der Leeuw (Santa Fe Institute), Guido Schmidt-Traub, (SDSN network) and Falk Schmidt (IASS, National/German SDG Science Platform).

The workshop focused on the role that planetary boundaries and related opportunities within the safe operating space play for integrated SDG implementation, helping to operationalize their universality principle. **Holger Hoff** highlighted that the (downscaled) planetary boundaries can serve as benchmarks for national performance and inform vertical (global/regional/national), horizontal

(cross-sectoral) and temporal (short and long term) policy coherence.

He quoted the 2030 Agenda, according to which the national implementation of the SDGs should account for „global ambitions". The planetary boundaries provide a framework that determines these global (environmental) ambitions. The new German National Sustainability Strategy refers to these global ambitions by requesting SDG implementation in, by and with Germany. However, Hoff also highlighted that the synergies between the environmental and development goals of the SDGs are not yet clear and would benefit from further discussion.

Detlef van Vuuren focused on the integration of planetary boundaries and SDGs. He argued that it would be important to use a backcasting method after determining the desired end point, and then develop possible pathways to get there. It would then be central to have multiple stories or pathways for reaching the end point. For example, while implementing SDG 15 (biodiversity) we want to achieve SDG 2 (zero hunger). One pathway for this would be to produce 60 percent more food, which in turn would require 60 percent more land or an increase in yield, and as a consequence increased nitrification from additional fertilizer use, which in turn would have an impact on SDG 13 (climate action). Alternatively, a dietary change solution would improve SDG 3 (good health and wellbeing) without the tradeoffs contained in the first option. Integrated assessment models are a good way to force one to be explicit about different strategies and describe different scales and relationships, thus developing different pathways such as lifestyle change, decentralized

solutions and global technologies.

The „World in 2050" (TWI 2050) project is a large, multi-institute project that aims to look at the implementation of the 2030 Agenda, and in particular the synergies and tradeoffs between different goals. One principle is to use the planetary boundaries for 2050 and, through the backcasting exercise, to look at pathways for staying within the safe operating space that the planetary boundaries delimit, while reaching the SDGs in 2030. The question is, who besides the modelers should be involved in the design of these pathways?

Sander van der Leeuw focused on social boundaries. Society decides what it thinks the problem is, and society defines the solutions. The SDGs address these societal challenges. However, linear extrapolations will not do justice to the complexity of these dynamics: We need to bring social and environmental planetary dynamics together.

Van der Leeuw further argued that demography is the elephant in the room in the debates. The second major unspoken planetary boundary is the ICT revolution. Information acceleration has hardly been explored from a sustainability perspective. There is a revolution in ICT every five years, while our society needs fifteen years to integrate it. The lack of shared opinions limits the societal boundary; the distinction between a „signal" and what is „noise" on the global scale leaves our society at a loss as to know where to go, and if we should go there. The data volume doubles every 12 months and society will be overtaken by the information revolution possibly through artificial intelligence and automation, which may leave 40 percent of the world population unemployed.

Van der Leeuw also touched on the issue of globalization, pointing out that most societies have a very complex sense of wellbeing. When we globalize, we often go for the lowest common denominator. As a result, we „level" internationally what it means to be happy. Furthermore, political parties are starting to disappear. We need to reassess the stability of our societies and what leads to the disintegration of our communities. For example, Greece is surviving its current situation because families can rely on each other there.

Guido Schmidt-Traub spoke about top-down, bottom-up, long-term and short-term sustainability criteria. Planetary boundaries are extremely useful for framing SDGs, and the SDSN supports the interlinkages between the two through backcasting and developing pathways. This approach has several difficulties, however: the dynamics of the appropriation of models (your model versus my model), the problem of granularity (the details of national assessments), and the definition of system boundaries. Understanding what the (downscaled) planetary boundaries mean at the country level is critical for setting innovative challenges and identifying solution pathways. The need for sustainability transitions is well recognized, but the operationalization is still unknown, in particular, the translation of long-term frameworks into short-term policies. Spatial approaches can also use backcasting, in particular the urban space.

Falk Schmid introduced the SDG science platform hosted by IASS, which will be launched in May 2017. The aim is to align sustainability science with sustainability policy. A key challenge is to fully integrate planetary boundaries and the SDGs in a system. This integration requires nexus governance. For example, water was an MDG and is now implicitly integrated into several SDGs, such as the one on natural resources. Hence, its implementation from a nexus governance perspective would require action in several SDGs. Another difficulty is collaborating with other countries to assess the impact of domestic consumption patterns on resource use abroad, and understanding if the impact of resource governance is positive (for example, renewable energy) or negative (for example, virtual water or trade agreements). Improving domestic resource management does not automatically improve the global management of the resource in question; science should provide alternative scenarios, argues Schmid. This could come in the form of a „pledge and review" system.

4.4.9 Planetary boundaries for sustainability and environmental strategies

Workshop 9 focused on sustainability and environmental strategies, and the potential contribution of the planetary boundaries concept for such strategies. It built on past experiences, discussing lessons learned and identifying further ways to include the concept in environmental and sustainability strategies. It also reflected on the lessons learned from the guardrail concept and how these can inform the discussion on planetary boundaries and sustainability strategies. The workshop was chaired by Professor Harald Heinrichs (Leuphana Universität Lüneburg). Participants included Astrid Schulz (German Advisory Council on Global Change, WGBU), Annika Lindblom (Secretary General of the Finnish National Commission on Sustainable Development), Michael Frein (Rhineland-Palatinate Ministry of Economy, Traffic, Agriculture and Viniculture) and Elena Montani (European Commission and DG Environment).

Harald Heinrichs introduced the workshop by reflecting on how the debate about the relationship between planetary boundaries and policymaking has been going on for almost 200 years now, if one considers great thinkers such as Malthus, Marx and Mill in the eighteenth and nineteenth centuries and Meadows in the twentieth century. Moreover, approaches such as „ecospace", „guardrails" or „ecological footprint" can be seen as attempts to make scientific insights into the limits of natural, life-supporting systems policy-relevant. Heinrich stated that scientific knowledge on planetary boundaries has improved significantly over the past decades; yet, the question remains as to whether, finally, our knowledge is sufficiently detailed and

certain to guide concrete policymaking. He then invited the four speakers to present their sustainability strategies and how they had incorporated the planetary boundary concept.

