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Science, technology and innovation in the context of development

An overview of concepts and corresponding policies recommended by international organisations



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Abstract

Beyond the impact that Science, Technology and Innovation (ST&I) have for creating knowledge-based economies, they may also contribute to social and ecological dimensions of development. This would require beneficial ST&I policies to be in place. While authors have studied single ST&I impacts, scientific overviews of the entire range of possible impacts of ST&I and its policies are currently still lacking. In our paper on “Science, technology and innovation in the context of development– an overview of concepts and corresponding policies” we therefore present different scientific models and conceptions of how ST&I contribute to different aspects of development. After a first introduction to ST&I in the context of development and the role of policies, we group scientific models and conceptions into three ideal-type categories: ST&I for economic development, ST&I for sustainable development and ST&I for inclusive development. In addition to outlining underlying scientific concepts, we focus on the recommendations for ST&I policies of OECD, World Bank and UNESCO that correspond to each category. In the concluding section, we discuss the role of the ST&I policy models issued by international organisations and discuss how far they are transferrable to developing countries.

Keywords: Science, Technology, Innovation, Science Policy, Sustainability, Social development, economic development

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Introduction: Science, Technology and Innovation in Development

Evidence suggests that those countries that are able to steer Science, Technology and Innovation (ST&I) processes towards knowledge-based economies enjoy more economic growth and prosperity than those who do not (Hornidge 2011; Bechmann et al. 2009). In addition, ST&I may also contribute to social and ecological dimensions of development through providing solutions for specific problems and by enhancing a knowledge base for self-determined development (among others Sumner et al. 2009; STEPS Centre 2010). However, the potential impacts of ST&I on society as well as their analysis are complex and take place on multiple scales. Additionally, there are potential negative side effects or drawbacks for parts of society. Therefore, it is no surprise that the study of ST&I and their relation with society have been of increasing interest to different social disciplines including development studies (J. Smith 2009).

In the here presented working paper, we discuss the different dimensions of ST&I and development. We start with an introduction on various conceptualisations of ST&I, development and their interrelation, before highlighting the role of international organisations in shaping worldwide views on ST&I and development. In the subsequent sections of the working paper, we then delineate the paradigms of ST&I policy until the 1990s, before we present different perspectives on ST&I along the dimensions of economic, environmental and social development.

Different conceptualisations of ST&I, development and their interrelation

Working with terms such as ‘science’, ‘technology’, ‘innovation’, ‘development’ or ‘sustainability’ is not an easy endeavour, given that each term is open to multiple interpretations and definitions. It therefore seems necessary to start our working paper with introducing our understanding of the concepts. The terms ‘science’ and ‘technology’ have spurred philosophical discussions on their nature and on the boundaries among them. Within the working paper, we follow Barnes (1982) in his findings of the increasing blurriness of the two concepts, and we propose not to differentiate between science as directed to produce new knowledge and technology as its practical application, but suggest their usage on equal terms: Clear-cut definitions between science and technology or applied and basic science fail in technology areas heavily based on science, such as biotechnology or nanotechnology (Rosenberg 1991).

Regarding the notion of ‘development’, we feel the need to point out that ‘development’ is a contested concept, which we do not mean to redefine in this paper¹. For the sake of operationalising it within this work, we acknowledge ‘development’ to be complex and multidimensional, including ecological, social and cultural dimensions next to the economic one. This also means that the notion of sustainability mobilised for this working paper does not only emphasise environmental sustainability but instead the triad of environmental, social and economic sustainability, with each of the three types building on and contributing to the other two with a long-term perspective of change.

Within different development paradigms, the role of ST&I and knowledge for development have varied. Often, concepts revolve around the idea of ‘innovation’, which currently is most frequently defined as the commercial usage of scientific findings, thus putting an emphasis on knowledge as a competitive factor. In this economic development perspective, technological innovation is often

¹ See Ziai (2011) for a detailed overview of concepts and contestations of ‘development’.

considered as a means of structural development of the economy. Many scientific authors emphasise the economic benefits of technological innovations in developing countries (among others: Conway et al. 2010; Lundvall et al. 2009). However, as we will see in the section on ST&I for economic development, the concept of economically focussed innovation has not been stable, but has been subjected to changes and refinements over time. Innovation is now depicted as a complex, multi-dimensional process, that can take place at different levels of analysis and whose interpretation depends on the field in which it is being used (among others: Henderson and Clark 1990; Crossan and Apaydin 2010; Tidd and Bessant 2011).

Beyond economic definitions, in the last decades alternative conceptions of innovation have emerged. Innovation from these alternative points of view refers to a novelty implemented in a specific context, or to the process of its implementation, which are not necessarily aimed at economic benefits (Röling 2009). Objects of innovation can be material phenomena, such as a technology, and non-material innovations, such as a new technique, or organisational or process-related changes, or social processes (Ul Hassan et al. 2011).

In contrast to the contribution that innovation can make towards economic growth, in alternative conceptions its ability to provide solutions for other problems is stressed. In general these approaches adopt a more holistic view on the phenomenon of innovation for development and strongly emphasise the notion of ST&I for poverty alleviation, social justice and/or environmental sustainability. In contrast to the economic view, these alternative models point towards broader institutional, cultural and social dimensions of the innovation process which should be taken into account next to the economic and technical ones (STEPS Centre 2010; Hornidge et al. 2011). Thus, the approach to innovation focused on economic growth is challenged to consider more inclusive innovation pathways.

Alternative innovation concepts also highlight the importance of knowledge sources beyond those coming from science and technology, for example bottom-up grassroots innovations. Here the Indian Honey Bee network is a good example of innovations based on the creativity and traditional knowledge of marginalised people (Arocena and Sutz 2012; Leach et al. 2012). Another example is the green belt movement in Kenya with its famous representative Prof. Wangari Maathai². While we acknowledge the transformative power of these non-scientific innovations, in this working paper we focus on innovation as an outcome from science and technology and on the processes and interactions between them that potentially contribute to development. We also focus our work rather on the scientific inputs within the innovation process rather than on its application side.

The role of international organisations in shaping views on ST&I and development

In the context of fluid and changing definitions of ST&I³, the aim of this working paper is to consider how different contemporary conceptualisations of ST&I address different aspects of development, and how specific conceptualisations of ST&I are reflected in policies and policy recommendations⁴ in international organisations such as the OECD, the World Bank, and UNESCO. To achieve these objectives, on the one hand we review different scientific models and theories that relate ST&I and development. On the other hand, we delineate which concepts of ST&I have been taken up within

² Please see <http://www.youtube.com/watch?v=DM0275Uqiho> for an introductory video.

³ Shifting definitions and labelling uncertainties are also reflected in the research field's name dedicated to study such processes, shifting from "science policy studies" to "innovation studies" or more recently "science policy and innovation studies" in order to grasp both the original meaning of the term and the most recent theoretical knowledge in the field (Martin et al. 2012)

⁴ We will thus focus on the **policies** as contents of political actions, which manifest themselves in strategies, programmes, or measures (Blum and Schubert 2011).

worldwide political discourses, manifest in reports or policy recommendations of these three influential international organisations. Consequently, we do not base this working paper on an empirical evaluation of implemented policies in specific countries. Based on the two types of sources - scientific literature as well as the documents by international organisations - we order the main models for ST&I and their promotion in three ideal-type categories, which can mainly be related to one of the dimensions of development: the economic, the environmental and the social sphere. Of course these categories in reality are intermixed; ST&I policies usually include many objectives and priorities. By ordering scientific approaches and policies in three categories we also do not aim to establish a priority of one category over the other. On the contrary, we believe that in order to reach long-term sustainability, concepts as well as policies should touch upon all three dimensions of development or sustainability – economic, environmental as well as social.

Following Ruivo (1994), we propose to regard the different conceptualisations as paradigms of ST&I policy, which emerge in discursive processes. Manifesting themselves in “policies, speeches and mission statements”⁵, a discourse provides a perspective, a certain interpretation of the world, and “define[s] paths of action, containing in their problem-statements certain kinds of solutions” (Cornwall and Brock 2005: 1047). Discourses thus help to establish certain ways of framing problems. Viewing policy-making as shaped by interests, subjected to dominant discourses, helps to understand why alternative paradigms – those not focussed on economic dimensions – do not easily gain momentum in the capitalist world economy and thus do not easily enter concrete policies (among others: Sutton 1999; Keeley and Scoones 1999; Hajer 2006)

Reason for examining the World Bank’s, OECD’s and UNESCO’s standpoints on ST&I policies is that as international organisations, they contribute to a dominant discourse on ST&I and development and set the scene for national policies: UNESCO-, OECD- and World Bank-programs and agendas guide many national governments in their decisions to follow specific models for ST&I policies in order to trigger a certain type of development. Studies suggest that international organisations play an important part in spreading particular paradigmatic ways of viewing ST&I and their importance for certain dimensions of development (Ruivo 1994).⁶

All three organisations consider it part of their mandate to advise national governments regarding ST&I policy options and their impact on development (OECD 2013a; World Bank 2013). Their advice and recommendations are highly influential. Albert and Laberge (2007) trace how governments attribute authority and power to OECD experts, which led to the dissemination of the idea of innovation systems into national policies, as promoted in OECD publications such as the biannual *OECD Science, Technology and Industry Outlook* last published in 2012. The report draws upon the OECD’s extensive data collection on ST&I and aims at informing policymakers world wide about current trends (OECD 2012a). Henriques and Larédo (2013) show the OECD’s impact on member countries as well as on non-member countries, not only in terms of science policy concepts, but in innovation policies as well. The authority attributed to the OECD is evidenced by the request of non-OECD countries to have reports written by OECD experts on their national innovation systems. Examples of these are Chile, China, Korea, Mexico, South Africa, among others⁷.

The World Bank, as a further organisation to be considered here, strongly influences development countries’ policymaking. The World Bank has long recognised the role that ST&I can play for enhancing development, including sustainable growth and poverty reduction. Since the 1970s, the Bank has carried out ST&I capacity building programmes in emerging economies and developing countries (World Bank 2008), and it brought ST&I and knowledge on the international agenda in its

⁵ Within the scope of this working paper, we focus on discourse represented in documents, and do not examine actions and practices of the organisations, which of course are part of their overall discursive model of the world.

⁶ Within this working paper, we focus on the views established by international organizations forming part of a larger discourse on ST&I and development. We do not touch on other aspects of international organisation research, such as how these are organized, structured or interacting.

⁷ For a list of countries and reports, check <http://www.oecd.org/sti/inno/oecdreviewsofinnovationpolicy.htm>.

1998/99 report on *Knowledge for Development* (World Bank 1999). In this last document the World Bank emphasised the role of ST&I and knowledge as economic factor of growth and proposed to include knowledge in development strategies, in order to 'catch up' with developed countries. Although discussed controversially, the report has been influential in establishing the notion of knowledge for development on the agenda of national and international development policy and theory (Evers et al. 2006). In addition, the World Bank carries out global forums to address the needs for developing countries to build ST&I capacity and to create an action plan for their ST&I capacity building measures (World Bank 2010a). ST&I capacities are seen as a tool to "achieving each country's priority social and economic development objectives" (World Bank 2010a: 3).

