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Enabling the Great Transformation: Transdisciplinarity as Individual and Institutional Challenge

Introduction

Realizing a sustainable future in the Anthropocene requires a 'great transformation.' The massive technological, economic, social, and cultural change this implies is based on new forms of literacy and knowledge integration. It depends on a highly transdisciplinary 'transformative science,' i.e., scientific knowledge production that not only focuses on 'system knowledge' but also on 'target' and on 'transformation' knowledge, and thus integrates different disciplines and practical expertise.

The existing science system is actually not fulfilling this new social contract between science and society. Frontrunner institutions like the IASS and 'transdisciplinary personalities' like Klaus Töpfer are important change agents to bring forward the transformative mission of a future Earth science.

The Great Transformation: A New Social Contract for Sustainability

In 2009, Johan Rockström from the Stockholm Resilience Center, together with about 30 co-authors, published a seminal article in *Nature* journal on the 'planetary boundaries' that reframed the sustainability debate. The study demonstrated in an impressive manner the concept of the Anthropocene proposed by Paul Crutzen: humankind is the engine of dramatic developments in global ecosystems. In nine different areas (e.g., climate change or the loss of biodiversity), bio-physical thresholds can be identified; for seven of them, thresholds can even be quantified precisely. If these thresholds are exceeded, then we will face risks in other areas that cannot yet be calculated. A popular and widely discussed area is climate change. The international commitment to limiting global warming to two degrees Celsius is based on the insight that, with greater global warming there will be so-called tipping points. These tipping points initiate non-linear changes of huge dimensions and their consequences will be irreversible (e.g., the massive melting of the polar ice caps).

Science has contributed extensively to the roots of this development. Modern societies are driven by innovations and they follow a path of growth that is purported to be the only possibility to stabilize social systems. The science system, largely financed by the public sector, thereby forces the development of new and innovative technologies. These technologies further contribute to the increasing exploitation of resources and pollution of the environment.

Many of the new technologies influence the surrounding environment in ways that seem to be irreversible, because the consequences have such far-reaching ecological, social, and economic impacts. They cause new and also incalculable side effects; modern societies can thus be characterized as 'side effect societies' or risk-societies (see Beck 1998; Schneidewind & Singer-Brodowski 2013).

The relationship between science and society is out of balance; it can even be argued that an estrangement of science and society has taken place over the past decades. The science system itself abdicates its own responsibility as it calls for the freedom of research and teaching at universities. Helga Nowotny's 'Insatiable Curiosity: Innovation in a Fragile Future' (2008) shows the pressure of innovation, i.e., the urge to continually invent material things in modern societies—and the consequences of it. The current debate about fracking and oil sands is one of the best examples of this disturbed relationship between science and society. Currently, huge investment is being made to improve the technologies for extracting unconventional gas and oil reserves, despite the essential need to prepare alternative pathways towards a post-fossil economy.

To avoid further exceeding planetary boundaries, a great transformation and a new social contract for sustainability are needed (see WBGU 2011). This social contract consists of a new cooperation between different stakeholders. The new social contract forms a bridge between these different stakeholders (see Figure 1), who have changed fundamentally in their own self-concept and their role in society in the 21st century. The strong, proactive, and empowering state plays an important role in the flagship report of the German Advisory Council on Global Change (WBGU). The economy has to be developed towards a more sustainable direction through investments and alternative economic branches. One important stakeholder is science, which has to contribute to the development of sustainable technologies, but also the production of knowledge about transformation processes. Scientific research should focus on the Grand Challenges and produce knowledge for facilitating the transitions needed to