Astrid Schulz began by briefly introducing the WGBU's work in advising the German government on how to address long-term global trends. She noted that, as it was difficult to define what is sustainable, the WGBU had opted to define what was not sustainable and what developments should be avoided in order to protect planetary support systems. Beginning in 1995, the WGBU had thus gradually developed and refined the concept of ecological „guardrails". These were intended as broad, normative guidelines for delimiting dangerous human interference in the environment and informing the political and public debate on environmental and social issues. For example, in 2014 the WGBU produced a report with recommendations for global institutions for incorporating the planetary guardrails concept into the SDGs.

Schulz continued that targets and timelines were important for effective policymaking. As many of the forces that the team identified as driving environmental destruction had a cumulative effect, they concluded that the aim had to be to reduce these drivers to zero, so as to never exceed the planetary guardrails they had defined. As the guardrails were global, the targets had to apply universally, too, so all countries would eventually need to reduce these driving forces to zero. Furthermore, setting the targets at zero has the advantage that it is much easier to track progress toward them.

Naturally, this still left the questions of when these drivers should be reduced to zero, how best to achieve them, and how to set national targets. The WGBU proposed strong international governance structures to enforce a planetary budget and national quotas. However, Schulz recognized that rigorous enforcement was politically unfeasible. She noted that while all countries had the common responsibility to reduce the drivers of environmental destruction to zero, there should be differentiated responsibility in terms of who should pay for mitigation and adaptation measures.

Annika Lindblom also began by introducing her organization. The Finnish National Commission is led by the Prime Minister of Finland, but comprises a broad range of stakeholders so as to reflect the various needs and interests across Finnish society.

Lindblom remarked that the „doughnut economics" concept had been inspirational in Finland. By showing the complexity of sustainable development, it had expanded the debate beyond climate change and led to more emphasis on the social, economic and global dimensions in their strategic thinking and planning. She said that this had also shaped Finland's understanding of the 2030 Agenda and the 17 SDGs. The Commission's latest strategy – „Society's Commitment to Sustainable Development" – integrates the 2030 Agenda and SDGs, as well as the planetary boundary concept, into eight overarching goals for achieving „a prosperous Finland living within the limits of the carrying capacity of nature". The strategy also includes policy principles such as long-term action and transformation, policy coherence, global partnership, and ownership and participation. Lindblom remarked that this integrated, transformative approach had already been more successful than previous SD strategies in inspiring business and civil society into action.

She emphasized that the Finnish model was to be as inclusive as possible, so as to build mutual trust. The latest sustainable development strategy was negotiated and drafted by all members of the Commission, which includes representatives of government, business and civil society. The government was then responsible for planning and implementing the strategy. Furthermore, the government has created an online platform where companies, schools, NGOs, associations and other groups can register their own commitments for achieving the eight goals in the strategy and measure their progress against key indicators. She said that over 600 commitments had been made so far, and that they were generating positive feedback, with more and more groups hearing about the platform and registering commitments.

She summed up the core messages from Finland as follows:

- Work towards long-term goals and aim for policy coherence
- The process is as important as the product (societal learning)
- Demystify concepts by concretizing them to encourage ownership and action
- Ensure high-level leadership but do not politicize sustainable development (a „whole-of-government" approach)
- Partner in an open dialogue with civil society and other stakeholders (a „whole-of-society" approach)
- Invest in communication, visualization and operationalization to create common understanding and tools for action

Michael Frein spoke about the previous governments of Rhineland-Palatinate's work on sustainable development, as the new government was still developing its approach.

The state government had produced its first strategy in 2001 and was the only state in Germany to have fulfilled its obligation to update the strategy every two years. However, Frein remarked that while the strategies had often been outlined in lengthy documents, the actual content of the strategies had been very vague.

His own role had been to help define goals, set targets, outline priorities and core areas for action, and develop an overall vision and concept. First of all, this meant defining sustainability. He agreed with Astrid Schulz's assertion that it is hard to define, and echoed comments from the morning session that the sustainability triangle had often led to economic sustainability being prioritized over ecological and social sustainability.

The government of Rhineland-Palatinate opted to take the limitations aspect of the Brundtland definition of sustainable development as its starting point. The planetary boundaries concept was then brought in and had an „amplifying" effect. It

stressed the urgency of action on sustainable development, confirmed Rhineland-Palatinate's responsibility for global problems, reconfirmed the state's willingness to contribute to solutions, and reinforced the urgency of taking action in fields outside or at the margin of a safe operating space. It also had a focusing effect, showing that all goals could be linked to both planetary boundary and local environmental concerns. However, as foreign and development policy are federal competencies, the government of Rhineland-Palatinate recognized that the main area where it could act was public procurement.

Frein summed up his main conclusions as follows:

- Planetary boundaries are most useful as an „amplifier", placing a clear focus on environmental limits and preventing sustainability from becoming a catch-all term
- The more the concept is used, the more compelling it becomes. During internal discussions within his state, it had been helpful to point out the concept's international resonance
- The concept would become more useful if it is possible to develop more exact figures for the boundaries for countries or sub-national regions. This did not necessarily have to take the form of a budget; it would also suffice to make it clear what kind of action was required in Germany or within a state to stay within the global safe operating space

Following his presentation, Frein answered two short questions. He said that twelve states in Germany have sustainability strategies, and two or three of those connect to the logic of the SDGs and the national strategy. He said that there was therefore much potential to improve action on sustainability at the state level. However, he noted that not all of the SDGs were relevant for German states, due to their lack of competency in development and foreign policy. His particular state had identified its own tasks and responsibilities for fulfilling the SDGs and had then focused on those.

Elena Montani gave the fourth and final presentation. She began by stating that DG Environment provides horizontal coherence and acts as an interface between the spheres of science and policy. Outlining the EU policy context, she noted that sustainable development was enshrined in the treaties (Article 3, TEU) and, in setting out the general guidelines for the current Commission, Jean-Claude Juncker had declared sustainable development „a lofty ambition, a long-range project, and an imperative daily concern." The European response to the 2030 Agenda and the SDGs was also set out in the Commission's communication „Next steps for a sustainable European future" from November 2016, and in the EU Global Strategy of June 2016, which includes several references to the planetary boundaries concept – for example, „a prosperous Union also hinges on an open and fair international economic system and sustainable access to the global commons." The influence of the planetary boundaries concept is also clear in the first line of the vision for the EU's 7th Environmental Action Programme, which states that „in 2050, we live well, within the planet's ecological limits."