A further organisation active in terms of ST&I policies in developing countries and emerging economies is the UNESCO. Describing itself as "the principal agency in the UN system with a mandate for the promotion of science and technology" and as a "think tank on policy development" (UNESCO 2008: 0–1), the institution has promoted the inclusion of science policy in governments around the world, and helped to institutionalise it with their post-WWII efforts (Finnemore 1993). UNESCO creates individual country reports on ST&I policy, supports regional ST&I initiatives and publishes recurring *UNESCO Science Reports* and *World Social Science* reports (Brito and Schneegans 2010; ISSC and UNESCO 2013). Although the organisation had a pioneering role to introduce ST&I on governments' agendas, nowadays on a global level its role is much more descriptive than normative: UNESCO works on inventories of existing ST&I policies worldwide in their initiative entitled 'Global Observatory of Science, Technology and Innovation Policy Instruments' (UNESCO 2013a).

Paradigms of ST&I Policy until the 1990s: from Science Policy to Innovation Policy

In essence, definitions of science policy refer to the set of policies directed towards the research community and the development and use of knowledge. Sarewitz et al. for example define it as

“the decision process through which individuals and institutions allocate and organise the intellectual and fiscal resources that enable the conduct of scientific research” (2004: 67).

The interpretation of science policy and what should be considered as such has been changing over time. In a comparative analysis on implemented science policy, Ruivo (1994) traced similar patterns that she considered to be paradigms. Inspired by Kuhn’s approach to scientific revolutions, Ruivo argues that there have been different dominant ways of organising research systems in different periods of time, which are influenced by the action of international organisations. Up to the 1990s, she suggests three main paradigms: ‘science as a motor of progress’, ‘science as a problem solver’ and ‘science as source of strategic opportunity’ (Ruivo 1994: 162).

The first paradigm emerged during the post-war period, when science was considered to be a key ingredient for progress. The US-government declared its need to strongly support science for achieving different economic and social goals (Arond et al. 2011). This strong importance given to research, mainly basic, was later to be known as the ‘science push’ model of innovation, which assumes that the creation of scientific knowledge, irrespective of whether it can be immediately applied or not, creates positive effects in society. Following this paradigm, the US became the leading country to invest into scientific knowledge production, mainly focused in advancing military and nuclear technology, later embracing space research as well (Ruttan 2001; Mattelart 2003). Among the traditional science policy initiatives, one can find the creation of Science and Technology (S&T) institutes, the investment in Research and Development (R&D), the selection of national research priority areas, as well as the general support of scientific knowledge production (Lundvall and Borrás 2005).

The ‘science push’ was followed by a ‘problem solving’ paradigm, characterised by a reversal of the previous tendency: The strategic priorities now were more directed to solve problems, crack technical challenges, and to contribute to economic growth. The model for explaining technological change is named ‘demand pull’, since the role of basic research was no longer the principal originator of innovations: At the end of the 70’s the science and technology policy model relied on market and industrial demands for innovations. The model drew on statistics supporting the importance of the demand to attract most capable innovators to work in problems of diverse technological sectors (Schmookler 1966). Later more research showed that both demand and offer are important factors for innovation to take place (Mowery and Rosenberg 1979).

The third paradigm, ‘science as a source of strategic opportunity’, shows how states strategically linked the outputs of their research system with general national policy objectives, for instance international competitiveness, through the rise of international research collaboration and promoting interface or transfer institutions for disseminating knowledge from academia to other actors (Ruivo 1994). Most importantly, the key difference lies in the conceptualisation of how technological change takes place. This paradigm leaves behind the linear view, adopting a more complex and interactive approach, though still centred on the research system.

These three paradigms explain different approaches in science policy up to the 1990s. At the same time, a terminological change has taken place from the 1970s onwards that has brought a conceptual variation with it as well: The stand-alone use of the term ‘science policy’ has been in decay. It has slowly been embraced within the broader term ‘innovation policy’ or ‘science, technology and

innovation policy', or other variants where innovation plays a central role. Although innovation has been among the objectives of science policy since the 1970s, now there is a stronger focus on the policies for innovation (Weingart 2011: 20). The entrance of innovation in the agenda of science policy paved the way for a new paradigm, which embraced the previous ones, but also went beyond the focus of science policies and the analysis of research systems. These changes were expressed through the idea of the 'innovation system' (Freeman 1995; Lundvall et al. 2002), which underlies the current 'economic innovation' paradigm and will be explained in detail in the section on ST&I for economic growth.

After this historical review of the main conceptualisations of ST&I and corresponding policy approaches, we picture the current economic, social, and ecological ST&I policy paradigms in the following sections. Within each section, we first review the scientific models and theories of ST&I that underlie the corresponding paradigm before outlining how these have entered the discursive level of policy recommendations in the World Bank, OECD, and UNESCO. We are aware that the categories used in this working paper for the sake of typologising the existing scientific approaches and ST&I policies are of ideal-type nature, and that these are interlinked in reality. It is interesting to note however, that only very few scientific models, let alone policies, manage to come up with a model adequately integrating economic, social and ecological dimensions of ST&I impacts.⁸

⁸ See Leach et al. (2010) for a scientific approach combining environmental and social aspects of ST&I.

The Dominant Paradigm: ST&I for Economic Growth

Economic growth lies at the heart of most countries' development strategies. As such, it is not surprising that ST&I policies shall contribute to such broader aims. Knowledge and innovation are considered to be the key for economies to become competitive on the world market (Drucker 1993). Focused on competitive technological change as driver of development, many developing countries follow economic innovation thinking as a 'standard recipe' of growth, which is based on the idea of a free market economy and on a top down policy promotion for technology production (Röling 2009). The idea of the interlinkage between development and ST&I gained prominence in the 1960s, when scholars started to postulate that differences in worldwide development were rooted in technological differences, and that technological capacities needed to be developed in order to close the technological gap and to stop countries from 'lagging behind' (Fagerberg and Srholec 2009).

Conceptually closely related to science and technology-based economic innovation is the concept of the knowledge society, which is assumed to emerge as result of technological developments. Most concepts of the knowledge society focus on the economic aspects, but at the same time they stress the crucial role of information and communication technologies for distributing and diffusing knowledge (Hornidge 2011).

Scientific models of economic innovation

The Austrian economist Joseph Schumpeter originally introduced the concept of 'innovation' in the 1930s. He defined innovation as a new combination of factors that lead to a commercial or industrial application of a new product, process, or the opening of a new market, the conquest of a new supply source or an organisational change (Schumpeter 1934; Fagerberg 2006). Since Schumpeter, the concept has undergone constant redefinitions. For a long time, 'linear models of innovation' were in use, suggesting that the process from idea to product is a straightforward one: new knowledge is created in a laboratory and then transformed (though with feedbacks from the market) into a product. In the 1980s it became clear that technology was not something simply available to everyone as an external input, developed in a mechanical way as neoclassical economics assumed (Nelson 1995). Instead of having a mechanistic and simplistic understanding of technology production, the evolutionary school of economics argued that economic change could be explained as an evolutionary process (using the biological metaphor), where technology and innovation process play a crucial role (Nelson and Winter 1982). This was reinforced by the interactive innovation model (Kline and Rosenberg 1986) that debunked the idea that there was always a simple and linear connection between knowledge production and its posterior application. In its place it gave more attention to different interactions, feedbacks and exchanges of information that take place in every innovation process; in which S&T are not necessarily the main source of knowledge, but just one part, though still important, among others.

Nowadays, thinking in terms of innovation systems, a concept developed in the 1980s by scholars such as Freeman and Lundvall (Lundvall et al. 2009), is the most wide spread approach. However, there is no unified accepted definition of an 'innovation system' (Fagerberg and Srholec 2009). According to Edquist (2005), it is broadly understood as any system where actors, both private and public, interrelate with the aim of producing technological innovations and where learning plays a central role. One of the keys is that innovation is no longer seen as an isolated phenomenon that emerges only inside certain organisations, but rather it is a social one, where several actors and institutions intervene. Of course, the system approach implies that the connections, their strengths and densities are relevant to understand the structure and features of a given system under analysis.

A more functionalist definition stresses that such a system has an aim followed by all the factors that contribute in one way or another to the innovation process (Edquist 2005). Despite the variants, the firm is the main actor in the innovation system approach where innovations take place, though universities, governments and other organisations are considered too; in these actors the approach raises awareness about their learning skills, both explicit and tacit knowledge, their capacity to interact and to deal with institutions in several scales (Lundvall 2007). Different variants of the innovation system approach appeared, such as 'national innovation systems' (Nelson 1993), 'sectoral innovation systems' (Malerba 2002), and 'regional' or 'local innovation systems' (Cooke et al. 1997), where the difference lies on the demarcation of the geographical boundaries of the system to study (Carlsson et al. 2002). In addition, a 'technological innovation systems' approach emerged, where instead of delimiting the system by geography, it is demarcated by the technology or group of technologies of interest (Carlsson et al. 2002). Another recent variant is the 'systems of innovation functions' approach, which elucidates central elements of the system that are quantified and assessed in view of designing policy interventions (Hekkert et al. 2007).

The expansion of the innovation system concept has been influenced by activities of epistemic communities. One such example is the so-called 'Globelics - The global network for the economics of learning, innovation and competence building systems'⁹, pioneered by Lundvall. The worldwide network aims to discuss innovation from an academic perspective. This suggests the influence such concepts have had in attracting academic attention, which at the same time might be influencing its adoption in policy circles in each country and region.

Although the innovation system idea has widely spread within science and policy communities, there is no absolute consensus about the overall validity of the model. As Weingart (2011) notes, there is a gap between the complexities of an innovation system and the capability or incapability of science and innovation policy to comprehend the logics of the system and set policies accordingly.

International organisations

OECD

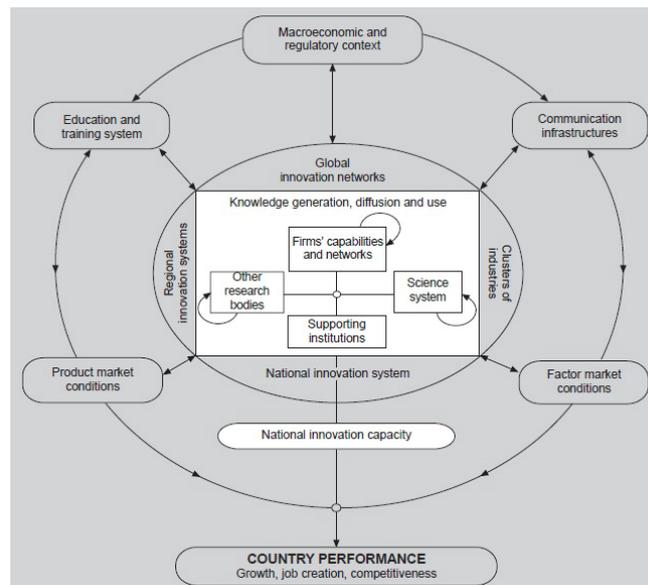
The OECD is considered one of the pioneering international organisations disseminating both science policy and innovation systems concepts for economic growth (Lundvall and Borrás 2005; Henriques and Larédo 2012). The organisation describes its mandate as follows:

“The OECD Directorate for Science, Technology and Industry (STI) develops evidence-based policy advice on the contribution of science, technology and industry to well-being and economic growth” (OECD 2013a).