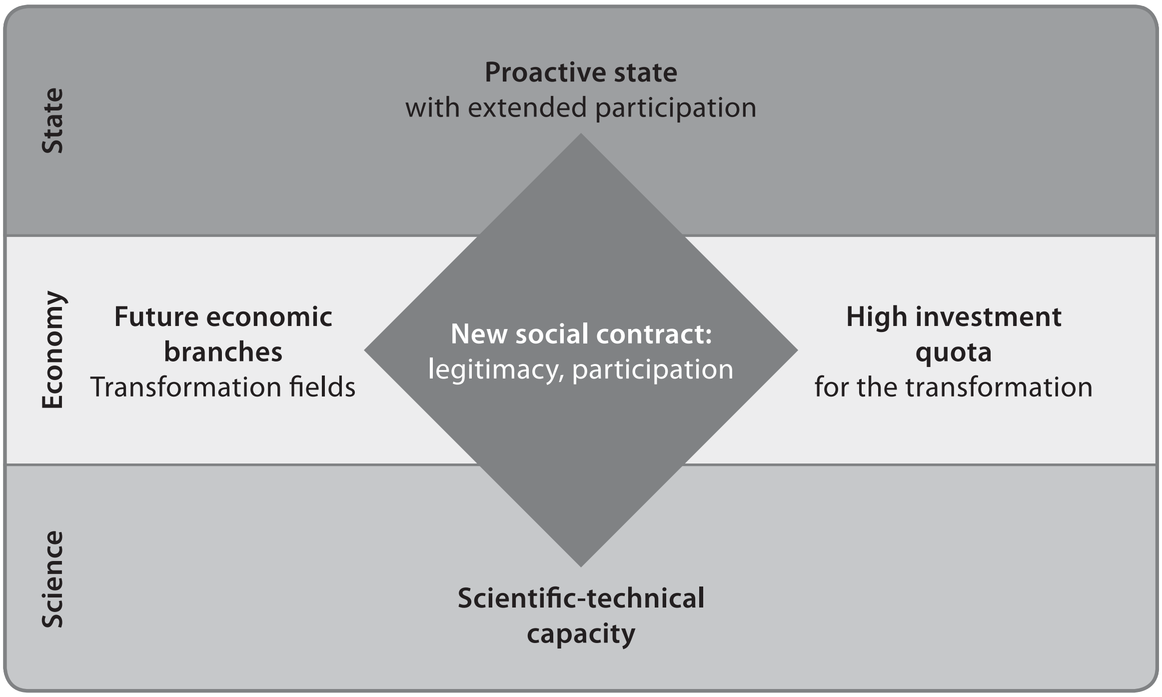

Figure 1: *New social contract (Source: WBGU 2011, p. 275).*

reach a sustainable future. Finally, all these stakeholders are part of a contract with civil society, which appears to become increasingly self-confident, competent, and aware of its role in this relationship.

In the flagship report of the WBGU (2011), several contract theories are described. Now, from the perspective of the WBGU, a revised social contract accompanies huge challenges, because the contract has to be adapted to the reality of a globalized society:

1. "Because of progressive economic and cultural globalisation, the nation state can no longer be considered the sole basis for the contractual relationship. Its inhabitants must responsibly take into account transnational risks and natural dangers, and the legitimate interests of 'third parties,' i.e., other members of the world community.
2. Traditional contract philosophy presupposed the fictitious belief that all members of a society are equal. Considering the disproportionate distribution of resources and capabilities in today's international community of states, we must have effective, fair global compensation mechanisms in place.
3. The natural environment should be given increased consideration when revising the social contract.
4. The contract has to bring two important new protagonists into the equation: the selforganised civil society and the community of scientific experts." (WBGU 2011, p. 277).

Citizens consent to expectations of innovations that are connected with the sustainability postulate. They exchange their own spontaneous wishes (for example to consume in an exorbitant way) for the advantages that are expected with the contract (for example a safe operating space within planetary boundaries or the right to participate in a strong state) (see WBGU 2011, p. 277). The strong, proactive, and empowering state guarantees these advantages, and actively involves its citizens in decisions that are made for the future and which aim to achieve sustainability targets. It is important to note that this is not the same as merely calling for citizens' acceptance of decisions after a political decision has actually been made. In Germany, the energy transition — the 'Energiewende' — is a prominent example of a situation where many people agree with the overall aim of developing renewable energy but refuse to accept new technologies within their own environment for esthetic reasons. This is called the "not in my back yard" (NIMBY) mentality, and it seems to be grounded — at least partly — in governments' unrealistic expectation of public acceptance and in a lack of opportunities for citizens to participate in the transition process. "This links a culture of attentiveness (born of a sense of ecological responsibility) with a culture of participation (as democratic responsibility) and a culture of obligation towards future generations (future responsibility). This is no demand for a merely superficial or even resigned acceptance on the part of civil society; rather, it is acknowledged as an actively involved partner with shared responsibility for the success of the transformation process, and mobilised, thereby entering into the contract voluntarily — as assumed by the republican-liberal version of the original social contract. The idea of a powerful state is therefore indelibly linked with the recognition of civil society and the way it has evolved since the 19th century, the innovative powers inherent in the economy, and the proactive and proinnovation forces active in political and administrative elites. Today, all of this always applies in the global arena as well" (WBGU 2011, p. 277).