Montani further explained that the policy priorities for DG Environment are the SDGs, the 2015 Circular Economy Action Plan, and the implementation of the EU's wide range of policies on water, marine habitats, air, chemicals, nature and biodiversity, and land-use. She said that improving „the knowledge and evidence base for EU environmental policy" was also a priority, in particular addressing key knowledge gaps and adopting a systematic and integrated approach to risk management. This knowledge was essential for understanding environmental processes and their interactions, providing evidence for impact assessments, ensuring effective implementation, monitoring progress, and providing the evidence that the judicial system required for judgments. The European Environment Agency was also an important actor in this context, as was the Environment Knowledge Community and the „Within the limits of the Planet" (WILOP) program. The knowledge generated by these various actors could also support the SDGs and Agenda 2030.

Returning to the theme of the workshop, Montani said that while all this showed that the planetary boundary concept was already evident in many EU policies, communications and strategies, it was not clear how the EU should take the concept further. She noted that the concept was useful for unifying science and policy, and that many of the EU's policies were obviously related to the planetary boundaries. There was therefore a lot of potential for communicating the EU's environmental policies through the lens of maintaining the safe operating space. For example, as existing EU policies are not sufficient for staying within the planetary boundaries, the concept could also be useful for showing the scale and urgency of the action required. However, the EU environmental acquis had been developed over 40 years and it would therefore not be easy to restructure it to fit the concept. She asked for ideas and opinions from the group as to whether planetary boundaries had the potential to become the leading frame for EU policies, whether the EU should seek to tackle each boundary separately or take an integrated approach, and how the EU could derive concrete policy recommendations from the general planetary boundaries concept.

Following the presentation, a member of the audience asked how the EU could work with the concept in its external relations. Some countries were against incorporating the concept further, as it could be viewed as the Global North imposing limits on the Global South. As it was hard to achieve agreement on this concept, the questioner suggested that the SDGs presented a better overarching approach. Montani responded that there was work being conducted at a European level to examine the effects of EU consumption outside the EU. She said that the priority for DG Environment was biodiversity inte-

grity, as for them this was the most urgent issue to address with regard to planetary boundaries.

Annika Lindblom said that in her experience as part of the EU delegation to international negotiations such as Rio+20, the developing world was not unified in its criticism of the planetary boundaries concept. Some countries, for example, in Latin America, had even criticized the EU for being against them. She said there were many competing concepts at the international level – for example, „buen vivir" in Latin America and „ecological civilization" in China. She said the emergence of other global concepts and increasing scientific certainty about the planetary boundaries meant that there was now greater potential at international level.

One participant also noted that there were too few representatives from the Global South at the conference. A truly global dialogue on the potential and limits of the concept of planetary boundaries for strategic sustainability policy was necessary, especially because the concept is driven by a natural-science perspective without sufficiently including social dimensions, such as inequality, power relations and requirements. At the end of the workshop, Harald Heinrichs concluded that, on the basis of the four presentations and the brief discussion, it appeared that the concept of planetary boundaries could be of use for policymaking as a reference point, and potentially have the function of framing and guiding policy-making on environmental sustainable development; however, there were limits on operationalizing the concept for specific policy decisions.

4.4.10 Planetary boundaries: Implications for planetary security

Chaired by Prof. Dr. Johan Rockström (Director, Stockholm Resilience Centre) and Janani Vivekananda (Senior Project Manager, Adelphi), Workshop 10 discussed the geopolitical implications of planetary boundaries. Different perspectives were provided by the following panelists: Prof. Dr. Johan Rockström, Kate Raworth (Oxford University), Prof. Dr. Randolph Kent (Kings College, London) and Michel van Winden (Dutch Ministry of Foreign Affairs).

The workshop discussions commenced with input from **Kate Raworth** on the importance of the 17 SDGs (Sustainable Development Goals) and the fact that human wellbeing is dependent on their effective implementation. Humanity currently finds itself facing a unique generational challenge: What will the consequences be for us all if we move beyond these boundaries: social vulnerability, a squeeze on political voice, peace and justice? Raworth noted that narratives are extremely important, especially the ways in which we communicate our contemporary resource challenges. She raised the question of how it is possible to talk in a language which „embraces" geo-politics (and which is therefore more understandable for security actors) and shifts our mindset.

Johan Rockström then talked about the scientific community's apprehension about planetary boundaries. He raised the question of exactly how many buttons we have to press before Earth's system takes over (for example, runaway climate change sets in), feedback loops spiral and we lose control. Furthermore, he asked whether planetary boundaries are already influencing societal collapse today, referring to the journalistic work of Thomas Friedman, and the examples of Syria, Libya and, more generally, the Arab Spring. The lingering question is how to position the planetary boundaries concept in the domain of foreign policy.

Randolph Kent highlighted the role of international organizations and their seeming inability to respond to longer-term issues. Short-termism must be replaced by horizon scanning, and this needs to be linked to United States military reform. Kent used the example of the UN's response to Rwanda in 1994/1995, in that the institutional response to this major humanitarian crisis was slow. History has shown that institutions often sleepwalk into the next crisis.

Michel van Winden noted that the concept of planetary boundaries

has gained increasing recognition in recent years. For far too long the concept has been firmly in the domain of environment and development, whereas it should be in the domain of security. It is not quite there yet, but raising its political profile will assist in drafting potential solutions, especially in context-specific locations – for example, in Syria, where many factors were involved in the civil war. Generic lessons can be learned.

The panelists were in broad agreement that narratives are extremely important when it comes to the planetary boundaries concept. People and institutions need to understand where issues may arise in the future. Improved forecasting and scenario development are hugely significant. In this vein, alternative narratives that promote the concept must be developed, as perceptions can improve its validity and relevance.

Van Winden deliberated on how we can achieve a security discourse that fully considers planetary boundaries, as the Security Council is usually limited to hard topics; indeed, climate change only made a relatively recent appearance, in 2007. Some issues, such as rising sea levels, have induced a stronger national reaction than climate change on its own. In terms of international security, if security actors had known about the Syrian drought in 2010, perhaps the whole war could have been averted. Van Winden added that he was not calling for a securitization of climate policies, but these threats need to be on the radar. The panelists questioned whether security communities need to be redesigned and exactly what should complement military actors.

In conclusion, the panelists agreed that in order to change the paradigm and promote change, the focus needs

to be on language. Raworth noted that we are all storytellers, so it is vital to repeat the words until politicians also feel comfortable using this language. In terms of the planetary boundaries concept, vast efforts are still needed with regard to the narrative. The question remains of how we can change people's minds. Van Winden echoed earlier comments, re-emphasizing that it is important to use concrete examples in relation to climate change, such as the fact of rising sea levels.