Figure 1 is an early example of the OECD conceptualisation of the innovation system. The picture's message is clear: All elements contribute to economic growth in one way or another, increasing job opportunities and competitiveness. This is said to be produced by the interaction of firms with supporting institutions and research organisations, where networks, national and regional innovation systems, clusters and market conditions, among others, all appear as dimensions to be considered in their analysis. The concept takes into account the differences among countries in several dimensions, such as population, knowledge base, industrial specialisation, among others, that have been captured in statistics as a way to measure the relative differences and comparisons among OECD members (OECD 1999).

⁹ <http://www.globelics.org>

Figure 1: Actors and linkages in the innovation system



Source: OECD 1999: 23.

Since the 1990s, the OECD has continued to emphasise the importance of innovation for growth. The *OECD Innovation Strategy* states that “[i]nnovation is a key driver of growth performance, and its contribution to economic growth is likely to increase” (OECD 2010: 25). The publication furthermore illustrates the OECD’s view on innovation as a silver bullet to solve challenges in the context of the European crisis. In the report, five pillars are identified for innovation support. First, capacity development through training and education, the diffusion of entrepreneurial skills and more participation of users and consumers in innovation processes that are considered to be necessary to empower people to innovate. Second, it affirms that states should assure financial and framework conditions necessary for innovations to flourish, like fostering open markets, taking risks, promoting innovation in small and medium sized firms and private finance for innovation. Third, the report stresses knowledge creation and usage, where knowledge is mainly of scientific and technical sort, considering its diffusion, its use in public sectors and mentioning the importance of having an efficient system of intellectual property rights protection. Fourth, international research cooperation, the application of innovation to address global challenges and technology transfer to lower income countries are mentioned, while the last pillar highlights the need to include innovation policies at every level of government, to measure it and apply evidence-based policy making and evaluation.

World Bank

Similarly to the OECD, the World Bank describes its tasks in view of ST&I policies as:

“The mission of the Science, Technology and Innovation (STI) team is to help identify, design, and implement science, technology and innovation capacity building policies and programs, based on global experience, which are essential to generate wealth in today’s increasingly competitive global economy and which are tailored to each country’s social and economic development challenges” (World Bank 2013).

The World Bank recognised the importance of knowledge for development quite early: In 1996, the World Bank President, James Wolfensohn, rebranded the bank from a ‘lending bank’ into ‘the knowledge bank’ (King and McGrath 2004; Hornidge 2012). In 1997, and with reference to the G-7

Global Information Society meeting in Brussels in 1995 as well as the Information Society and Development conference in South Africa in 1996, the Global Knowledge Partnership then organised the first Global Knowledge Conference in Toronto, Canada (Global Knowledge Partnership 1997a). The conference brought together the global development and donor community, government and planning officials from developing countries, non-governmental organisations and the private sector with the aim to discuss “the role of the ‘information revolution’ in the development process” (Global Knowledge Partnership 1997b).

Inspired by these predecessors, the idea of ‘knowledge’ being a key element of successful development cooperation and poverty alleviation culminated in 1999 in the publishing of the World Bank report entitled ‘Knowledge for Development’. Envisioning a future saturated with knowledge and knowledge application, the report states: “Knowledge is like light. Weightless and intangible, it can easily travel the world, enlighten the lives of people everywhere” (World Bank 1999: 1). With this report, the notion of ‘knowledge’ as driver of development, and topic of debate since centuries, reached the summit of global (donor-driven) development discourse (for details, see Hornidge 2012). Since then, quite a number of World Bank publications have dealt with topics related to economic innovation, mostly framed by the knowledge economy and economic innovation system thinking. These include for example titles such as: *World Bank support of science and technology development* (Goel et al. 2004), *Promoting innovation in developing countries: a conceptual framework* (Aubert 2005) or *Building knowledge economies: advanced strategies for development* (World Bank 2007). In 2010, *Innovation policy: A guide for developing countries* was published (World Bank 2010b).

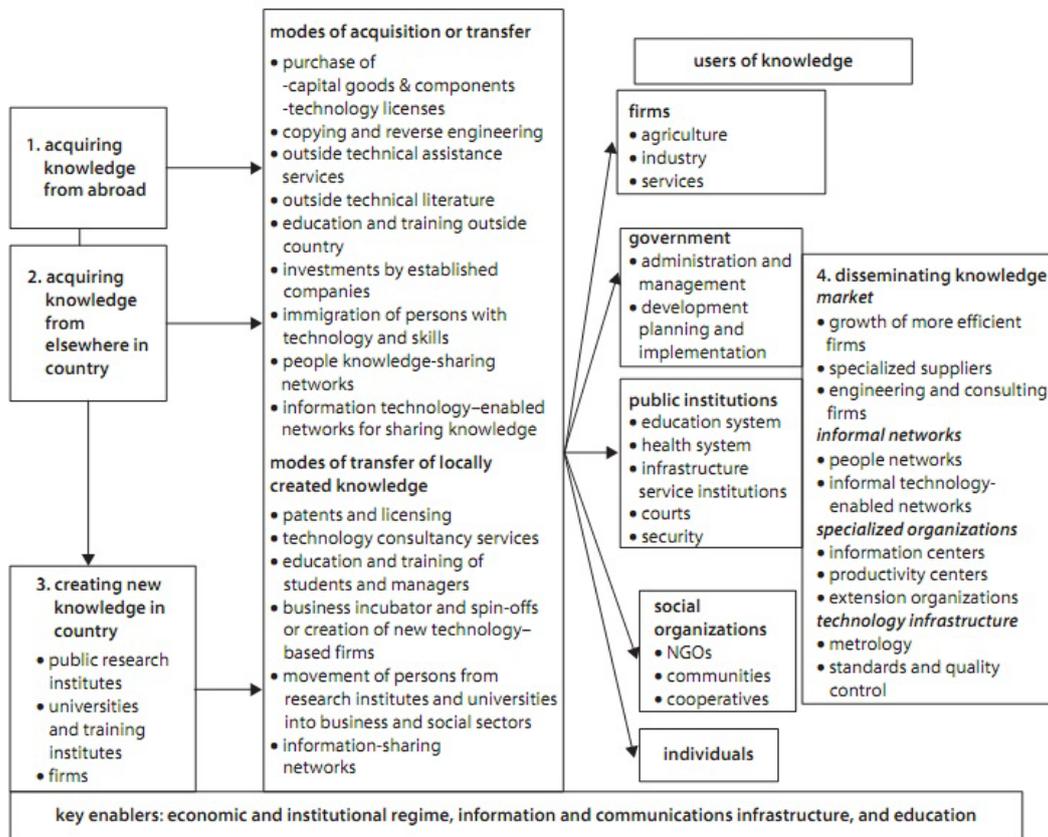
The World Bank’s conceptualisation is thus a clear example of how science policy has been extended towards an innovation policy concept. For example, in a recent report directed to policy makers in “developing countries” the bank states that innovation policy is

“broader than, and different from, science and technology policy, with which it tends to be merged. It also takes place as part of an overall trend toward knowledge-based economic strategies. Innovation policy requires action in many different policy areas—education, trade, investment, finance, and decentralisation, among others—and it is the right combination of interventions in these diverse domains that creates a fruitful innovation climate” (World Bank 2010b: 9).

The last part of the quote reveals a perspective different from the OECD, in the sense that besides the importance of firms, the role that governments play in innovation is more explicit. The World Bank recognises the increasing complexity of innovation policies, and aims to situate them as a policy that crosses several governmental bodies, arguing in favour of an active governmental stance in the support of innovation (World Bank 2010b). This can be seen in the use of the peculiar metaphor of the government as gardener. In essence, such a gardener is said to be in charge of: fostering entrepreneurs by giving the needed resources (“watering”); removing barriers (“controlling weeds and pests”); supporting research (“fertilizing”) and education (“preparing the ground”) (World Bank 2010b: 2). While the report highlights the importance of a research system where the results of S&T are as relevant as their transfer into practical applications, it also highlights the role of the government to remove barriers against innovative projects such as excessive bureaucracy or intervening against interests that block the development of innovations; and to actively promote entrepreneurs. The World Bank underlines the importance of efficient institutions for innovation systems to work. Here they stress that agencies working with innovators should be flexible to meet their demands, they also speak of the need of having a centralised coordination governmental body; and finally the importance of having a wide array of financial and stimulus instruments.

To clarify the approach recommended in one of the World Bank’s reports, figure 2 offers a synthesis of its conceptualisation on how knowledge is created or acquired in developing countries.

Figure 2: World Bank conceptualisation of innovation in developing countries



Source: World Bank 2010b: 59.

Interestingly, the scientific generation of knowledge for innovation only plays a minor role in the World Bank’s conceptualisation. Developing countries supposedly firstly should rely on knowledge transfer from more “developed” countries. Also, the conceptualisation is still very linear. Feedback loops – or consumer-interaction in the innovation process do not occur, thus this long-known opportunity of enhancing user adoption is neglected (Lundvall 1985).

UNESCO

In the UNESCO science reports, UNESCO’s country studies, or its regional reports and initiatives such as on *National Science, Technology and Innovation Systems in Latin America and the Caribbean* or the *African Science, Technology and Innovation Policy Initiative* (Brito and Schneegans 2010; Lemarchand 2010; UNESCO 2008), the UNESCO stresses the worldwide importance of knowledge in form of applied technological research and development for economic growth.

The UNESCO science reports give a worldwide overview of ST&I in the world. In the last report (2010), ‘science’ includes natural sciences as well as applied sciences such as clinical medicine, engineering and technology. It contains country chapters and regional sections which describe national and regional ST&I landscapes – including statistical data such as investments in R&D, number of patents etc. – and give recommendations for ST&I policies aimed at strengthening the respective national innovation systems.

The report exclusively considers the role of ST&I for economic development, opening with a chapter on “the growing role of knowledge in the global economy”. The conceptualisation of innovation is

thus a narrow one: It is a purely economically defined concept, based on the traditional paradigm of innovation as result of technology-oriented research which is transferred into a product. Different conceptualisations of ST&I and different dimensions of development next to the economic one do barely enter the report.

Regarding the role of developing countries in the global ST&I context, the report states that

“the old notion of a technological gap can today be considered a blessing for those economies possessing sufficient absorptive capacity and efficiency to enable them to exploit their ‘advantage of relative backwardness’. Countries lagging behind can grow faster than the early leaders of technology by building on the backlog of unexploited technology and benefiting from lower risks” (Brito and Schneegans 2010: 25).

The report thus recommends these countries to „improve their absorptive capacity and remove any ‘barriers’ preventing the flow of positive technological spillovers from technologically leading economies, be they from the North or South“ (Brito and Schneegans 2010: 26).

In addition to the science reports, national country studies are elaborated for member countries which seek the UNESCO’s advice on ST&I policies and ST&I systems (UNESCO 2013b). The underlying assumptions of how ST&I and ST&I policies impact development according to UNESCO can be abstracted from some exemplary country reports, such as the country report for Brunei (UNESCO 2005). It is an example for a strategy of ST&I and ST&I policies targeted purely at economic aspects of development. In the report, UNESCO explicitly draws upon the OECD’s concepts of innovation “as the key to long-term competitiveness”, thus as a motor of growth (2005: 7). The recommendations given are based once again on the national innovation system model, which are thus aimed at strengthening its governance and set up.