A New Social Contract between Science and Society

A pivotal part of the new social contract for sustainability is the contract between science and society. It comprises not only the integration of sustainability aspects, but also structural reform of the institutions where scientific knowledge is produced, and the infrastructures that frame the conditions of these institutions.

Helga Nowotny and colleagues (2001) have pleaded for a new cooperative relationship between science and society, and have developed the concept of a Mode-1 and Mode-2 science in reflexive modernity. The conventional mode of knowledge production in the science system is mono-disciplinary and technocratic. Scientists seem to produce findings that are certain and predictive. The production of scientific knowledge takes place in well-insulated areas, for example "large research laboratories and their closed walls." This kind of research is displaced "by Mode-2 research, which is a more open undertaking that is characterized by a transdisciplinary orientation toward social, environmental, industrial, or medical problems" (Nordmann et al. 2011, p. 5).

In the age of reflexive modernity (Beck et al. 1994, Beck in this volume), a new type of research is required that accepts different forms of knowledge, i.e., knowledge of stakeholders and scientific knowledge. In an age of uncertainty we therefore need transdisciplinary research processes and a non-hierarchical structure of research organizations. This is also mentioned in the IASS TransGovernance project, which described the new interdependence and interplay between different societal actors such as the media, representative democracy, and scientists (in 't Veld et al. 2011). Furthermore, in a transdisciplinary research project, the evaluation and quality control of research outcomes should be organized in a participatory way. In our latest book, 'Transformative Wissenschaft' (Transformative Science, Schneidewind & Singer-Brodowski 2013), we develop — based on the idea of a Mode-1 and Mode-2 science — the concept of a Mode-3 science.

This Mode-3 science represents the institutionalization of a permanent self-reflection in the science system. It refers to Niklas Luhmann's idea of an observation of the third order. Luhmann says: "The observer of the first order only reads a text; the observer of the second order asks how the text is to be read and understood and what arguments the text supports; the observer of the third order wonders why the text is written and which function the arguments have." (see Luhmann 1997, p. 1126). A Mode-3 science therefore asks which functions the current science system has, which routines are established, and which dependencies exist between the science system and society. It reflects its own interplay with society and questions its institutional basic conditions (e.g., incentives, structures in the funding of research, career pathways, and the balance between society-oriented and technology-oriented approaches). These basic conditions include individual and institutional matters as well as the scientific infrastructures.

Miller et al. (2011) advocate a different approach to the organization of academic institutions. The production of sustainability knowledge requires a fundamental shift towards an epistemological pluralism and reflexivity: "epistemological pluralism involves promoting the use of all relevant knowledge, perspectives, and viewpoints in a structured, rigorous manner […] Reflexivity involves the understanding that the institution itself is part of the dynamics of the system that it seeks to change, thus it continually reexamines and reevaluates the foundational assumptions of its work by 'opening up' its boundaries to multiple representations and discourses outside the institution." (Miller et al. 2011, p. 178). They argue that there exist both internal reflexivity and external reflexivity, which emerge in the cooperation with society. Civil society therefore has a very important role to play in this context — it reflects the blind spots of the current scientific mainstream and calls the members, institutions, and infrastructures of the scientific community to transform themselves and their work permanently into the direction of society-based research. In the end, this may lead to a new innovation-capability within the science system, addressing a fundamental paradox that has long existed within the science system: while it is under constant pressure to produce innovations (and quite successfully does so), it is itself characterized by complete inertia as regards changes in its own established institutions, structures, and processes.