4.4.11 Planetary boundaries for large companies: Past experience and future potential

Workshop 11 focused on success stories in applying the concept: creating business value while protecting the environment. The discussion centered on how to increase momentum and the implications for CSR and footprint reporting, as well as risk and environmental management. The workshop was chaired by Jens Dinkel (Siemens AG), and the participants were Sophie Carler (JERNKONTORET Steel Foundation), Christina Båge-Friborg (Sandvik AB) and Andreas Streubig (Otto Group).

Jens Dinkel opened the workshop by asking the audience about their affiliations. Roughly a quarter of the audience came from the private sector, another quarter from academia, and another quarter from think tanks. Other affiliations included government agencies and standard setters.

Three presentations were given, each showcasing how the planetary boundaries concept has informed or can inform the CSR activities of large companies.

The first presentation was given by **Sophie Carler**. She related how steel producer Outukumpu adopted an ecosystem service perspective for one of its factories that helped to examine the environmental impact of its activities, and which highlighted the company's dependence on a healthy natural environment. She remarked that the main achievement of adopting an ecosystem perspective is to make the ecosystem services from which the company benefits visible. In the case of the steel factory, these services included the provision of cooling water. Furthermore, Carler highlighted the ecosystem services that the company had helped put in place, such as the creation of a museum in an old factory and the introduction of bison – now a protected species – into the area many decades ago. She underlined that the company engaged in developing a vision of its own business until 2050. However, she admitted that there were challenges in defining limits in the context of a large company's business.

The second presentation was by **Christina Båge-Friborg** of Sandvik AB. She presented the CSR framework of her company. This framework aims to maximize shareholder, customer and employer value. To become more sustainable, the company distinguishes between its „offerings" (products and services) and its operations. In both respects, the company seeks to be a responsible and sustainable business. To achieve these objectives, the company aims to increase the share of recycled materials, improve the health and safety of their products and to be innovative, for example.

Båge-Friborg also presented the results of an enterprise risk assessment. In the assessment, two risks were found to relate to the planetary boundaries concept: wildfire and flooding. Alongside the risks, opportunities were also identified: to strive for energy and water efficiency innovations, and to initiate local energy initiatives. Båge-Friborg highlighted the high recycling rate of the company. It buys material back from its customers and achieves an 80 percent recycling rate on steel and 50 percent on other materials. Båge-Friborg admitted that communicating the planetary boundaries concept within the company was challenging. She emphasized the importance of adopting the company's own language and linking the concept to the company's strategy. She also saw potential in using the planetary boundaries concept as a basis for the company's CSR activities.

The third presentation was given by **Andreas Streubig.** Streubig pointed to the long track record of his company regarding sustainable management,

now lasting over 30 years. He does not consider the company sustainable, however, but as continuously improving. He presented three key steps for large companies to address planetary challenges according to the planetary boundaries concept, namely: understand the environment in which your business is operating; determine the hot spots along your company's supply chain regarding unintended consequences; and manage according to what is material to your company and report about it.

Streubig presented the CSR activities of his company. Working together with an external consulting group, the company aims to reduce its material use. For this, an input output analysis was used to develop potential material reduction measures. These measures were then examined in a cost-benefit assessment, and selected measures implemented. The company's CSR activities fall into five strategies: textile, furniture, paper strategies, social program, and climate strategy. Since 2014/15, board member compensation has been linked to meeting the company's environmental targets, such as reducing carbon dioxide emissions to a certain level. Streubig regards this mechanism as very helpful for pushing sustainability activities within the company.

In the plenary debate, participants pointed out that the concept of planetary boundaries has not yet been picked up as such by any of the companies. The discussion revealed two alternative approaches to implementing the concept: top-down by regulation, or bottom-up by voluntary activities. The implementation of the Paris Agreement is seen as an example of the fact that top-down is too slow, and that private, voluntary activities are needed. However, it remains open as to whether the sum

total of these activities is sufficient to respect planetary boundaries.

The presentations revealed that implementation of the planetary boundaries concept can be supported by:

- Making the planetary boundary your own tool
- Thinking about the whole supply chain
- Make your activities and their consequences visible and transparent

The discussion revealed a potential conflict between absolute environmental limits and the capitalist economic mechanisms that cause companies to grow. In the last ten years, significant progress has been made. For example, ten years ago the steel industry paid no attention to carbon dioxide emissions. Today, several major steel producers cooperate on research into carbon-free steel production. It was pointed out that planetary boundaries should not substitute other CSR activities. Furthermore, it was argued that planetary boundaries cannot be translated into environmental limits for individual companies. A risk-based lens on a company's activities, however, could be helpful for respecting planetary boundaries. Finally, participants drew attention to the potential of planetary boundaries for advocating for sustainable behavior, also from companies toward their own employees and customers.

4.4.12 Planetary boundaries for civil society: Past experience and potential for socio-ecological transformation

Workshop 12 focused on the potential use of the concept of planetary boundaries by civil-society organizations to support sustainability transformation and sustainable development. The workshop discussed the relationship between planetary boundaries and bottom-up socio-ecological transformation, as well as how to operationalize the concept for civil-society organizations. It built on lessons learned from existing initiatives and initial experiences with applying the concept in civil society. The workshop was chaired by Maja Göpel, head of the Berlin office of the Wuppertal Institute. The session began with contributions by Leida Rijnhout, Program Coordinator for Resource Justice and Sustainability at Friends of the Earth Europe, and Richard Haep, head of the Berlin office of the NGO Deutsche Welthungerhilfe.

Leida Rijnhout pointed out that there have been warning signs of the limits of the planet at least since the Club of Rome report. She differentiated between a market-oriented approach to sustainable development (viewing sustainable development as three pillars and focusing especially on economic development) and a recognition of limits (thinking in ecosystems and realizing that economic and social capital are embedded within the ecological capital). She argued that recognizing that the global economy is already far beyond the limits of the planet means accepting the consequences. This implies focusing on sufficiency and resource justice, cutting down on the use of natural resources in absolute amounts, and stopping the „economic growth obsession" – which she said is also the main objective of the European Union, namely to generate growth and jobs. Technical solutions (eco-efficiency) will not be enough to reduce pressure on ecosystems, and there is no data or research available to assess where the natural resources should come from for the EU's three percent GDP growth objective.

Regarding the planetary boundaries concept, she stated that it is one of the concepts helpful for advocacy work. Other such concepts include „environmental space", the Earth's „carrying capacity", the „ecological footprint", „ecological debt", „consumption corridors" and Raworth's „doughnut economy". In her opinion, planetary boundaries are still not integrated enough into mainstream policymaking. The concept was mentioned during the Rio+20 summit and the SDG negotiations, but there was a reluctance to use it at UN Environment as it was perceived as „not scientific". Rijnhout closed her remarks by highlighting the political role of civil society within sustainable development: Civil society actors should focus on sufficiency, social innovation and sustainable lifestyles, as well as communicating the link between the

overconsumption of natural resources and poverty, and developing resource-capping schemes.

