Chapter 13
Sustainability and Science Policy

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Abstract What is the role and importance of science policy for a transformation toward a more sustainable society? In what ways can science policy influence science and innovation systems? More specifically, how can science policy create the institutional conditions needed for developing a sustainability science? Where do we see the strongest impetus for a reorientation of science policy toward sustainable development? These are the guiding questions of the following chapter, which provides an insight into science policy – a policy field that is quite often underestimated yet decisive for sustainable development.

Drivers and incentives for a stronger society orientation in the science system are delineated for the case of the German science system, which serves as an example for many other European science systems.

Keywords Sustainability-oriented science policy • "Mode-2 science" • Innovation policy • Institutional embeddedness of sustainability science • Science system transformation

1 The Importance of Science for a Transformation to Sustainability

Why is science policy important for transformation toward a more sustainable society?

Given the growing environmental burden on a global scale and the overstepping of planetary boundaries (cf. Rockström et al. 2009), humanity in the twenty-first century is facing radical change: it is imperative to guarantee a good life for nine billion people within ecological limits. This goal cannot be reached by continuing today's economic and societal development patterns. Rather, a "great transformation"

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(WBGU 2011) of global technological, economic, societal, and cultural developments is needed. This amounts to a highly complex system innovation.

New forms of knowledge will be needed for ecological monitoring and ecological problem analysis, as well as for the development of technological, economic, and social innovations. Therefore, science and the production of knowledge play an important role and will be critical to whether or not the goal of a great transformation can be achieved.

Thus, with the growing importance of knowledge production in the twenty-first century, the field of science policy appears in a new light. Historically, working toward sustainable development has mainly been viewed as a task for environmental policy and, recently, for development of social and economic policy as well – while science policy has not played a vital role. At the moment, this is beginning slowly to change. It is more and more recognized that a sustainability-oriented science policy is at least equally important for the needed transformation processes.

- ***Question***: *Why is science and research becoming so important for sustainability transitions?*

2 Three Perspectives on Science and Sustainability: Being Aware of the Institutional Embeddedness of Science

What kind of science is needed to achieve sustainable development? This question needs to be answered on three different levels (see Fig. 13.1).

1. **The concrete research fields of sustainability science**. What are the topics and dimensions that a sustainability science needs to address? Early on, the so-called Earth sciences played a central role regarding their knowledge of geological, ecological, and meteorological processes, in order to understand the current dynamics of human-induced global environmental change. It soon became clear

Fields of Sustainability Science (=) e.g., Earth Science, Engineering, Economics, Social and Cultural Sciences,…)
Methodology of Sustainability Science (=) Transdisciplinarity)
Institutional Setting of Sustainability Science (=) Science Policy)

Fig. 13.1 Three perspectives on science and sustainability

that, if the objective of science is not only to analyze the ecological state of the global system but also to contribute to the development of sustainability-oriented transformation processes, new fields of science would have to be included: there is a need for technological knowledge and innovations, knowledge on economic processes, as well as social and cultural dynamics. Therefore, sustainability science today is a highly interdisciplinary field (Kates et al. 2001; Clark and Dickson 2003; Jerneck et al. 2011; Wiek et al. 2012, 2015; Miller et al. 2014).

2. **The methodology of sustainability science**. The scientific discourse on sustainability and the role of science has revealed that a sustainability science requires not only a combination of different academic disciplines but also a new mode of knowledge production (Nowotny et al. 2001). Modern societies are shaped by traditional scientific knowledge production and continue to exist based on this type of knowledge. In sociological literatures, this phenomenon and the problems that arise from it are, for instance, discussed in terms of "reflexive modernity" (Beck et al. 1994). New demands and requirements related to the production of knowledge are emerging in this context. A new type of science, which integrates knowledge from different academic disciplines, as well as practical and contextual knowledge of concrete actors, is referred to as "Mode-2 science" by Nowotny and Gibbons (Box 13.1).

Especially with regard to sustainability-oriented transformation processes, this new mode of science plays a decisive role (Wiek et al. 2012). Apart from traditional system knowledge (e.g., about the functioning of ecosystems, technological processes, or societal dynamics), there is a need for target knowledge about desirable futures and transformation knowledge that provides orientation for actors in the respective practical contexts of their activities (Fig. 13.2) (see Chap. 3 in this book).