What is currently needed seems to be a harmonization between science and society—a re-embedding of the science system in society, creating both awareness for the great societal challenges and a new contract between science and society. This is also the aim of Mode-3 science. To support the co-design and co-production of knowledge together with civil society, new institutional settings are required. The central question is thus: how might the permanent participation of civil society be organized in a science system that normally strives for mono-disciplinary excellence? With regard to research (as one central task of the science system), the answer can be a transdisciplinary approach, which has been developed during the last 10 years in the context of the debate on sustainability science (see Lang et al. 2013). This has been enriched by the call for acceptance of different epistemic cultures in recent years. This new approach is able to cope with different forms of knowledge beside the original scientific knowledge: system knowledge, target knowledge, and transformation knowledge—all these forms of knowledge are required to deal with sustainability challenges.

In the field of education, this new approach would lead to an embedded curriculum that enables education for participation and transformative learning with societal impact. It complements the concept of employability, which is prominent in the EU Bologna Declaration, by also addressing the development of young personalities in the 21st century. For university students, Higher Education for Sustainable Development could frame a 'learning for change' and contribute to sustainable development in fostering three dimensions of learning: 1. individual action and behavioral change; 2. organizational change and social learning; and 3. inter- and transdisciplinary cooperation (see Michelsen & Barth 2013). This kind of learning often appears in project-oriented settings (see Brundiers et al. 2011) and can be explained via social-constructive theories. According to these theories, learning is mainly guided by the activity of the learner; happens with concrete experiences (see Dewey 1925); and takes place with cooperative participation in a community of practice (see Lave & Wenger 1994). Self-organized learning settings therefore offer an ideal context for developing key competencies. As Stephen Sterling argues, "Sustainability is not just another issue to be added to an overcrowded curriculum, but a gateway to a different view of curriculum, of pedagogy, of organizational change, of policy and particularly of ethos." (Sterling 2004, p. 50).

How Do We Reach the Great Transformation in the Science System?

Apart from the description of this unwritten social contract for sustainability in its flagship report, the WBGU has created something very interesting, which is extremely important for our debate: the council members introduced the concept of a 'great transformation for sustainability' into the discussion and based it on the description of societal transitions in general. It refers to a heuristic approach to transformations and focuses on a fundamental question: "Do we want to suffer from a transformation by disaster or proactively create a transformation by design?" In its analysis, the WBGU looks for historical transformation processes like the Neolithic (when mankind developed agriculture) or the industrial revolution. In particular, the industrial revolution was (more or less) a planned process where new concepts, infrastructures, and technologies fundamentally changed the lifestyle of humankind in terms of social, cultural, and technological innovations. What can be learned from this? That we are already in the process of the transformation of our world-society, and that we can shape it actively and creatively.

The WBGU refers to a new research approach developed in the Netherlands: the transition approach. Members of the Dutch Research Institute for Transitions (DRIFT) observed and analyzed the diffusion of innovations into the societal mainstream, and through this built up a new theoretical approach. They started with the observation of sectoral transformation processes and then continued to transfer their emerging model to societal transformations in general. The model can be used for different levels of observation (for example an economic sector, a nation, or a single organization). This is its strength, because it can be used to describe different transitions. Uwe Schneidewind and Karoline Augenstein (2012) have applied the transition theory model to the German science system (see Figure 2, which also shows the functional and interdependent levels within a system that are important in order to understand the model). The level of the landscape includes great global and societal trends, like demographic change or the revolution through information and communication technologies. They cannot be influenced by the stakeholders of the other two levels; The level of the regime frames all the rules, routines, and institutional habits that contribute to the stabilization of the current system; Last but not least, there is the level of the niche, wherein change agents develop technological and social innovations. These change agents are trendsetters: they modify and improve their innovations until they have reached readiness for marketing; and through the ongoing process of networking between the different change agents, they contribute intensively to the mainstreaming of innovation, especially through the use of so-called 'windows of opportunity.'