Richard Haep focused on the perspective of the Welthungerhilfe development NGO. He stressed that the planetary boundaries concept, as a recent scientific concept, is not widely known within the development NGO sector. However, he argued that as a principle within the sustainable development concept it has been known and used for decades in both project work abroad and policy work in Germany and the rest of Europe. It defines, among other things, the long-term feasibility of development processes. From his point of view, the planetary boundaries concept needs to be translated into policies, agreements and indicators. But advocating for it will likely represent an enormous struggle with interest groups. He highlighted relevant boundaries for his NGO's development work, in particular climate change, biosphere integrity, land-system change, fresh water use and biochemical flows. In his opinion, the concept and the aspired-to transformation need to be fully compatible with democratic principles and human rights as regards the inclusion of economic, social and cultural rights. He argued that while it is possible to agree on the need for transformation, it is less clear what the specific transformative goals are, the means/pathways to reach these goals, and who would be part of the transformation. One way to approach these challenges is to look at institutional visions and assess whether they are compatible with the 2030 Agenda and really sufficiently transformative.

Haep drew attention to additional challenges for transforming economies and societies. This transformation needs to occur in all countries, but in different ways. Thus, developing

countries, for example, would need support for transformation (resources, knowhow, technology, and so on). Transformation furthermore requires strong political will, good governance, and above all a „transformation of minds". Moving from GDP and growth to global wellbeing and homeostasis would require a reduction of social and economic inequalities. Haep also argued that besides opportunities for shaping the safe operating space, there are also real threats for greenwashing and camouflaging the continuation of „business as usual" by powerful interest groups. He also raised doubts at to whether efficiency and innovation will suffice for the required transformation. Referring to the work of the Welthungerhilfe, Haep detailed that development NGOs actively promote and advocate for transformation using Agenda 2030 as a framework. There are several important factors for transformation, namely: space or an enabling environment for civil society (as a watchdog, think tank, implementer, and so on); consideration of the local context, respecting culture, traditions and beliefs; meaningful participation and ownership; the link from local to national to global, upscaling bottom-up approaches; and adopting a „no-one-size-fits-all" approach, raising questions rather than simply communicating perceived answers or solutions.

The discussion focused on the question of change. It was asked why no real transformation has occurred in the past years although sustainability and development problems have been well known for decades. Some participants pointed out that younger generations now have more opportunities than any generation before, and that some positive change has taken place as a result. Plenary participants also emphasized that older generations often focus on successes, and less often on failures, which would imply a communicative imbalance within civil society. Some argued that reaction to developmental and sustainability challenges is inherently hampered by the balance of power, which is unequal between, on the one hand, those who have power and are less affected by global environmental change, and on the other, those who are most motivated to transform society and the economy but have fewer opportunities or abilities to induce a structural transformation.

The discussion also highlighted the importance of the „de-growth", which stresses the need to care for each other as well as for nature, and implies a notion of good life necessitating lifestyle changes. Some participants argued that the planetary boundaries concept is an interesting model for researchers and policymakers, but that the sustainability and development problems societies are facing are inherently about power relations that will not be changed by the concept. It would be necessary to strengthen civil-society organizations to give society a voice and empower different perspectives on transformations. Large parts of society are currently used to a world where there is economic growth. A central task would therefore be convincing these sectors of society that a transformation without economic growth was a worthwhile goal.

4.5 Reaching out: Planetary boundaries and the humanities

The final session of the main conference was an interview with Kirsten Meyer, Chair for Practical Philosophy and Philosophy Education at Humboldt-Universität zu Berlin, and Hanna Dölle, Co-Founder of CUCO – Curatorial Concepts Berlin e.V.

Kirsten Meyer pointed out that the humanities have much to offer in terms of developing the planetary boundaries concept, particularly with regard to environmental ethics and the concept's underlying and normative judgments. For example, the humanities can address the reasons for staying within planetary boundaries, for dealing with risk and uncertainty, for assessing how safe the safe operating space would need to be, and who the main groups affected by environmental change are – who is responsible for these changes and who is morally obliged to address them.

According to Meyer, policy action in the name of sustainability can lead to exclusion and suppression of rights. It is therefore important to consider issues of social and intergenerational justice, and any tradeoffs that might occur when pursuing sustainable development. This means taking a broader ethical view of the planetary boundaries concept. The esthetic value of nature is an important asset when seeking to highlight the importance of staying within the

From left to right: Hanna Dölle, Co-Founder, CUCO – curatorial concepts berlin e.V.; Kirsten Meyer, Chair for Practical Philosophy and Philosophy Education, Humboldt Universität zu Berlin

safe operating space. It could also be used to broaden the debate about the kinds of wellbeing that are threatened when we transgress the planetary boundaries. The focus is currently on human survival, but nature plays a far broader role in human wellbeing and this should be emphasized.

When thinking about the planetary boundaries concept from the point of view of the precautionary principle, it is more likely that we will focus most on human survival. However, there are other approaches, for example, the „expected value" approach, which can open up a broader perspective. Interdisciplinary forms of cooperation are important – between the arts and public policy, but also between different academic disciplines. Institutions need to become more flexible to encourage cooperation and dialogue. Young researchers need to be encouraged to work with other disciplines; currently it is easier to be successful in your academic career if you specialize in one area, whereas it should not in fact be a disadvantage to work across disciplines.

Hanna Dölle argued that images are important for communicating and educating about planetary boundaries. The arts therefore have an important role to play. Art is also a reflection of the zeitgeist and should show society's concerns. Photography is an important medium in this regard; Dölle's association has organized a photography exhibition about changing landscapes in the Anthropocene. Images can provide people from very different backgrounds with a way to understand the scale of the changes happening. They can also have a more profound impact as they allow people to connect more personally with complex topics such as climate change and planetary boundaries. Dölle said that visitors to the exhibition remarked that they were still thinking about the images months after viewing it. This may also be because galleries and images provide space and time for reflection. Galleries and exhibition spaces are also neutral spaces, and artists are seen as more credible and not having a hidden agenda.

Artists and curators are aware of the problem of climate change and the Earth's limited carrying capacity, and artists are seeking out collaboration with scientists to bring these issues into cultural spaces, said Dölle. There are fewer scientists seeking collaboration with artists, and this could be improved. However, finding spaces where we can think freely can be difficult in a world governed by efficiency and economic considerations.