Usually, actors outside academia are more likely to possess target and transformation knowledge – even if not formalized or generalized – which makes it necessary

Box 13.1: Helga Nowotny

Helga Nowotny (* 9 August 1937 in Vienna) is a sociologist with a focus on the interface of science and society, science and technology studies, and science policy. She published a number of books and journal articles on the topics of scientific controversies and technological risks, social time, coping with uncertainty, self-organization in science, and gender relations in science. Nowotny was Professor at the ETH Zurich and a founding member and president of the European Research Council. She has been and continues to be a member of many international advisory boards and selection committees in the field of science and research policy.

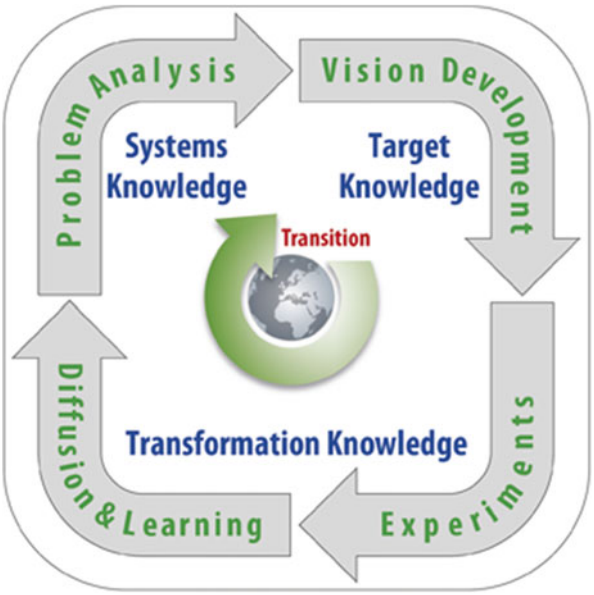

Fig. 13.2 Transition research including different forms of knowledge (Source: http://wupperinst.org/en/our-research/transition-research/)

to cooperate with these actors on an equal footing. The participation of nonacademic actors creates challenges for the design of research processes, but the field has developed a set of robust coping strategies (Bergmann et al. 2012; Lang et al. 2012). Forms of science that manage to integrate the different types of knowledge are referred to as transdisciplinary science.

3. **The institutional setting of science**. Whether the relevant fields of a sustainability science will be dealt with sufficiently and whether new forms and modes of knowledge production can be established depend to a large extent on the institutional framework conditions of the science system (Talwar et al. 2011; Lyall and Fletcher 2013). They determine what kind of research and which research fields are generally eligible for funding, and they also shape the incentive and reputation mechanisms, which provide orientation to scientists with regard to their selection of research questions and methods. There is considerable evidence that the existing institutional framework conditions of most national science systems hamper the development of sustainability science and researchers in this field tend to be marginalized (Jahn et al. 2012: 1). Science policy, therefore, plays a central role, because it has a significant impact on institutional conditions in the science system. In fact, it is the responsibility of science policy to guarantee that knowledge is produced, which helps societies to develop in more sustainable ways (Sarewitz 2009).

- ***Questions***:
  1. *Which kind of interplays can one differentiate between science and sustainability?*
  2. *What are the characteristics of these interplays?*

3 Institutional Reforms and Their Relevance for Supporting Sustainability Science

What research questions are dealt with by scientists? What methods do they apply? What type of research is being funded? All of these issues are decided in the context of established institutional settings: the incentive and reputation mechanisms in the science system, the way that financial resources are allocated, and the system structures by which politics influence the science system.