Discussion

ST&I policies targeted at economic development

The changes in scientific conceptualisations of ST&I have gone hand in hand with modifications in science, technology and innovation politics. Based on concepts of the knowledge society or economic innovation, governments design concrete policies as a part of a national development agenda (Hornidge 2011). For a long time, ST&I policies were mainly grounded in linear models of innovation. Although this model has been criticised for its linearity, it is still used in the design of policy instruments and in general in ST&I policy making in several countries (Godin 2006; Albornoz et al. 2010). Currently, the innovation system model underlies many ST&I policies (Freeman 1995; Lundvall et al. 2002). This is also shown in our analysis of OECD, UNESCO and World Bank, who rely on the innovation system model in their conceptualisations.

Empirical analysis carried out on innovation policies following the national innovation systems model has found that policies tend to emphasise and support the interaction of all actors in the innovation system. Related to innovation system thinking, ‘triple helix’ policy models affirm that the state, universities, and firms are in mutual interaction, which are seen as the engines of growth of an economy (Etzkowitz and Leydesdorff 2000).

Instruments to support innovation policies for economic growth are horizontal in nature. They mainly aim at strengthening the interaction among different types of actors, promoting learning and organisational innovations as well as passing laws and regulations, among others. Instruments can be directed at all levels and actors within innovation systems, or at strengthening links between them (Kadura et al. 2011). But the support is also mixed with vertical and market stimulating policies. This wide policy mix is also one of the reasons why science and technology policies can be understood as subsets of the more general innovation policy approach (Lundvall and Borrás 2005), or also as a set

of interdependent policies (Stehnken 2010). To have an idea of the main instruments that have been applied to strengthen innovation systems, it is useful to look at surveys spearheaded by UNESCO on ST&I policy around the world to recollect such information¹⁰. The UNESCO Science Policy Indicator Network, which started as an initiative on Latin America and has now been extended globally (UNESCO 2013a), defines and orders innovation instruments in different categories. As the production of knowledge lies at the heart of many instruments for innovation policies, funds to finance and stimulate S&T in universities and private companies are seen as key. A second relevant factor is capacity development on the level of research in order to create human resources for innovation processes. At the national level, several instruments such as focalised funds have been detected that aim to develop specific strategic technology areas. Examples are ICT, biotechnology and nanotechnology. Assuming that firms play an important role in the innovation system, many instruments are directed at promoting innovation and business competitiveness; including a range of financial mechanisms and incentives for innovation projects. Further instruments are directed at strengthening networks across the actors of innovation systems. Examples include the creation of knowledge clusters or the promotion of public and private partnerships between research institutions and firms to increase knowledge transfer and application. Another set of mechanisms focus on the construction of regulatory frameworks in innovation systems. This includes laws that institutionalise the support for innovation activities, control and extension of property rights, among others. And, last but not least, several instruments target the improvement of information systems on ST&I and to conduct foresight studies that could help to adapt to future changes (UNESCO n.d.)

Critique

The innovation systems approach can be criticised from different perspectives: As evolutionary development approaches, the innovation system approach can be accused of diffusing a general recipe to achieve economic growth, where the research system, in interaction with firms and the state, assure that the country will reach and/or keep a 'developed' state. In a crude way, this approach tries to emulate the societal energy that can be found in the US, where a wealth of technology entrepreneurs are one of the essential resources to have an innovative and growing economy, such as Japan, the East Asian 'tiger states' or Israel (Fagerberg and Godinho 2006; Nelson 1993).

Another point of criticism of the approach is that it considers private firms as most important agents of innovation, which is not always the case. The state or other civil society organisations can be innovative as well: The approach underestimates the role of national or transnational NGOs or social movements in the generation of technologies and innovations, which are relevant in some developing countries, such as for instance environmentalists or free software promoters (Mulgan et al. 2007).

Another critique is the request for developing countries to set up appropriate intellectual property rights systems that encourage innovation processes (OECD 2012b). This is a debatable point, challenged by many local and also global movements in favour of open access, such as the free software foundation¹¹. A further known struggle in the context of intellectual property is the one between pharmaceutical multinationals who want to limit the diffusion and production of needed cheaper generics in medium and low resource scarce countries (t' Hoen 2002).

Finally, in the context of developing countries, the informal economy and the particular innovations that take place there do not enter the picture, while these are central to many medium and low income countries. Therefore, despite the successes of the innovation system approach, there is still much room for improvement and search for alternatives in developing countries (Dagnino 2002)

¹⁰<http://www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/global-observatory-on-policy-instruments/>

¹¹ For more information about its philosophy and practice see <https://fsf.org/>

Beyond these entry points of criticism, a more fundamental question concerns the main aim of the model - the exclusive promotion of economic growth. As general development debates show, many other spheres of development have to be taken into consideration, such as the environmental consequences of growth or negative social consequences that some innovations might have. Alternative thinking on ST&I has not entered mainstream policy making yet. However, conceptualisations of innovation for sustainable development or for other development aspects, such as inclusive innovation are currently gaining momentum, as manifested in the OECD recommendations for inclusive innovation (Paunov 2013) or other non-economic (or at least not exclusively economic) conceptualisations of ST&I and ST&I policy. New approaches of ST&I address the challenges that deal with two main aspects that previous models ignore: The first one is related to the environmental crisis in which the world is. The second one is associated with the ignorance that the traditional innovation system approach shows towards resource scarce actors that cannot enter into the innovation dynamics theoretically described. These alternatives are explained in the following sections.

ST&I for Sustainability

One central criticism to the innovation systems approach is that it does not consider the direction, objectives or politics of innovation – besides triggering economic growth. In this specific section, alternative concepts are described that were developed addressing the lack of consideration of environmental issues in traditional innovation models. As alternative conceptions to the mainstream paradigm of innovation for economic growth, they are not broadly implemented policies yet, but rather to be seen as critique of mainstream policy.

Sustainability issues are of increasing public concern and remain high up on the agenda of policy makers, at least at the discursive level. A few related terms which connect innovation with sustainability have come into usage. Terms such as ‘green economy’, ‘eco-innovation’, ‘green growth’, and other variants appear in official documents of international organisations as well as governments. These alternative concepts of sustainability-oriented innovation have to be seen in the larger context of environmental thinking, such as ‘ecological modernisation’ and ‘sustainable development’.

The idea of ‘ecological modernisation’ aimed at fostering environmental reform in society, can be traced back to the mid-1980s. On a conceptual plane there are different ways of understanding it, for instance as a social theory or as an alternative discourse (Buttel 2000; Hajer 1995). The discourse includes different strands of knowledge like ‘industrial ecology’, ‘cleaner production’ and ‘industrial metabolism’ (Mol 2010). The approach is based on a positive belief in the power of S&T, building on the fact that many technologies have an environmental bend. In this vein, biotechnology is pictured as a promise to feed a growing world population of almost 9 billion people in a sustainable way (Borlaug 2000), or nanotechnology pictured as promise to improve the environment. In part, remediation technologies are already reality (Tratnyek and Johnson 2006). In addition, the importance of renewable energies to mitigate the dependence on fossil fuels is growing. German policy and implementation are often counted as a good example of a conscious transition towards renewable energy technologies (Leggewie and Messner 2012).

The second, more influential concept was ‘**sustainable development**’ whose origin can be traced to the publication of the *Brundtland report* (WCED 1987). For the first time international organisations replied to the growing concern and claims by civil society and activist groups over the effects of technological developments and its consequences in industrialised countries, like the green revolution, nuclear power, or oil crisis, among others. The concept of sustainable development, originally defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987: 41), got installed in the global agenda in the first Rio conference that took place in 1992. It mobilised worldwide efforts and agendas towards such aim, nevertheless not always with results matching expectations (Unmüßig et al. 2012). In the report, the development of S&T capabilities in developing countries was considered as a way to deal with environmental challenges (WCED 1987).

Both ‘sustainable development’ and ‘ecological modernisation’ have been conceptually criticised for achieving scarce results and being technocratic (Hopwood et al. 2005; Wright and Kurian 2009). Nevertheless, sustainability became a wide-spread idea, in tune with the increasing international environmental concern.

Scientific models and approaches to ST&I for sustainability

Innovation research has become active in developing approaches to address transitions towards sustainability. Several strands of research, which emerged in the last 15 years, can be identified

(Markard et al. 2012), focusing on different levels of ST&I, ranging from the system level to research practice.

Until today, no innovation systems – or national ST&I policies – focussed exclusively at transitions towards sustainability exist in practice yet. The models developed thus are of ideal type nature. In addition, transitions research always has a normative dimension. It shows pathways of change that are considered desirable in the sense of sustainability. The approaches thus share their ‘engaged’, normative nature in view of sustainability: Science or science policy are not seen only as promoters of growth, but are viewed as in need of a direction, as means of problem-solving (Ziegler 1998). While economic innovation thinking tends to view science in terms of its economic applicability, sustainability oriented ST&I thinking argues against this ‘commodification of science’ (Radder 2010: 4). This is also expressed in the following statement by A. Smith et al. (2010: 437):

“The challenge for innovation no longer rests solely in economic potential, but also in the societal changes induced by innovative activity and the consequences of this for environmental and social sustainability. Along with this broader problem framing, comes a need for broader analytical perspectives.”

Systemic innovation for sustainability

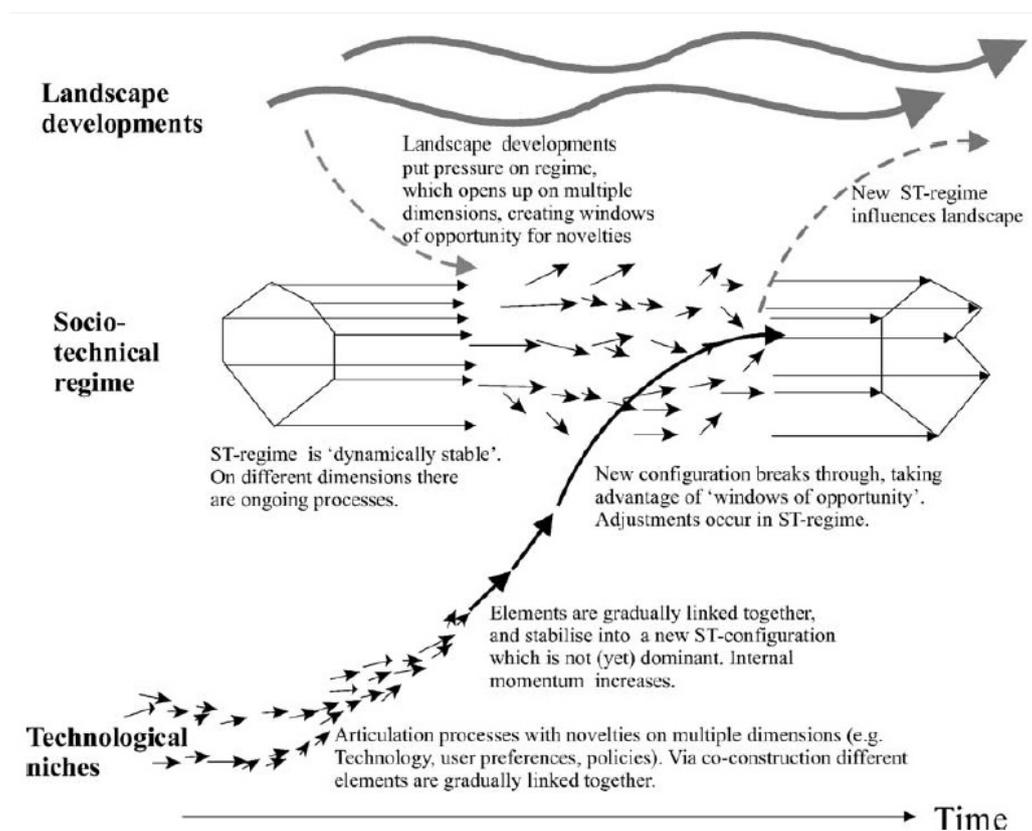
Since environmental concerns and innovation were first linked, a shift from a narrower focus of single innovations (such as end-of-pipe technologies, or later clean technologies) towards a broader system view (such as green innovation systems) can be detected (A. Smith et al. 2010). Among the most influential approaches in the scientific community are ‘strategic niche management’ and the ‘multi-level perspective of socio-technical transitions’ (Geels 2002; 2004). The main link between the different variants of innovation models for sustainability is that they seek an answer to the question on how to make a transition to socio-technological systems that are more sustainable (Markard et al. 2012).