Hanna Dölle, Co-Founder, CUCO – curatorial concepts berlin e.V.

Heinrich Bottermann, General Secretary, German Federal Environmental Foundation

5. CONFERENCE DAY 2

5.1 Opportunities for mainstreaming

Day 2 of the conference focused on opportunities for mainstreaming, that is to say, identifying ways to accelerate the take-up and dissemination of the planetary boundaries concept. It also debated the crucial question of how to build a global coalition between different societal sectors and between scales to stay within planetary boundaries while increasing social wellbeing. The first section began with contributions by Heinrich Bottermann, General Secretary of the DBU (German Federal Environmental Foundation), Walther Kahlenborn, Co-Founder and Managing Director of adelphi, Kai Nyberg from the Anthropocene Learning Lab of the University of Zurich, and Mathis Wackennagel, CEO of the Global Footprint Network.

5.1.1 Introducing planetary boundaries in the economy and society

Heinrich Bottermann began his remarks by quoting the German philosopher Immanuel Kant. Bottermann stressed that there is something positive about boundaries, namely that there are opportunities within boundaries. He pointed out that there is still a lack of awareness when it comes to the planetary boundaries concept, but that communication should not simplify the concept's main tenets. For communication, target orientation and empathy are crucial, especially as trust in science is diminishing. He called for a new age of enlightenment, built on evidence-based policymaking and countering the emerging „alternative facts" paradigm. One way to do that is the planetary boundaries concept, which has to be put into practice though communication, education and cooperation. This would also require scaling up sustainable public spending so as to set an example. Policies could focus on principles related to planetary boundaries, such as reconnecting to the biosphere and growth within limits. He finished by pointing out the DBU's forerunner role in putting the concept into practice, for example, by adopting new guidelines for funding.

5.1.2 Planetary boundaries and communication

The next speaker, **Walther Kahlenborn**, took up the issue of communication. He explained that planetary boundaries have a „mighty message", namely that there is only one world, that we should observe nine boundaries, and that four have already been transgressed. When looking at success factors, the concept initially appears to be easy to grasp, with universal appeal, a metaphorical/visual character and a basis in science. However, when looking at the actual uptake in the media, politics, the private sector and civil society, it appears that the concept is only reluctantly referenced. Indeed, when it is used, it is mainly to support existing discourses rather than changing them or opening up new debates. The reasons behind this are the complexity of the concept, its unclear message (or multitude of messages) and the low level of localization in time and space. Kahlenborn asserted that the concept still has more potential, for example, as a reference point, for orientation, as a wakeup call, or for legitimizing environmental policies. The next steps are to further clarify the concept's meaning, use appealing images and focus on stability as one of the main messages.

5.1.3 Planetary boundaries and education

Kai Niebert looked at education as another pathway for mainstreaming the concept of planetary boundaries. He began his speech by questioning whether more education or awareness is truly needed for pro-environmental behavior. Referring to different lifes-

Kai Niebert, Anthropocene Learning Lab, Universität Zürich

tyle patterns, Nyberg pointed out that there is no real connection between attitudes and resource consumption. The critical-creative lifestyle community, for example, is aware of global environmental impacts but has a very large footprint, while low-income families lack knowledge but have very limited resource use. With regard to eco-school programs, he argued that they impact students' knowledge but not their attitudes and routines. Instead of focusing on a program level, the focus should be on the education of teachers. Citing climate change as an example, Nyberg highlighted the widespread misunderstandings about effective climate change mitigation policies. The next steps for education are not to further define concepts such as planetary boundaries, but to afford experiences and to relate the concept to everyday thinking. In particular cultural shifts are necessary, moving from „more is better" to a society of grown-ups.

Mathis Wackernagel, CEO, Global Footprint Network

5.1.4 Planetary boundaries and footprints

Mathis Wackennagel argued that not enough people realize the implications of the Anthropocene for the economy. The planetary boundaries represent the key physical or qualitative conditions needed to maintain the biosphere and its crucial ecosystem functions. Maintaining bio-capacity is essential because it is the ultimate biophysical resource. The core questions are then how much bio-capacity we have and how much we use.

Wackernagel argued that the concept of „footprints" is based on the principle that life competes for ecologically productive space. Using this concept, he showed how every country differs in their bio-capacity consumption. Globally, we are in overshoot by a factor of 1.6. The reasons for the possibility of overconsumption are that countries rely on global commons, import goods, and overuse ecosystems. Alongside bio-capacity consumption, national income is also important in maintaining the supply of goods and resources. Wackernagel pointed out that a solid majority of the world's population lives in countries with a bio-capacity deficit and lower than average income. Future development should focus on resource security and not on increasing income. Poverty eradication and long-term prosperity critically depend on natural capital.

5.2 Next steps for mainstreaming: Planetary boundaries and global cooperation

The conference then turned to the topic of how to foster global cooperation in order to move back into the safe operating space. Keynote speeches were by Dirk Messner, Director of the German Development Institute, and Jaqueline McGlade, Director of the Science Division of UN Environment.

5.2.1 International cooperation for global sustainable development: Stagnation, erosion and windows of opportunity

Dirk Messner focused on stagnation, erosion and windows of opportunity for global cooperation. He highlighted the critical role of institutions in ensuring access to global commons. Citing examples from political science research, he revealed that one trend is to take a pessimistic view of the future of cooperation. Within his research team he has created a more positive outlook, identifying the basic drivers of cooperation (a basic mechanism). These are as follows: reciprocity, trust, a „we" identity, communication, reputation, fairness, and enforcement.

Dirk Messner, Director, German Development Institute

Jacqueline McGlade, Director, Science Division, UN Environment

Using these principles he analyzed the G20 meetings, pointing out that the cooperation there lacks several of these basic conditions. He argued that systems or cultures of cooperation emerge under the conditions of „collective intentionality", observable in the elements of joint „past and future", joint knowledge creation, joint practices and routines, joint narratives and perspectives, and joint norms and values. Using these elements, he assessed the global state of play of cooperation. Here, he found a trend toward stagnation, erosion and windows of opportunity observable simultaneously. Stagnation is visible in global multilateralism and IGOs. Erosion is seen in the movement toward „our country first" and „de-globalization". The windows of opportunity are the new inter-societal networks and cooperation that is emerging, resembling a growing global identity. Such networks are strongly needed to put the planetary boundaries concept into practice.