Currently, many of these institutional framework conditions hamper the development of transdisciplinary sustainability science:

- Incentive structures in the science system are organized within academic disciplines. Career pathways are determined by excellence in theory and methods of a scientist's respective discipline. Over the past decades, an integration of neighboring disciplines can be observed, especially between the natural and engineering sciences (see Simon et al. 2010, p. 9). However, building bridges between the natural and engineering sciences on the one hand and economic, social, and cultural sciences on the other hand was superimposed by the trend toward disciplinary specialization (Weingart 2014: 155 ff.), while interdisciplinary approaches across these fields are important for sustainability science. This is due to a lack of incentives, and scientists working at this interface usually do not have access to an academic career and established funding structures. Many countries have only begun to build long-term interdisciplinary research capacities (for the case of the UK, see Lyall et al. 2013). Particularly for transdisciplinary researchers in the field of sustainability science, this lack of incentives is more challenging and the institutional answers to it are quite at the beginning (see Yarime et al. 2012).
- There is a strong technological bias in private as well as public research funding. Technological solutions are an important element on the way toward sustainable development – if they are embedded in economic, social, and cultural developments in suitable ways. The focus on technologies of many research funding programs can be explained by the fact that direct economic opportunities can be expected from technological R&D projects. Over the last decade, research funding structures have largely served the development of technological innovations, which is in line with scientific findings that national economies can gain a competitive advantage by investing in innovations (see Fealing et al. 2011; Martin 2012; Knie and Simon 2010).

- ***Question***: *What are the main reasons for the importance of institutional reforms in the science system?*

4 The Nature and Impact of Science Policy

How can science policy influence the science and innovation system? The preceding section has shown that there are different institutional elements with an impact on scientific knowledge production, which may foster or hamper the development of transdisciplinary sustainability science. Not all of these institutional elements can be controlled and directed by the political process, e.g., reputation systems and relevance criteria in individual scientific communities. The field of science studies shows that epistemic communities in academia usually remain within disciplinary boundaries and evade nonacademic steering processes and thus also societal expectations (e.g., with regard to the development of transdisciplinary sustainability science) (see Gläser and Lange 2007, p. 441). Principles and routines of academic autonomy are a central element of the science system, which partly subverts or counteracts political steering efforts and which therefore needs to be balanced within new forms of science system governance (see Knie and Simon 2010, p. 36).

Nonetheless, science policy can exert influence on the science system in various ways, especially in national science systems that are mainly publicly funded – which is the case for most European countries and overall EU research funding.

It is thus worthwhile to take a closer look at science policy and the concrete policy instruments in this field. First, it can be observed that, over the past decades, science policy has increasingly been discussed together with innovation policy and that today, science and innovation policy have emerged as a common policy field: science policy and innovation studies (see Martin 2012, p. 1220).

Over the past 20 years, science policy has focused on the introduction of new steering instruments for scientific institutions and on the role of new actors at the interface of science, economy, politics, and society, the so-called intermediaries (e.g., policy consultancies).

Overall, an increase can be observed in third-party funding and, at the same time, a strengthening of academic autonomy through new steering instruments, especially at the level of governing boards of universities. This has led to universities becoming more "responsive" (cf. Jansen 2010, p. 47), i.e., they are better able to react quickly to external demands (e.g., developing in more market- and application-oriented ways).

Science policy could be utilized in such a situation by setting external incentives. This can be done in a number of ways (see also the following section for a more detailed discussion).

- Policy shapes *fundamental political paradigms* that provide orientation to the science system (e.g., "science as a driver for strengthening competitiveness," "academic autonomy," etc.). These paradigms have an impact on the activities and the topical focus of scientists and research institutions.

- *Funding policy* is a central starting point for political steering efforts. Through the allocation of financial means to specific research programs and institutions, the overall topical and methodological focus can be influenced.
- Established scientific institutions can be influenced by new *steering mechanisms*: e.g., indicator-based steering, target agreements, appointing advisory boards, or steering committees.

These science policy instruments range from the European level, across national policies, to the level of entities below the nation state level. The role and importance of the different levels vary according to the respective national science system structure. In Europe, at the turn of the millennium, the "Lisbon Strategy" has been of key importance. The EU has committed itself to the goal of becoming the most competitive knowledge-based economy and, to that end, to invest 3 % of annual GDP in R&D funding. As a result, steadily increasing budgets are available at the EU level for the so-called Research Framework Programmes. They are the central science political steering instrument at the European level. The 8th Research Framework Programme (2014–2020, "Horizon 2020") is explicitly addressing the grand societal challenges and, to some degree at least, seems to move away from a purely economic focus on increasing competitiveness.