‘Strategic niche management’ affirms that sustainability challenges can be addressed by purposefully creating and managing niches for developing new technologies. The basic idea resembles the evolutionary biology concept, transferred from living organisms to technologies (Schot and Geels 2007). The way to intervene is by acting against the resistance conditions that current technological trajectories have, the power constellation that defend a given technology, interests and institutions, which do not favour environmental technologies. This demands an active role from governments who must create platforms for new actors in niches to emerge, and also work in setting up experiments with technologies, to protect them from dominant market and selection mechanisms, so that they can evolve. Thus there is an intervention to foster diversity, trial and error in directions that would have otherwise not have been chosen (Kemp et al. 1998). A related strand of research is transitions management, aimed towards managing the transition in a given sector to a more sustainable state. The idea is to promote certain niches to produce such change, where policy makers learn while the experiment is on the run and have long term aims with actions in the short term to keep it alive. The approach has been criticised for the impossibility of managing every type of transition (Nill and Kemp 2009).

The ‘multi-level perspective of socio-technical transitions’ framework originally emerged as a theoretical improvement to the innovation system approach, incorporating the notion of systemic change. Though it was not originally concerned with normative change towards sustainability, it later got applied for such challenges (A. Smith et al. 2010). The framework explains historical transitions of different socio-technical systems, such as the transitions towards sewerage systems or changes in waste management (Geels and Kemp 2007). The approach has gained influence in the literature for incorporating new dimensions not considered previously in models advocated by ST&I. However, it is designed to be applied in countries of the global North, and it is not necessarily suitable in countries of the global South, for instance due to the different conditions of acquiring or producing ‘green

technology' in other places. The framework includes institutional issues such as the role of actors in the system, suggesting three levels of analysis (Geels 2002; 2004). First, a *socio-technical regime* coordinates six regimes on a meta-level. Each of these regimes – technology, science, market and user preferences, policy and socio-cultural, industry levels – is considered to be a semi-coherent group of institutions with actors, artefacts and institutions that reinforce a given trajectory of development (A. Smith 2007). In other words, the socio-technical regime refers to the structure that defines the dominant ways of doing things and resisting changes, defining a certain path dependency. Second, a *landscape* level represents external variables affecting the socio-technical regime, such as values or ideological change. Third and last, the *niches* are defined as protected spaces from dominant selection mechanisms in the dominant socio-technical regime. Figure 3 illustrates the different elements and their interconnections.

Figure 3: Socio-technical systems



Source: Geels 2004: 915.

Niches play a relevant role in the initial formulations of the framework, where they were thought as those spaces from where radical innovations could emerge (Schot and Geels 2008). They are seen as sources of new and diverse ideas that can influence the problematic practices in the former socio-technical regime (A. Smith 2007). The notion of 'green' niches emerged, which added a normative tag to the niche concept, expressing the consciousness over environmental issues of the protective space (A. Smith 2007).

The socio-technical transitions approach has been criticised, for example for not considering issues of power that influence niches and regimes (Avelino and Rotmans 2009; A. Smith and Raven 2012; Hoffman 2013); or for neglecting the influence that individual and collective actors can have on several levels of the socio-technical regime, and not just on the niches (Jørgensen 2012). An additional point of critique is that there is a lack of empirical data for an ex-post evaluation of the models (Stamm 2009a). Stamm thus concludes that there is still a need for further scientific

reflection about the characteristics of sustainability-oriented innovation systems, related policies and supportive international cooperation structures.

Transformative science

In addition to the models and theories on ST&I for sustainability on the level of systemic changes, other scholars in the field of sustainability science direct their attention to the research practice or mode of science; to the relation between science and society or to the direction of science policy necessary to create impact on sustainability. During the last years, the idea of transformative science has gained attention: Sustainability scholars call for ST&I policy which are determined through public interests and centred on major societal and environmental challenges – transformative sciences leading to sustainable development (WBGU 2011; Schneidewind and Augenstein 2012).

Addressing the direction of science – or its normative dimension – correlates with a larger philosophical debate on the societal role of science and thus the relation between science and society. Transformative science is closely linked to society; it is not conducted for its own sake but for fulfilling a societal task, for contributing to solving the current grand challenges of human life on earth such as climate change. In order to reach a transformative science system, the proponents argue that it is necessary to question and change current modes of science funding, science policy-making, and scientific knowledge production towards a closer interlinkage of science and society, where science corresponds to societal needs. The transformative science approach acknowledges the high impact of the science system – coined by different actors, interests and path dependencies – on the way that research is carried out and on the way that decisions are made regarding the direction of ST&I (Schneidewind and Singer-Brodowsky 2013). The authors acknowledge the importance of innovations for sustainability, but also hint at the danger of technological lock-in effects by focusing exclusively on technological innovations for sustainability. Instead of a narrow technological definition of innovation, they suggest that innovation is necessary on different levels, including systemic innovations as well as non-technological innovations, such as social innovations (Schneidewind and Augenstein 2012).

In order to come up with innovations that suit the societal needs, and correspond to the complex real life problems it wishes to solve, sustainability science suggests a mode of science that resembles 'Mode 2' science as defined by Gibbons et al (1994), where knowledge production is conducted towards an application aim, characterised by heterogeneous and often transdisciplinary organisational forms. Both inter- and transdisciplinary research is characterised by problem-orientation, policy-orientation, and impact-orientation, and both approaches are holistic in the sense that they consider all possible dimensions of a complex problem and all types of interventions, solutions or entry points for change, including the technical and physical structural environment as well as the non-structural economic, sociological, institutional, political environment. In addition to the cooperation among scientific disciplines, as postulated in interdisciplinary approaches, transdisciplinarity places even more emphasis on the democratisation of science by additionally including non-academic stakeholders such as problem owners and policy makers in all stages of research, knowledge production and problem setting. Mutual learning is stressed: Different types of knowledge coexist at equal footing, including traditional and local as well as scientific and expert knowledge (Mollinga 2008; Pohl and Hirsch Hadorn 2008; Lyall 2008; Nowotny et al. 2001).

International organisations

OECD

In essence, the approach of the OECD of innovation for green growth looks similar to the OECD approach for economic innovation. Innovation – even if green – is conceptualised as a market-driven phenomenon, even if policies play a role in shaping the environment in which green innovation

prosper (OECD 2011a). The main difference to the concept of mainstream economic innovation lies in the direction of innovation, which in this case is towards technologies that are 'green'. According to the OECD, green growth is "a way to foster economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (OECD 2011a: 11). Green growth is pictured as a way to reach a sustainable development through the use of more efficient and cost effective production and consumption practices (OECD 2013b). In general, the OECD does thus not question the growth paradigm, and no limits to growth are determined (Althaus 2013).

The OECD acknowledges that due to externalised environmental costs, it will require strong institutions and policies in place to reach a sustainability oriented innovation system. The instruments and policies recommended for green innovation are based on the OECD's systemic recommendations for mainstream economic innovation systems. In their green growth strategy for developing countries this is summarised as a mixture of supply-push and demand-side policies. The supply push aims to create new green technologies, whereas the demand side policies aim to foster their dissemination and use, spreading them in developing countries' markets. In addition, consumers' behaviour should be targeted by "consumer policy and consumer education, as well as green labelling and certification" (OECD 2013b: 13).

With a view to developing countries, the OECD recommends "putting green growth at the heart of development", as the title of a 2013 report suggests (OECD 2013b). For the OECD, green growth is especially recommendable in developing countries' settings, because these suffer strongly from environmental pressures and are more vulnerable to these, while at the same time continuing to rely on natural resources for growth. The OECD thus concludes that "[f]ailing to adjust economic growth to limit environmental risks, brings large costs and potentially irreversible consequences" (OECD 2013b: 18).

Green growth is pictured as an inherent part of sustainable development. Green innovation on product, process and technology level is an inherent part of green growth according to OECD thinking, and should be included in developing countries' green growth agendas. Three measures are suggested: First, to increase research and development cooperation worldwide, with the intention to harmonise research agendas and transfer knowledge. Second, to enhance technology transfer, which itself is based on a working national innovation system with sufficient capacities to adapt the foreign technologies. And finally, to implement an intellectual property rights system that works to enforce owners' rights of patents as a way to encourage innovation (OECD 2013b). International cooperation in ST&I as well as international technology transfer are pictured as necessary "to help developing countries push forward the technology frontier for green growth" (OECD 2013b: 132).

Contradicting the idea of necessary catch-up through technology transfer, in its 2011 worldwide strategy *Towards Green Growth*, the OECD argues that developing countries are in an optimal position to obtain green technologies through leapfrogging the intensive industrialisation and highly polluting processes that other developed countries once had (OECD 2011b: 12). However, research suggests that innovation – be it through innovation systems or green innovation – requires the development of capabilities beforehand in the country under question to adopt, adapt or develop their own technologies (Lall 1992). It is clear that the elaboration of such capabilities needs a lengthy process that depends on several factors and their interrelations, requiring resources to develop (Perkins 2003).

In total, the OECD approach to innovation for sustainability reflects a rather constrained view, mainly relying on green technologies. Green innovation is framed economically, and systemic or other forms of innovations for sustainability are not considered in the OECD concept.

World Bank

In its comprehensive report on *Innovation Policy: A Guide for Developing Countries* (2010), the World Bank omits strategies for sustainability oriented innovation, besides making a short statement regarding the severity of natural resource depletion and environmental limits and arguing that “more cross-national efforts to find innovative ways to deal with this and other issues of global public goods are urgently needed” (World Bank 2010b: 47).