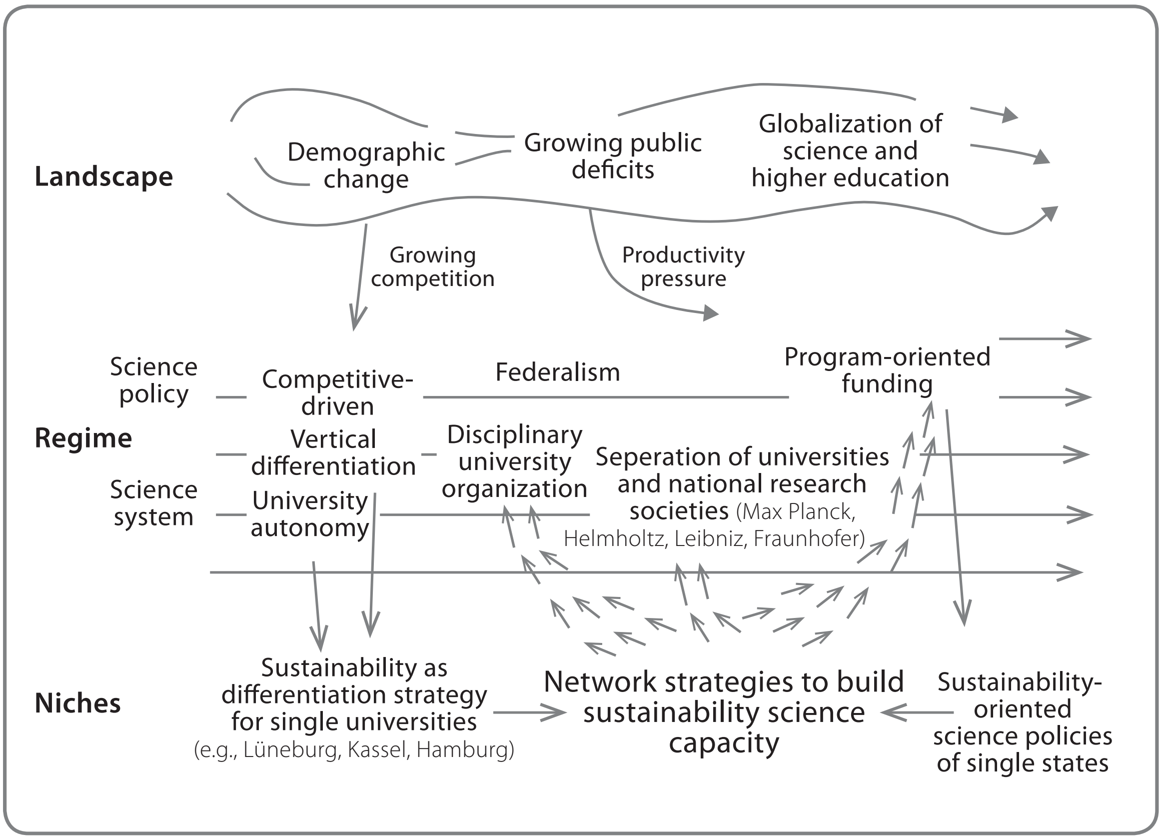

Fig. 2: *How to transform a science system? The example of the German Science System.*
Source: Schneidewind & Augenstein 2012.

A characteristic of the German science system is the existence of many independent research institutes that are unaffiliated to universities. Many of these institutes for sustainability (like the Öko-Institut in Freiburg) developed out of a protest movement against a strong mono-disciplinary bias in universities. They have supported the development of important concepts within the scientific debate on sustainability in Germany. One example is the socio-ecological research program of the German Government, which was developed by an alliance of these sustainability institutes and now receives funding of 12 million euros per year. The funding of this program also introduced institutional innovations into the science system, such as the discussion about quality criteria for transdisciplinary research projects, or the constitution of groups for young academics.

The second peculiarity of the German science system is the high responsibility of the federal states in the field of education and research. Change agents therefore have to navigate this shared responsibility between the national government and the federal states. At the same time, some of these federal states (for example Nordrhein-Westfalen and Baden-Württemberg) form the avant-garde, with the creation of a society-oriented and transformative science system in their territory. Nordrhein-Westfalen patronizes real-world-laboratories and Baden-Württemberg forces the development of sustainable profiles for its universities.