At the national level and below, apart from program funding, instruments of institutional funding are available as well. These can be used by political actors to exert direct influence on the capacity of specific research areas. Furthermore, there are indicator-based incentive instruments, e.g., performance-based indicators, which can be used to measure a research institution's output (e.g., in terms of number of graduates or publications) and allocate funds accordingly.

With regard to all of these science policy instruments, an orientation along key societal challenges and issues of a more sustainability-oriented science plays only a minor role. A fundamental reorientation is needed.

- ***Question***: *What are instruments of science policy and how can they influence the science system?*

5 Science Policy for Sustainability Transitions

What would be the type of new science policy that could create better institutional framework conditions for a sustainability science?

As a first step, the *guiding visions of science* policy would have to change.

At the global level, efforts in this direction are made in the context of the large international science organizations' joint research initiative "Future Earth" (http://www.icsu.org/future-earth/). This research program places significant value on interdisciplinary approaches for dealing with global sustainability challenges and cooperation with nonacademic actors. The "coproduction" of knowledge and "codesign" of research projects are called for and supported by the Future Earth program. It will be a major challenge to implement these new guiding principles in national research funding programs.

Similarly, an orientation along grand societal challenges also characterizes the EU's 8th Research Framework Programme (Horizon 2020[1]). It thus goes beyond the strategy of the 7th Research Framework Programme, which centered on increasing the EU's competitiveness.

The new paradigm also has an impact on *research program politics*. The Horizon 2020 program will, for instance, cover a 7-year period and includes an expenditure of almost 80 billion euros. In order to preclude that the "grand societal challenges" are primarily defined from an economic perspective, it will be vital that civil society organizations have an opportunity to participate in the development of the program's details and concrete structure. Over the past years, there have been various initiatives at the European level that have aimed at a more profound involvement of civil society organizations in specific fields of research. An actual science policy instrument in this regard can be civil society research funds,[2] i.e., research funds that can be shaped to a significant extent by civil society stakeholders. Due to a relatively small volume and high barriers posed by the application process, these new approaches to research funding remained ineffective in the 7th Research Framework Programme.

Funding for transdisciplinary research – at global, European, or national levels and below – proves to be useful for fostering sustainability science when it includes *structural incentives*, e.g., aiming at the establishment of interdisciplinary structures at universities, new research institutions, and career opportunities in the field of inter- and transdisciplinary sustainability science. Internationally, a lot of initiatives can be identified that strengthen transdisciplinary approaches for sustainability science, i.e. the EPSCoR (Experimental Program to Stimulate Competitive Research) funding program of the National Science Foundation in the USA, which aims among other funding strategies especially at building interdisciplinary Sustainability Research Networks (SRN).

Another good example for devising incentives is the Asia-Pacific ProSPER.Net, an alliance of leading universities that encourage each other to integrate sustainability into courses and curricula. Within the network there is also a focus on developing indicators of a sustainable university to enable the measurement of concrete progress at the institutional level (see Fadeeva and Mochizuki 2010).

Eventually, *traditional steering instruments* should also be used to foster a reorientation along sustainability goals. Examples could be the integration of sustainability-related aspects into target agreements within universities or the definition of sustainability-oriented performance indicators. Some of the German "Länder" are currently experimenting with these kinds of instruments.

- ***Task***: *Please mention a few developments on European, national, and regional levels of the science system that support the orientation toward more sustainability.*

[1] http://ec.europa.eu/research/horizon2020/index_en.cfm

[2] http://ec.europa.eu/research/science-society/index.cfm?fuseaction=public.topic&id=1298

6 Drivers of Progressive Science Policies

Where do we see the most powerful impetus for sustainability-oriented change in science policy coming from?