Green innovation is then addressed in the report on *Inclusive Green Growth* (World Bank 2012). From the World Bank perspective, green innovation can be defined as the “development and commercialisation of new ways to solve environmental problems through improvements in technology”, whereas green technologies are said to “comprise many fundamentally different technologies to achieve more resource efficient, clean and resilient growth” (World Bank 2012: 68). These include a variety of product, processes, and organisational innovations, in sectors relevant for the environment, such as energy production, food consumption, transport, climate change mitigation, among others.

The World Bank thus conceptualises innovations for sustainability in the frame of green growth as an economic concept. Here, green growth is defined as

“growth that is efficient in its use of natural resources, clean in that it minimises pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters. And this growth needs to be inclusive” (World Bank 2012: 2).

The policy recommendations that the World Bank gives to foster green innovation in developing countries are based on the innovation system and technology transfer concepts. As statistics in terms of patents show a huge monopolisation of green technologies in few countries, the World Bank suggests that advanced countries should produce frontier green technologies, while resource scarce ones specialise in adopting and adapting them after technology transfer to their local conditions (World Bank 2012). Strengthening innovation capacities at the academic level is not among the World Bank’s recommendations for developing countries except for the ones that already have functioning ST&I systems, as also indicated by the following recommendation to “limit local technology-push support to countries with enough technological capabilities” (World Bank 2012a: 76). For countries with weak technological capacities, the World Bank recommends that “stable, long-term global public spending on R&D should be increased and channelled into programs that facilitate the development and adoption of technologies applicable to developing countries” (World Bank 2012: 77).

The World Bank reports acknowledge that each country must develop its own policy-mix that is sensible to their national specific conditions, contributing to the solving of particular market failures. Nevertheless, the organisation recommends certain pillars to focus innovation efforts on. First, the support of entrepreneurship, second new knowledge creation and dissemination, third to stimulate technology transfer and the needed capacities to absorb and adapt knowledge (World Bank 2012).

It is interesting to note that the approach does not differ from traditional – i.e. economy focussed – innovation approaches in terms of the instruments used. The main difference lies within the aim for which they are used, and in the possibility of environmentally friendly solutions. However, more niche based sustainability approaches would require different instruments. Here the implementation of experiments and the scaling up of successful experiences would be vital. This is, however, not reflected in the World Bank’s recommendations.

In the World Bank’s working paper on *Green Growth, Technology and Innovation* (Dutz and Sharma 2012), the view on green innovation at first sight seems to be more inclusive: The paper acknowledges that “there is also a need to provide global technology-push support for base-of-pyramid and neglected technologies” (Dutz and Sharma 2012: n.n.). The paper lists several successful

green 'bottom of the pyramid' and local innovations and acknowledges their importance, while also stating that few of them have been upscaled, which the authors attribute to lacking supportive policies. However, the authors do not go as far as recommending such policies in their chapter on fostering green innovation through policies. In the policy recommendations, it becomes clear that the World Bank sticks to an economically defined innovation concept, based on innovation system and technology transfer thinking. Non-technological forms of innovation, such as social innovations or system level innovations for more sustainability are not taken into account as policy recommendations either (Dutz and Sharma 2012: 14).

UNESCO

Although UNESCO has a special 'Division of Science Policy and Sustainable Development', until recently the organisation published only few documents on its concepts of science for sustainability. Exceptions are the *World Social Science Report 2010*, co-published by UNESCO and the International Social Science Council (ISSC) (UNESCO and ISSC 2010). The report asks what the position of science in society is and how social sciences can contribute to solving global problems. The report stresses the importance of interdisciplinary research in order to address global challenges such as climate change. A two-pager entitled *Science Policy for Sustainable Development - the Power of Science to Empower Society* (UNESCO 2010a) recounts UNESCO initiatives of strengthening ST&I in developing countries, but only refers to innovation for sustainability in the sense of clean technologies. Equally shallow conceptualisations are given in *Science for Peace and Sustainable Development* (UNESCO 2013c). The publication highlights the importance of technological innovations for sustainability and the role of governance and capacity development to achieve them. The publication states that ST&I are important for economic and social development, but does not provide any arguments for that. No reference is made to sustainability within ST&I systems as a whole, entry points for analysis or change within these.

The picture changes with the second *World Social Science Report*, published by ISSC and UNESCO in late 2013. The report is focused entirely on *Changing Global Environments*, as its subtitle suggests. Focussing on the role of science for sustainability, the report follows the idea of transformative sustainability-oriented science, and highlights the importance of inter- and transdisciplinarity. It thereby also emphasises the role of social sciences in addressing and framing environmental problems, in understanding the human dimension of climate change, as well as in supporting transformation towards sustainability (ISSC and UNESCO 2013). The report also highlights the importance of closer science-policy interfaces and states that "[k]nowledge is vital for effective action – but for this, we must more tightly link science, policy and society and integrate scientific understanding with action" (ISSC and UNESCO 2013: 6).

In the context of the globally communicated notion of 'sustainable development', the report questions if development based on growth combined with the depletion of natural resources and carbon emissions should be a model to be followed:

"A simple question put to all nations is whether more concrete, more buildings, more cars, more roads and more industry is really the best model we have for development. If there is a better model, then the challenge before social scientists is to help define and understand it, and to contribute knowledge about effecting a shift in human behaviour and social practice towards a model of development and a lifestyle that leaves a much lighter carbon footprint and, it is to be hoped, a much greener world" (ISSC and UNESCO 2013: 12).

The report thus calls for the production of engaged, problem-oriented social science knowledge which is derived from and contributes to the close interaction between the sciences and political decision makers in charge of applying and diffusing the produced concepts, processes, approaches

etc.. The innovations to be developed thus are not new technologies but instead target systemic change (ISSC and UNESCO 2013).

However, in the individual UNESCO ST&I country reports, sustainable development is still rarely addressed. It remains to be seen in how far the new *World Social Science Report* has an impact on these mainstream UNESCO approaches to ST&I, and if sustainability-oriented thinking is introduced. It also remains to be seen if sustainability oriented science is reflected in the next *UNESCO Science report*, as the last edition in 2010 was largely focused on economic benefits of ST&I.

Discussion

As shown in the introduction to this section, sustainability oriented thinking is not new. *The Limits to Growth* were acknowledged by the Club of Rome in its report with the same title in 1972 already,

“and the first oil crisis of 1973 triggered an international scientific and public debate on how to deal with the fact that a growing world population with increasing levels of per capita material consumption cannot easily be harmonised with the limited resource base and sink capacities of the globe” (Stamm 2009a: 10).

Currently, scientific concern with sustainability is growing, such as detecting ‘planetary boundaries’ and a ‘safe operating space’ (Rockström et al. 2009). In developing countries, economic development goals, to be reached through higher growth rates, often compete with ecologically defined development goals – a dilemma. As a consequence, even in developing countries it seems necessary to find ways of decoupling economic growth from harmful impacts on the environment (Stamm 2009a). However, this would require a paradigmatic shift towards sustainability oriented innovation (and, as we would add, policy-making) systems (Altenburg and Pegels 2012).

Nevertheless, the idea of transitions towards more sustainability oriented innovation systems has not had far-reaching impact on worldwide policy making: Non-sustainable innovation systems continue to exist because environmental costs are externalised and have to be borne by society as a whole. Sustainability oriented innovation systems therefore will have to strongly rely on governance mechanisms, in order to internalise environmental costs, to “disrupt environmentally unsustainable technological pathways and encourage alternative technologies” (Altenburg and Pegels 2012: 10). In consequence, it would be recommendable to combine environmental and innovation policies that give incentives for non-environmentally harmful innovations (Stamm 2009a).

Sustainability approaches themselves have not been without its critics. Green growth strategies of industrialised countries are believed to hide an agenda to ‘colonise’ the developing countries through the introduction and new dependence on green technology, the commodification of natural resources, education, health, etc. (Unmüßig et al. 2012). Critique also comes from a degrowth perspective, which positions itself against the basis of previous approaches, namely economic growth. This concept challenges the mainstream view that growth is the only possible path for development, however it is also seen with suspicion by developing countries aiming to reach levels comparable to those reached in high income countries.

Looking at the World Bank, OECD and UNESCO, it is interesting to note that the influences of the most recent innovation research have not been completely reflected yet in the reports of international organisations. On the contrary, these seem to focus more on a relabeling of innovation system approaches, and not taking into account the specificities of promoting innovation for sustainability.

ST&I for Social Development

Past experiences have shown that growth does not necessarily go hand in hand with improved living conditions for all – it does not per se ‘trickle down’ or lead to social inclusion. The development science community therefore increasingly questions purely economic approaches to innovation.

Among other factors, innovation as driver of pro-poor economic growth would require the integration of social objectives and innovation policies (Stamm 2009b). However, most scholars in economic innovation systems do not yet take into account the specificities of developing countries, such as needs for poverty reduction or social inclusion through innovation and related policies (Altenburg 2009).

This has motivated alternative research – both from economic and non-economic innovation perspectives – that puts emphasis on the application of knowledge for inclusive aims and the incorporation of resource scarce population sectors in the benefits of innovation. Several concepts have emerged during the years to support a different perspective, among them concepts like ‘pro-poor innovation’, ‘social innovation’, ‘inclusive innovation’ as well as ‘grassroots innovation’. A further differentiation of approaches can be made according to economic and non-economic conceptualisations.

Scientific models and approaches to ST&I for social development

As pictured in the chapter on economic innovation for development, many authors stress the importance of economic productivity, arguing that a deficient economic system causes poverty. Here, innovation contributes to productivity and competitiveness, which leads to higher incomes. Thus, investing even high-tech innovation can indirectly contribute to overall poverty reduction (Altenburg 2009). However, neither innovation capacity nor economic growth guarantee “per se that a fairer society is on the horizon” (Arocena and Sutz 2012: 148). The socio-economic and political particularities of a country determine its capacities to develop, adapt or diffuse innovation, and the innovation systems in place can either enhance or relieve inequalities of income or education (Cozzens and Kaplinsky 2009). So far, most existing innovation systems in developing countries unfortunately do not contribute to inequality reduction:

“Even growth-producing technological change brings both benefits and costs, for example, by creating and eliminating jobs and creating effective but expensive new medical options. Thus while technological change seen from one angle is a source of progress, from another angle it creates the potential to increase gaps between rich and poor not just in wealth but also in well-being” (Cozzens 2008: 4).

Thus, mainstream approaches to innovation can also have negative distributional effects, meaning that only small parts of society benefit, while the costs are shared among all taxpayers. Other negative side effects of innovation include rising food prices, as witnessed in the biofuel sector (Altenburg 2009).

Reflecting on negative effects and unintended consequences of ST&I has inspired economic and social research on more inclusive innovation. From an economic perspective, one can classify possible entry points for inclusive effects of innovation into two categories: the poor can potentially benefit as consumers of innovative products, and/or can profit from being included in the process of innovation.

The development of products for the poor is one possible element of inclusive innovation (George et al. 2012). This approach, coming from management literature, stresses the social role that firms could play by elaborating affordable products for the so called 'bottom of the pyramid', people trapped in poverty cycles.

An additional economic innovation element would target a more systemic level of innovation – labour opportunities within the innovation system. People who were previously marginalised due to lacking competences and skills could benefit from an inclusion in the innovation process if they took part in it as workers. Inclusive innovation systems should thus ensure that not only skilled workers are part of the jobs within innovation processes, but also that capacities are developed in all parts of society and all parts of the innovation process, especially for adapting and adopting technologies (Altenburg 2009).