5.2.2 Planetary boundaries: A view from UN Environment

Jaqueline McGlade turned the discussion to the harsh reality of global environmental change, focusing on Africa. Heat waves and droughts in 2016 displaced 18 million people. Global environmental impacts such as climate change are an existential threat. Citing the Massai as an example, she indicated what „seeds of resilience" could look like: community and cooperation, as well as a sense of egalitarianism and reinterpretation of wealth in the light of droughts and the exodus of wildlife. Turning back to UN Environment, she said that currently they are focusing on a „pollution-free planet", to be discussed at the environmental assembly – a potential entry point for the planetary boundaries concept.

The subsequent plenary discussion stressed that it is important to convince decision-makers and society through environmental communication. The plenary also stressed that developing common trust is essential for effective global cooperation. The

next steps would be to make it clear that there is indeed a problem, to show that this problem is solvable, and to demonstrate that transformation can be an attractive option.

5.2.3 Panel: Building a global alliance for a sustainable Anthropocene

The panel discussion took on the question of how to build a global alliance for a sustainable Anthropocene. The participants were Heinrich Bottermann, Dirk Messner, Dagmar Dehmer (from the German newspaper Der Tagesspiegel), Katinka Abbenbroek (WWF) and Moritz Nill (Systain).

From a private-sector perspective, **Moritz Nill** argued that planetary boundaries are a very new subject for companies and compete with other topics such as SDGs and GRI. In general, companies struggle with their supply chains and need support to grapple with the inherent complexity. For private sector uptake a business case is crucial, that is, showing companies the economic gains from respecting boundaries. Nill argued that currently there are not enough market signals for sustainability in the private sector. **Katinka Abbenbroek** pointed out that it is crucial to focus on showcasing positive examples of change, later pressuring laggards with regards to environmental performance. She argued that there are incentives when it comes to pro-environmental corporate activities, such as attracting good employees, appealing to consumers and managing risk. Asked about how to impact major players with regard to environmental impacts along the supply chain, she pointed out that WWF is focusing on the 1 percent of

From left to right: Dirk Messner, Director, German Development Institute; Katinka Abbenbroek, Head One Planet Thinking, WWF; Moritz Nill, Head Berlin Office, Systain

companies that consume 65 percent of the Earth's resources.

From a civil-society perspective, Abbenbroek underlined that WWF's One Planet Thinking initiative aims at putting planetary boundaries into practice. WWF focuses on the minimal requirements for the private sector to live within boundaries, and looking for partners such as other NGOs, scientific organizations, companies and governments to support their cause. She also highlighted the importance of appealing to emotions when reaching out to consumers.

From a media perspective, **Dagmar Dehmer** argued that media outlets cannot be part of a global alliance for a sustainable Anthropocene. Instead, they should stand apart from political action, acting as observers. She pointed to the low level of trust in the media and the need to refrain from campaign journalism. Currently the media system is being eroded, so it is becoming increasingly difficult to reach people via these channels. She argued that the planetary boundaries illustration is a good tool for communication but that there is also a risk of inducing a feeling of helplessness when faced with the large sustainable development challenge and the risks inherent in the concept. **Dirk Messner** responded that he considers the concept easy to understand, especially the notions of tipping points and risks. As a narrative, it is easier to communicate than the SDGs. For the future, he underlined that communication should focus on telling success stories and political strategies should focus on the main sustainability challenges. He cautioned against relying purely on top-down approaches and global regimes; such political steps should be accompanied by supporting transnational networks. He also pointed to the possibility of a moral revolution, which could materialize when planetary boundaries are accepted, institutional change takes place and the educational system is transformed.

A number of crucial steps forward were mentioned by the participants. They included: making the concept understandable for companies and supporting them with implementation; translating methodologies for the private sector and beginning to work with consumer organizations; creating further knowledge and contributing to its dissemination, plus shaping an optimistic outlook; financing media projects that reach migrants, for example, as communication multipliers; focusing on the banking sector; and strengthening the ecological pillar within the Basel criteria.

5.3 Farewell

The final speech was given by Rita Schwarzelühr-Sutter, Parliamentary State Secretary of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety.

Schwarzelühr-Sutter opened by stressing that the conference had led to highly constructive discussions inspired by the diverse perspectives of the participants and speakers. The past days had shown that the discussion could open up enormous opportunities. Taking climate change as an example, she pointed out how German companies are well positioned in the global market for environmental technology due to Germany being a climate forerunner. This global market for environmental technology created 1.5 million jobs and is therefore of great importance to Germany. She also commented that increasing the use of renewable energy in Germany reduces the level of energy imports and lessens the burden on the state budget. She then applied this approach to the nitrogen boundary, which has been far exceeded and causes enormous damage both to business and the economy. She pointed out that the cost of the harmful impact of current nitrogen emissions by the European Union are estimated at EUR 70-320 billion per year. Reducing the nitrogen footprint to a manageable level could provide employment and opportunities for innovation in the economy comparable to the transformation undertaken in response to climate change.

Schwarzelühr-Sutter stated that planetary boundaries can create huge opportunities. The conference had been a great success in terms of developing concepts for how to make planetary boundaries work. She closed by saying that only a stable environment could provide the pathways needed to end poverty, create healthy living conditions and promote peace and justice.

Rita Schwarzelühr-Sutter, Parliamentary State Secretary, German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Kora Kristof, Head Department "Sustainability Strategies, Sustainable Resource Use, Instruments", German Environment Agency

6. SIDE EVENT: PLANETARY BOUNDARIES AND THE FINANCIAL SECTOR

The side event focused on how to translate the global scale planetary boundaries concept for the financial sector, building on the risk approach inherent in the concept. Participants discussed past experience with the planetary boundaries concept in the financial sector, lessons learned and potential future applications. They reflected on possible ways to operationalize the concept for eco-ratings. They also asked how the framework conditions for the financial sector need to be changed to make sure that the sector can cope effectively with the challenges posed by planetary boundaries. Keynote speeches and contributions were by Kora Kristof (German Environment Agency), Walter Kahlenborn, Kristoffer Lüthi (Ekobanken), Lorenz Stör (oekom research), Georg Schürmann (Triodos), Michael Dittrich (DBU), Martina Linnenluecke (University of Queensland, Australia), Davide Dal Maso (Research Coordinator, UNEP Inquiry) and Claudia Tober (FNG Forum Nachhaltige Geldanlagen).

Kora Kristof welcomed the audience, pinpointing two crucial questions, namely how to translate the planetary boundaries concept for the financial market, and how to create linkages between the financial sector and environmental issues. Starting points for sustainability already exists in the financial sector, such as the UNEP FI initiative, the G20 recommendations on voluntary action, and the UN principles for responsible investment. Tools available for relating investments to environmental impacts include the Environmental Impact Assessment (EIA), the taskforce on climate-related financial disclosure's recommendations, rules such as the Equator principles, and the Environmental Social and Governance (ESG) Risk Evaluation from UNEP. She added that the policy sector can define limits and raise awareness.