Science policy is only slowly beginning to adapt to the demands of sustainability science. Therefore, it is interesting to see where the needed impulses for change could most likely originate. In Germany, the issue of sustainability is high on political and societal agendas (i.e., the so-called Energiewende), and this also influences the science policies. The German government has proclaimed that it will invest around 500mio€ per year in research programs for sustainability during the legislative period 2013–2017. This amount has increased continuously over the last few years and is an effort to translate the European demands for a science oriented toward the "grand challenges." Furthermore, the German Ministry of Education and Research has launched an overall initiative, "Sustainability in Science," to strengthen the research communities' own capacity for reorientation toward sustainability research, education, and management. The German case, therefore, can be an interesting case for identifying the key drivers of reorientation toward sustainability in science policy and the science system in general (cf. Schneidewind and Augenstein 2012; Schneidewind and Singer-Brodowski 2013).

Key drivers are civil society organizations, students, scientific foundations, and pioneer initiatives by individual "Länder" or research institutions, which utilize their autonomy in order to improve conditions for sustainability science:

One of the most important pressure groups calling for a change in science policy is made up of **civil society organizations**. For instance, a large number of German environmental and development organizations, churches, and labor unions founded a platform called "Forschungswende" in 2012. In May 2013, they published ten core requirements for a future science and research policy. The first requirement is more participation by civil society in science, for instance, by active involvement in the formulation of research questions and programs and participation in committees or boards of publicly financed institutions. These claims were also integrated in the German coalition agreement of 2013.

Civil society initiatives for sustainable development are also carried out by **students**. They can be important catalysts for change in universities, because they are not bound to institutional structures and routines. In contrast, students' creativity and openness can create a culture of change within universities. An outstanding example in this respect can be found in the UK. A study on attitudes of freshmen students and the impact of sustainability criteria on their choice of university (cf. Drayson et al. 2012), as well as a university ranking initiated by students, the "People & Planet Green League," has attracted substantial media attention and created considerable pressure on UK universities to improve their sustainability performance.

Foundations can be important actors supporting innovative orientations of universities and other research institutions. They can fund risky pilot projects and, by this, contribute to new forms of knowledge production and diversity in the

science system. This can also create momentum for change in science policy. Examples are the Stockholm Resilience Centre, which was founded by the Swedish Mistra Foundation, or the Mercator Research Institute on Global Commons and Climate Change (MCC), founded by the Mercator Foundation together with the Potsdam Institute for Climate Impact Research and the Technical University of Berlin.

In many countries, **entities below the national level**, e.g., the German "Länder," are responsible for universities and science policy. These entities can thus become important pioneers for a more sustainability-oriented science policy by utilizing available steering instruments, in order to achieve a paradigmatic and programmatic reorientation of their science policy. From 2011 to 2013, some of the larger German "Länder," such as North Rhine-Westphalia, Baden-Württemberg, and Lower Saxony, have made such efforts.

Finally, innovative **sustainability research institutes and pioneer universities** are important actors for a reorientation of science policy. They demonstrate potential and opportunities, which can be strengthened by politics, and thus provide important starting points for change. Due to its traditional heritage of environmental and sustainability policies going back to the 1970s and 1980s, Germany has a strong network of such pioneering institutions – ranging from independent sustainability research institutes (e.g., the Öko-Institut (Institute for Applied Ecology), the Institute for Ecological Economy Research (IÖW), etc.) to universities with a focus on sustainability issues (e.g., the universities of Lüneburg, Kassel, and Oldenburg). Over the past years, these institutions have increasingly cooperated in networks, in order to strengthen their pioneering role and impact on political agenda-setting processes.

Although good initiatives and drivers of a transformation in existing science policy strategies toward fostering sustainability science were illustrated mainly by the example of the German science system, at the international level many interesting endeavors can be observed as well. At the institutional level, the process of redesigning Arizona State University is worth mentioning (see Crow and Dabars 2014). Last but not least, the successful networks of civil society (i.e., the AASHE – Association for the Advancement of Sustainability in Higher Education) are important examples for driving the sustainability agenda forward in the science system as a whole.

- ***Question***: *Who are the key drivers of sustainability-oriented science policies in Germany and how do they take effect?*

7 Conclusion

Science policy can be a decisive driver for sustainable development in modern knowledge societies. However, in its current form, today's science policy is barely oriented toward this end. Thus far, only early attempts and experiments can be

observed in this respect, some of which have been discussed in this contribution. It is therefore important that science policy in general is discovered and further developed as an important policy field with regard to the goals of sustainable development.

Further Reading

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