Solving large-scale social problems that affect developing countries, such as in the health sector (especially poverty related and neglected diseases), food security, sanitation, or public infrastructure are another dimension of pro-poor problem-solving ST&I.¹² However, as sustainability oriented innovation systems, inclusive innovation systems are coined by a 'market failure' situation if regarded from an economic innovation perspective:

“What markets are unlikely to produce are basic goods and services for the poor, even though society as a whole would benefit from maintaining minimum standards in areas like health, nutrition, housing, and education. [...] private markets produce less than the socially-optimal amount because the incentive is private, not public, return” (Cozzens 2008: 9-10).

Current incentive schemes do not provide for these so-called orphan problems. They lack a market of affluent consumers as well as strong stakeholders who push the issues on the public agenda. Thus, “related research is underfunded and related innovation is weak” (Arocena and Sutz 2012: 149).

ST&I for inclusive, pro-poor problem solving have also been conceptualised from non-economic, i.e. non-market driven or profit-oriented points of view. Alternative innovation thinking argues that investments in innovation systems in developing countries only have a legitimate basis if ST&I are embedded in and aiming at economic as well as social development (Arocena and Sutz 2012). Inspired by discussions in political ecology and economy, alternative conceptions go beyond the traditional economic innovation thinking by asking who benefits and who loses from which type of innovation, who pursues which interests and who has which level of power to do so. While most authors following alternative thinking do not argue against science as a motor of economic growth, they argue in favour of a more complex array of objectives of science policies and innovation as such. In this line, Bozeman and Sarewitz (2005) point out that a narrow focus of ST&I policies on the market often means that social or environmental aspects are not covered adequately. They therefore propose to conceptualise ST&I and its policies around the idea of 'public failure', instead of 'market failure' in order to stress the accountability of policies towards the public.

Alternative inclusive innovation concepts are often related to the idea of appropriate technology. This thinking can be traced back to the essay “Small is beautiful” which argues in favour of locally adjusted 'small scale technology' (Schumacher 1973). The appropriate technology movement took

¹² A further concept linking innovation with society is **social innovation**, a term that has come up in recent years. Its definition is mostly still vague and contested apart from the broader notion that social innovations relate to societal wellbeing and institutional change. Pol and Ville define innovation as social “if the implied new idea has the potential to improve either the quality or the quantity of life.” (Pol and Ville 2009: 881). Other authors define social innovation as a set of activities and services whose aim is to solve challenges in society. In essence, the approach extends the economic approach to innovation, but shifting the central actor who performs it (not necessarily a private firm), and modifying the main objective (from economic to social benefits) (Mulgan et al. 2007). Apart from these changes, these initial proposals do not offer much theory or detailed experiences to understand and promote innovation processes in developing countries.

up the idea and aimed at developing the right technology for the right people, context-adjusted instead of passively adopting external, large-scale technology which does not always suit the users' needs. Complementary, the movement argues for capacity development activities in larger sectors of the population (Akubue 2000). However, critics of appropriate technology counter-argue that proposing the adoption of small or low-tech innovation to developing countries is patronising and excludes these from more advanced high technologies (Shamsavari 2007). More recently, the idea of appropriate technologies has been taken up by grassroots innovation thinking. Researchers point to experiences that link innovation with community action, and highlight the role of small communities activities to achieve sustainable development goals. As the name suggests, grassroots innovation relies on bottom-up networks to recollect, systematise and diffuse information of local innovations – so called products by the poor. Mutual learning experiences are an essential part of the innovation process (Seyfang and Smith 2007).

While appropriate technologies and grassroots innovations are not necessarily S&T-related, alternative innovation scholars acknowledge the opportunities inherent to ST&I, while also acknowledging local innovation developments, their local adaptiveness and embedding into local institutional contexts (Rhodes and Sulston 2009; UI Hassan et al. 2011; Hornidge and Scholtes 2011). As the appropriate technology movement, alternative inclusive innovation concepts point to the importance of appropriateness of the innovation for the problem owners as the key stakeholders.

Alternative concepts thereby put into question if high-tech and high-cost innovations, which are aimed at economic benefits, are equally beneficial and suitable for poverty reduction, as usually they make adopters more dependent on the market and more vulnerable in case of failure of the innovation. Next to dominant high-tech, science-based and economically viable innovations, low-tech, social and institutional innovations, possibly based on local knowledge and practices, might be equally effective in finding socially just solutions for developmental challenges (STEPS Centre 2010; Ely et al. 2010). The authors also take a critical stance of technology transfer in which research and innovation efforts often fail to produce 'impact', meaning that the innovative technology, product or process is not adopted, and thus no poverty alleviation, enhanced food security, or other socio-economic improvements are achieved (Röling 2009; Douthwaite 2002).

A last dimension targeted in inclusive innovation concepts is the transformation of power relations in place in innovation systems. Research has shown how the characteristics of research systems create lock-in effects of selecting one type of technological regime instead of another, for example genetic engineering in demise of more agro-ecologic, holistic approaches to agriculture (Vanloqueren and Baret 2009). Leach et al., who stress the political nature of technological choices and pathways, make a similar point. In an attempt to make inherited norms and values within ST&I systems more transparent, Leach et al. argue that innovation and innovation policy for social and environmental sustainability has to be participatorily conceptualised in a '3D' way. This means that the direction (of envisaged change), the diversity (of technological options and innovations) and the distribution (of costs and benefits of an innovation among different societal groups) should be discussed across policy and the public, in order to "reveal the nature and stakes of such choices and guide decision makers as they grapple with challenges in their own particular settings" (Leach et al. 2012: 5).

Alternative innovation theory therefore suggests the inclusion of a wide group of stakeholders such as NGOs, citizen initiatives, social movements or farmer organisations etc. in the policy debates on innovation in order to discuss the direction, distribution and diversity of ST&I (STEPS Centre 2010; Cozzens 2008). Other authors stress the importance of partnering between scientists and non-scientific stakeholders in the research process itself in order to ensure high adoption rates (Douthwaite et al. 2001). Although "the importance of fluid communication between producers and users of innovation has been acknowledged long ago" (Arocena and Sutz 2012: 150), this inclusion of a wide group of stakeholders in decisions on ST&I is still not reality.

Strong institutions and governance as well as adequate policies are perceived as necessary from economic as well as alternative inclusive innovation concepts – to overcome market failure situations

in case of orphan problems (Cozzens 2008), to link social wellbeing and innovation policies (Bozeman and Sarewitz 2005). However, authors acknowledge that there is no blueprint model for inclusive innovation systems. These need to be based on the existing actors, institutions, and historical background of the country, they need to build on reliable data, and they shouldn't be designed by theorists in the north, but by the local actors, who should "adapt goals to real necessities by means of context-dependent strategies" (Arocena and Sutz 2012: 152).

International organisations

OECD

Acknowledging that economic growth has not always benefitted lower income groups of society and that innovation is an essential element of growth, the OECD has lately begun to discuss the concept of inclusive innovation and its implications for policies in developing countries and emerging economies, first in a discussion report (OECD 2012c), which was then republished as a working paper on *Innovation and Inclusive Development* (Paunov 2013). In the report and working paper, inclusiveness in ST&I is conceptualised on the background of persisting inequalities in developing countries, which "reduce opportunities for the poor and thus their contribution to the economy, they then hinder the development process" (Paunov 2013: 6).

For the OECD, the relation between innovation and inequalities is twofold: inequality is conceptualised as a hindrance to innovation, while innovation is also pictured as a driver of reducing inequality. Inclusive innovation incorporates two elements of how lower income groups of society benefit from innovation. First, inclusive innovation means innovations which address the needs of lower income groups, e.g. through frugal innovations, products for the poor with fewer features to be sold in resource scarce markets. According to the OECD, "[e]ntrepreneurs have used innovative pricing and financing strategies and business process innovations to serve lower-income markets profitably" (Paunov 2013: 7).

Second, inclusive innovation according to the OECD's conceptualisation also embraces innovations by lower income groups, so-called grassroots innovations based on local knowledge or adapted external technologies, which provide business opportunities. Inclusive innovations are thought not necessarily to be high-tech, but adapted to the needs and purchasing power of the target group (Paunov 2013).

Interestingly, all these inclusive development dimensions in the OECD concept are related to economic definitions of innovation, rooted within economic benefits. Innovation is purely seen as motor of economic growth. STI for social problems, for solutions outside of business opportunities – like new irrigation techniques, new water management schemes etc. – not aiming at private profits – are not considered.

Although the paper states that "the relationship between innovation and inequalities in income and opportunities raises some important policy questions" (Paunov 2013: 6), it does not bring forward specific policy recommendations for inclusive ST&I. Instead, the report states that inequalities should be addressed by redistributive and social policies. The systemic level of the national innovation system is thus left untouched.

World Bank

The World Bank has discussed aspects of inclusive innovation in various publications in the last years, above all within their *Handbook on Innovation Policy for Developing Countries* (World Bank 2010b).¹³ The guide is written mainly from a point of departure that stresses the overall economic benefits of ST&I, but it does contain a section on pro-poor innovation. While the other chapters and sections are

¹³ Interestingly, in the publication on *Inclusive Green Growth* (World Bank 2012), little is said about inclusive aspects of innovation, while more room is given to explaining paths of sustainability-oriented growth.

related content-wise – they all centre around policies that promote innovation for economic growth – pro-poor innovation seems to be less integrated into the main body of the text conceptually. Although the report briefly states that social wellbeing partly stems from the broad dissemination of technologies such as vaccines or sanitation, no section is dedicated to examining prerequisites of such improvements, such as questioning overall directions of ST&I. It thus seems that for the World Bank, pro-poor innovation is not an integral, but merely a minor part of the innovation system. Notwithstanding, it seems worthwhile to consider how the World Bank conceptualises pro-poor innovation. For the bank,

“a pro-poor innovation system can be defined as a multistakeholder social learning process that generates new knowledge, puts it to use, and expands the capabilities and opportunities of the poor” (World Bank 2010b: 336).

Innovations in fields relevant to those people at the ‘bottom of the pyramid’ and aimed at reaching the Millennium Development Goals, such as agricultural research, alternative energies, public health, or drinking water supply, are considered as important for reaching inclusive development through innovation (World Bank 2008). In order to reach this objective, the World Bank proposes to strengthen all elements and connections within the ST&I system. In general, the World Bank therefore stresses the importance of capacity development in all social segments, including the poor, in order to foster the capacity of adapting technologies to local conditions (World Bank 2010b). In this line, the World Bank argues that

“[i]t is not sufficient for OECD institutions simply to parachute ‘inclusive’ technologies into developing countries. Inclusive solutions will be much more sustainable in the long run if developing countries build the capacity to generate their own inclusive innovation solutions” (World Bank 2010a: 10).

In view of S&T-based innovations, the World Bank recommends universities in developing countries to dedicate more research to social problems. In view of that, the organisation also recognises the need for stronger incentives, such as more funding through research grants. ST&I policy should therefore also be targeted at orienting research into relevant directions; and funding should also cover upscaling and dissemination activities for both innovations as public goods as well as commercial products or technologies for the poor (World Bank 2010b).