Walter Kahlenborn, Co-Founder and Managing Director, adelphi

Walter Kahlenborn introduced the side event. Focusing on the main messages for the financial sector, he argued that risks could emerge when boundaries are crossed, such as substantial resource constraints, loss of ecosystem services, long-term damage to technical infrastructure, risks for the social infrastructure, and risks for governing transformation. These could lead to market volatility, stranded assets and changing risk structures. But they could also lead to new markets and new investment opportunities. Key next steps for the financial sector include improving operational capacities, creating a more resilient financial architecture, and supporting the transition to a more sustainable economy. Planetary boundaries offer support here: they can function as benchmarks and a risk approach, moving beyond climate change and efficiency gains to science-based targets and analyzing the entire value chain. To build a more resilient architecture, planetary boundaries could potentially be used to increase transparency. To support the sustainability transformation, planetary boundaries help by focusing on long-term risks and the cultural shift. Kahlenborn highlighted several initiatives both for specific boundaries (for example, climate change: climate finance, fossil fuel divestment) and for broader topics such as the Agenda for SDG investments. Furthermore, action is beginning on the financial architecture, for example, through UNEP inquiry and the Shareholder Rights Directive.

Kristoffer Lüthi spoke about his experience at a cooperative and sustainable bank. He pointed out that the financial system is like an eco-system, including imbalances and disruptions. From his perspective, a sustainable financial system and its institutions would need to work within the planetary boundaries. In particular, the financial sector's perceived need to maximize profit is exhausting the planet and its inhabitants. The financial sector needs to serve humanity and the planet, not itself. For this, credits and loans are key; in particular, the loan portfolio should be directly related to SDGs. Next steps include developing guidelines for the financial sector that better reflect the planetary boundaries and the social limitations in their credit processes. It is crucial to

From left to right: Georg Schürmann, Managing Director, Triodos Bank; Lorenz Stör, Manager Client Relations, oekom research; Kristoffer Lüthi, Deputy Managing Director, Ekobanken

better educate consumers on how to move their money in a more sustainable way.

Lorenz Stör presented the methodology used to develop ESG criteria at oekom research. One pathway for influencing these criteria is scientific findings, under which he included the planetary boundaries concept. Taking the planetary boundaries concept as a starting point, he related the ESG criteria oekom research uses to the nine boundaries, highlighting in particular the criteria „Climate change strategy", „Soil and biodiversity management in agricultural production", „Environmental aspects along the value chain", „Water risk and impact", „Sewage sludge treatment" and „Eco-efficiency" – all of which relate back to the nine boundaries. Using the example of climate change, he highlighted how ESG criteria can help assess the performance of companies with regard to de-carbonization.

Georg Schürmann focused on SRI funds and how they contribute to the wellbeing of the planet. He highlighted the challenge of taking into account the manifold concepts already in place, such as UN Global Compact, SDGs and planetary boundaries. According to Schürmann, Triodos is already taking their responsibility for the planet very seriously by only lending money to companies, institutions and projects that contribute to the wellbeing of people and the planet. Triodos focuses on positive selection, a best-in-class approach and minimum standards. The minimum standards also reflect some of the planetary boundaries.

Questions put to the speakers included whether banks can afford not to address risks in their business models, how to apply the planetary boundaries concept to the safe operating space, how to strengthen the novel entities boundary incorporated in the concept, how independent rating agencies are with regard to the clients they rate, and how the speakers view the concept of „post-growth".

Michael Dittrich focused on sustainable investments in the DBU's asset management. He pointed out that the DBU's asset management focuses mainly on Europe, taking into account several sustainability indices such as

Michael Dittrich, Head of Department Finance and Administration, German Federal Environmental Foundation

the Dow Jones Sustainability Indices and the FTSE4Good index. Since 2005 sustainability has been incorporated into the DBU's investment guidelines; currently approximately 85 percent of all shares and 90 percent of all bonds issued by listed companies are included in sustainability indices. Current developments within the DBU are accession to UN PRI in 2012, the expansion of sustainability viewing on non-listed financial institutions and government bonds, investments in funds for the production of renewable energy, and refraining from new investments in the coal sector. Dittrich concluded that sustainable criteria can easily be integrated into asset management. Experience at the DBU shows that, in the case of a broadly-based universe or portfolio, sustainable criteria are no reason to expect performance disadvantages. Sustainable investment is a convincing strategy as it becomes possible to indirectly influence big companies to join sustainability indexes or stay in them. He argued that methods for measuring the carbon dioxide footprint of asset management must be improved and that the financial sector, especially financial investors, should report on their activities aimed at integrating sustainability into asset management.

Martina Linnenluecke presented via video ways to operationalize environmental risks for the finance sector using the planetary boundaries concept. She highlighted that businesses exist in order to create value. Any business that does not create value will either be forced to change or cease to exist. But she also pointed out that the natural environment is now introducing new changes that alter the foundation of value creation. There is now a new policy context with the Paris Agreement, which represents a strong policy signal for action, with implications for investors and markets. Highlighting examples from her work, she argued that asset impairment represents a major risk for firms, potentially emerging from breaching planetary boundaries. In addition, stranded asset value could occur as the impact of global environmental change and policy restrictions around the use of fossil fuels could render fossil fuel assets and fossil fuel infrastructure „stranded" assets.

Davide Dal Maso, Partner, Avanzi / UNEP research coordinator

Davide Dal Maso focused on lessons learned by UNEP Inquiry. He argued that mobilizing the world's capital is essential for the transition to a sustainable, low-carbon economy. Today, however, too little capital supports the transition, and too much capital continues to be invested in a high-carbon and resource-intensive, polluting economy. A key step forward would therefore be to better align the financial system to the resilience and long-term success of the real economy. He further pointed out that there is some momentum toward more sustainable investments and reshaping the financial architecture. New policies are underpinning this momentum, such as the adoption of the Sustainable Development Goals and the Paris Agreement on climate change. So far, however, the momentum seen is not sufficient to truly transform the financial system. The next steps would be as follows: to anchor sustainability in national strategies for financial reform and development; to channel technological innovation into financing sustainable development; to realize the triple leverage potential of public finance; to raise awareness and build capabilities across the system; and to embed sustainability into common methods, tools and standards across the financial system.

Claudia Tober closed the session by summarizing the main points made in the presentations and giving a positive outlook on the growing market potential of sustainable investments around the globe.

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