To support the transformation of the German science system (i.e., at the level of the 'regime' in accordance with the DRIFT transition model), networks have formed between advanced universities and sustainability institutes. Ecornet, the ecological research network is one of these networks, bringing together advanced institutes; NaWis-Runde, the group for sustainability science is a network of universities *and* independent research institutes. The Wuppertal Institute participates in both networks; the IASS is a core member of the NaWis network. Both explore common paths for sustainable innovations within the science system. In 2012 the networks collaboratively organized a campaign called "Creating transformative knowledge." During the course of several events, we discussed with more than 1500 participants the institutional potential for the transition of the German science system, such as the funding of new initiatives by foundations, or the potential for engaging with civil society. In May 2013, the corganization Plattform Forschungswende published, for the first time, demands for transparency and the participation of civil society.

Transformative Individuals, Institutions, and Infrastructures as Catalysts for a Science System Shift

A glance at the ongoing processes of change within the German science system reveals three important motors for transitioning towards production of more transformative knowledge:

1. ***Transformative individuals/personalities.*** Science is ultimately driven by scientists and scientific minds. Without having researchers that take societally relevant challenges as the starting point for their own work, and who are willing to interact with other disciplines and field practitioners, transformative science will not emerge. 'Context partisans' are of crucial importance, meaning people that have developed an understanding of change within different societal environments and a deep empathy for different scientific, political, societal, and cultural contexts. That explains the specific importance of individuals like Klaus Töpfer, who have bridged different environments: Coming from the science system, entering the political sphere on a national and later global level, before returning to the science system to lead a new innovative sustainable think-tank in the German science system—always motivated to address the same challenge in different contexts: a more sustainable world at all levels, from local to global.

2. ***Transformative institutions.*** A critical mass of transformative individuals will only develop if institutional environments exist that support the growth of such personalities. There must be opportunities to develop theoretical and methodological skills as well as career pathways for scientists working in transdisciplinary contexts. The science system still has a long way to go in developing sufficient transdisciplinary environments. Transdisciplinary research institutes like the IASS in Potsdam or the Wuppertal Institute are important hubs practicing and advocating the need for this development. However, much stronger links are needed to similar developments in universities, where disciplinary training and career pathways are formed. Networks such as NaWis offer an approach to bring together pioneering institutions from the spheres of research institutes and universities.

3. ***Transformative infrastructures.*** A transformative science needs 'laboratories for transition processes,' i.e., real-world laboratories to initiate and better understand socio-technological change processes. Cities, specific regions, 'transition towns,' or a regional mobility system can be 'real-world labs'. In such contexts, scientific knowledge production and reflection are deeply embedded in concrete transformation processes. They can be understood as new forms of scientific infrastructure that are urgently needed to create transformative knowledge. For instance, the German 'Energiewende' actually constitutes one large 'real-world lab' on a national scale, with significant impact also on global developments. The process of creating a deeper and more comprehensive interlinkage of this transition experiment with the science system is still under way. The IASS and Klaus Töpfer—as one of the 'fathers' of the German Energiewende who headed the Ethics Commission that initiated and prepared the Energiewende—are playing a central role in establishing this new science–society link.

Conclusion

There is an urgent need for a transition in the science system as a whole. This transition must encompass not only a greening of campuses but a more fundamental and paradigmatical transformation of the way in which science institutions carry out their principal tasks of conducting research and providing education. This also implies a structural transformation among the organizations funding research and in the typical career pathways of scientists, that should not focus exclusively on mono-disciplinary excellence. According to the transformation-perspective adopted by the WBGU this 'turn' includes a deep transformation of scientific infrastructures (universities and research institutes), political decision making, the ways in which way scientific knowledge is produced, and the quality assurance processes in place that tend to reproduce current structures (e.g., the peer-review processes) as well as the self-conception of scientists in terms of their values and basic understanding of the role of science in society. The social contract that the WBGU is calling for builds the unwritten but basic foundation of this process. It enables a new awareness of the relationship and interlinkages between different societal systems—and it may eventually release the scientific system from its ivory tower.

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