The role of so-called ‘products for the poor’ is strongly emphasised by the World Bank. According to the organisation,

“The objective of inclusive innovation is to harness sophisticated science and technology know-how to invent, design, produce, and distribute, primarily via private sector SMEs, high performance technologies at prices that can be afforded by the billions of people at the [bottom of the pyramid]” (World Bank 2010a: 9).

The World Bank argues that the ‘bottom of the pyramid’ is a market segment with significant overall purchasing power, and thus stresses that the private sector should target them as customers through

“developing affordable products and services tailored to the needs of low-income consumers, by creating job opportunities and increasing the productivity of the poor” (World Bank 2010b: 368).

The bank therefore encourages governments to provide incentives and remove legal barriers to enable the private sector to develop products for the poor (World Bank 2010b).

In addition, the World Bank also conceptualises inclusive innovation around the inclusion of the poor in the production of innovations, such as grassroots innovations or innovations within the informal

sector ('products by the poor'). According to the World Bank, these innovations can contribute to inclusiveness in two ways: They can function as a way of income generation and at the same time provide adapted solutions (World Bank 2010b).

The World Bank recognises some policy issues attached to inclusive innovation. According to them, some challenges to grassroots or informal sector innovation exist, like lacking IP rights for non-scientific knowledge, which need policy approaches to be solved (World Bank 2010b). In addition, the bank acknowledges that

“[t]op-down, supply-driven initiatives have often proved ineffective for addressing the needs of the poor. Inclusive innovation policy presupposes a change in institutional culture and mandates the involvement of the poor in identifying their development priorities and in providing incentives for various actors to serve their needs more effectively” (World Bank 2010b: 362).

UNESCO

The UNESCO so far has not published any document dealing exclusively with inclusive ST&I. However, while the UNESCO's most prominent publication on ST&I, the *UNESCO Science Report* (Brito and Schneegans 2010) is focussed exclusively on potential economic contributions of ST&I and little is said about other directions that science might have, other publications offer some insights about the UNESCO's conceptualisation of science and societal issues. The *World Social Science Reports* (UNESCO and ISSC 2010; ISSC and UNESCO 2013), for example, offer a reflective picture of science in society, and ask how science-policy interfaces can be built. In the report on *National Science, Technology and Innovation Systems in Latin America and the Caribbean*, it is argued that ST&I should be instrumentalised to contribute to reaching the Millennium Development Goals. It is suggested to integrate social and innovation policies, which might also lead to improved economic development in the long run though

“the generation of a ‘virtuous circle’ as the social legitimacy of these policies could prove to be an important path towards strengthening capacities in favour of actions towards building a Knowledge Society” (Gorfinkiel 2010).

A publication on the *Science, Technology & Innovation Initiative. Responding to the Needs of Africa* (UNESCO 2008), which sums up the UNESCO's action in the field, argues in similar ways, stating that ST&I are the

“key contributors to poverty reduction, disease prevention and environmental conservation. Strengthening capacity in science for sustainable development, and harnessing the fruits of scientific discoveries, can only be achieved within a comprehensive framework of science and technology” (UNESCO 2008: 3).

Looking at one of the most recent UNESCO initiatives on ST&I in developing countries, the ‘Project for strengthening science and technology policy capacities in the Republic of Congo - Repositioning the National Science System’ also reveals a conceptualisation of ST&I beyond mere economic thinking. The document recommends the integration of ST&I “in the social and economic development strategies of developing countries in order to ensure growth and sustainable development” (UNESCO 2010b).

Discussion

Although UNESCO, OECD as well as the World Bank have made first attempts to pick up ‘inclusive innovation’ in their documents, ST&I for social development – in any potential way of conceptualising it – has still not been adequately translated into mainstream policy recommendations of international organisations.

The potential of ST&I to provide solutions to poverty and inequality issues still faced by many countries – including those in the global North – is thus not fully exploited in policy recommendations. The ‘inclusive innovation’ paradigm is far less influential in comparison to the dominant ‘innovation for economic growth’ approach, and as such, scientific models and theories for understanding inclusive innovation are also less researched and theorised. Nevertheless, the field is attracting more interest because of the promises to tackle development challenges.

In general, the discussion of inclusive innovation in the policy documents analysed does not move beyond its grounding in market-based, profit-oriented innovation thinking, which culminates in almost cynical considerations of the poor as consumers and profitable target-group of economical activities. The definition of what is to be considered an innovation worth pursuing is thus predetermined. Interestingly, this focus on economically attractive innovations is combined with an emphasis of the need to involve stakeholders on various levels (local, provincial, national, international): In one document, the World Bank (2010b) proposes participatory bottom up approaches which might challenge traditional power relations within the ST&I system (and which might also challenge the influence of economy-oriented actors within the system). While this might be attributed to the diversity of voices among World Bank consultants commissioned with the reports, one could also argue that international organisations like World Bank, UNESCO and OECD are trying to jump on the bandwagon of producing ‘context-relevant’ knowledge and applicable solutions to developmental problems.

Concluding Remarks and Outlook

This paper aims at reviewing some of the ongoing debates within academia and international development on the role of ST&I for development by focusing on how OECD, the World Bank and UNESCO define and operationalise these concepts and thus 'development' as a whole in their respective publications and reports. Overall the hegemony of the economic in all definitions and conceptualisations of 'innovation', 'technology' and 'development' is apparent, side-lining the two additional pillars of long-term sustainability, namely the social and environmental.

Following the path depicted in President Truman's inauguration speech, all organisations reviewed ST&I as key elements of 'development', while their potential contribution to economic growth acts as vehicle of discourse construction (of sense-making and opinion-shaping). 'Development' in itself is consequently repeatedly narrowed down to economic growth, largely disregarding substantial past and ongoing debates on long-term development relying on and going hand in hand with social, economic and environmental sustainability.

Interestingly, the World Bank publications offer the greatest variety in conceptualisations. In the different publications, different pathways for development through ST&I are brought forward, often not harmonising well. While in some, hardcore economic growth through innovation is pushed, in other publications the World Bank even expresses that "current development models are not sustainable and better ones must be found" (World Bank 2010b: 50) The seeming clash of visions represented in the different documents of a single organisation are surprising, but to us tell the story of decentralised development of ideas; ranges of different researchers and consultants being employed to contribute their expertise and publishing under the name of the bank, yet without an institution wide consensus on which type of relationship between ST&I and 'development' is supposed to be fostered through the future programs and projects of the bank.

A similar situation can be found when contrasting the *Social Science Report* and *Science Report* of UNESCO: both reports develop substantially diverging definitions and conceptualisations of ST&I and development. Altenburg and Pegels explain this diversity of conceptualisations in the visions put forth by international organisations by pointing to the multitude of stresses that the visions of these organisations are influenced by:

"Naturally, policymakers need a certain degree of societal support to be able to enforce sustainability policies, be they market-based or command-and-control. The degree of such support may differ from one country to another, and even from one group to another within countries. However, the support of societies and governments alike in the case of such long term issues as environmental degradation tends to melt away as soon as a pressing economic problem appears on the agenda. An example is the recent European debt and currency crisis, which largely crowded climate change out of minds and media in 2011" (Altenburg and Pegels 2012: 17).

In their reports, all three organisations draw on concepts of technology, innovation and capacity transfer from the global North to the global South. As such, the OECD reports for example postulate that the solution for environmental issues in the developing world lies within the transfer of already developed technology from the North and its posterior adoption and adaption in the South. This is further underpinned by demands of implementing strong intellectual property right systems. Similarly, for countries with weak technological capacities, the World Bank recommends that capacity development should be focused at selection, adaption and adoption capacities, not at developing own innovations. Although this might be recommendable in order to accelerate the

worldwide uptake of green technologies, global hierarchies of knowledge with strong dependencies of the global South on the 'knowledge monopolies' and epistemic centres of the global North, captured for example in 'technology transfer' approaches, strongly resonate here. Even though the economic innovation approach acknowledges the inherent differences in systems given the different institutions and context in each country, such as in the World Bank and OECD reports, there is a blueprint model propagated in the innovation systems literature that resembles the same time of assessment conducted between 'developed' and 'developing' countries in development studies (Ziai 2004). This emerges from the fact that innovation systems are compared among countries and assessed taking into account one model where the connections are stronger, such as in northern European countries, USA or Israel. The OECD reviews on innovation policy are examples of this practice. They compare, assess and diagnose how a given STI national model performs in contrast to the 'leading' ones, together with the biannual reports on science, technology and industry, which consider OECD but also some non OECD countries in their statistics.

The problem of transferring models and blueprints should not be ignored or treated lightly. Even though globalisation has led to the interdependence of technological mechanisms, this does not mean that a universal model for the type of production of technology should be applied to every place. The danger of translating the mentioned approaches is similar to the one that many more general development models had and still have. For instance, even though nanotechnology and biotechnology look promising in the science sphere, it is not so evident that every country will solve its economic problems by supporting such techniques if they do not have a given previous strong background in the field. Perhaps other areas more in tune with their capacities, skills, etc., are available and also more in tune with a specific, autochthonous technology model, in connection with their own culture.

As shown in the sections on ST&I for environmental sustainability and social development, ideas of sustainability oriented or inclusive innovation systems have not had great impact on worldwide policy making. On the one hand, scientific discussions of ST&I too often still argue along the lines of the dominant economic, for profit orientation of ST&I, and scientific endeavours to reflect on and provide models for sustainability oriented ST&I – in its encompassing definition spanning social as well as environmental and economic sustainability – are still scarce and have not entered mainstream discussions.

On the other hand, the existing body of scientific literature providing alternatives to purely economic ST&I and development conceptualisations have only been able to find entries into policy to a smaller extent. This in itself calls for intensified (transdisciplinary) interactions along the sciences-practitioners-interface. While the activities of all three organisations outlined in this paper seem strongly influenced by global knowledge, innovations and information and communication technologies for economic development discourses (Hornidge 2012), little awareness and interest of this development needing to be environmentally and socially sustainable is portrayed.

This is especially surprising as ongoing environmental and socio-economic change processes constantly increase the urgency for our state of the art knowledges to assure that we remain capable of acting even if our social, economic and ecologic environments are rapidly changing. This 'remaining capable of acting' nevertheless is only given if long-term and thus economically, environmentally and socially sustainable, perspectives are taken. While we acknowledge that policy choices made are highly political and reflect dominant discourses and interests, we nevertheless believe that the discussion of a broader range of conceptualisations and potential pathways along the science-policy interface could open up alternative scientific and technological trajectories (Stirling 2009) which ultimately might lead to more sustainability.

In addition, to make ST&I work for development, ongoing reflections on the type of scientific knowledge production required, and thus to be especially nurtured, point us to applied interdisciplinary and even transdisciplinary research together with the stakeholders and potential

end users of the knowledge to be produced. Innovations are to be developed together with those in need of them in order to assure the local/context fit of the innovations themselves.

Finally, given the rising importance of innovation in terms of theory, but most importantly, in practice, ZEF and the German speaking development community should extend research in this direction, engaging in discussions of which concepts, models and ideas are more useful to meet the aims of development agencies and countries that try to use ST&I for a more sustainable and just world.

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