Towards a Global Technology Assessment –
Insights from Cases in Germany, China, India and Beyond

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Zusammenfassung

Die vorliegende Arbeit untersucht Fragen und Implikationen einer globalen Ebene von Technikfolgenabschätzung (TA). Im Zuge von Globalisierungsentwicklungen, Wandel der Wissensproduktion sowie internationalen Herausforderungen wie Klimawandel, argumentiert diese Arbeit für eine Erweiterung von TA, als ein geeigneter Ansatz um diesen Veränderungen zu begegnen. Die zentrale Forschungsfrage dieser Dissertation ist demnach: Wie kann, im Kontext von globalen Herausforderungen und weltweiten Auswirkungen von Technologien, TA auf eine globale Ebene ausgeweitet werden? Hierbei wird erwogen warum TA besonders passend scheint um diesen „global challenges“ zu begegnen und als Herangehensweise verspricht gesellschaftliche Vorstellungen und Bedürfnisse mit zunehmend weltweiten und simultanen Entwicklungen von Technologien besser in Einklang zu bringen. Hierfür werden zunächst in Kapitel 2 Globalisierungs-Debatten, die globalen Dimensionen von Wissenschaft und Technologie, sowie international Strategien diesbezüglich präsentiert. Als nächster Schritt wird in Kapitel 3 die Entwicklung von TA im Europäischen Kontext beleuchtet und detailliert auf Formate, Methoden und „Impact“ sowie zukünftige Herausforderungen von TA verweisen. Ziel ist es auf dieser Basis zu zeigen, dass der Versuch einer globalen Ausweitung von TA auf konzeptioneller und auf praktischer Ebene sinnvoll sein kann. In Kapitel 4 wird dann auf fundamentalen Elemente von TA als problem-orientierter Ansatz verweisen: Beteiligung (Engagement) und ein weites Verständnis von Ethik (Ethics). Diese beiden Aspekte scheinen für eine globale Ebene besonders nützlich, da sie in nationalen und internationalen Kontexten eine wichtige Rolle im Verhältnis von Wissenschaft, Technologie und Gesellschaft spielen. Um dies in der Tiefe zu beleuchten, ist Kapitel 5 Fallbeispielen aus Deutschland, China und Indien gewidmet. Diese Länder präsentieren Kontexte in denen Technologieentwicklungen eine wichtige nationale Rolle spielen und wo versucht wird diese mit gesellschaftlichen Werten und Zielen zu verbinden – wo also TA(-ähnliche) Aktivitäten stattfinden. Diese Fallbeispiele sind für eine globale TA besonders interessant, weil sie scheinbar sehr unterschiedliche sozio-politische Strukturen, gesellschaftliche Debatten und Bedürfnisse sowie Wertsysteme repräsentieren. In Indien und China wurden Interviews mit relevanten Akteuren in Wissenschaft, TA, und „policy“ geführt, um TA-ähnliche Aktivitäten nachzuvollziehen und deren Einbettung in die nationalen Kontexte. Leitfragen hierbei waren u.a.: Wie werden nationale Debatten um Technologien geführt und politische Entscheidungen getroffen? Welche Rollen spielen dabei Ethik und Beteiligung als mögliche gemeinsame Nenner für TA? Wie wird TA im nationalen Kontext verstanden und praktiziert? Aufbauend auf den Erkenntnissen und Reflektionen der Fallbeispiele werden die drei Länder in Bezug auf TA, Ethics und Engagement in Kapitel 6 gegenübergestellt. Ziel ist es zu verstehen, welche Aspekte besonders wichtig sind und wie diese kontextualisiert werden. Besonderer Fokus ist dabei auf Habitaten in denen TA funktionieren kann, auch um mögliche Grenzen einer globalen Ausweitung zu erkennen. Ein wichtiger Schritt hierbei ist die Reflektion über die normativen Fundamente von TA sowie mögliche Parameter als Rahmen einer globalen TA. Im letzten Kapitel 7 werden dann, aufbauend auf den Erkenntnissen der Fallbeispiele und deren Gegenüberstellung, Empfehlungen für eine Weiterentwicklung von TA in allen drei Ländern formuliert. In einem abschließenden Teil werden, basierend auf den konzeptionellen sowie empirischen Erkenntnissen der Arbeit, initiale Ideen und nächste Schritte in Bezug auf Struktur, Methoden und Konzepte sowie konkrete Projekte einer globalen TA aufgezeigt.

Abstract

The following thesis aims to examine the questions and implications of moving towards a global Technology Assessment (TA). Worldwide effects of globalization, changes in modes of science and large-scale challenges such as climate change call for an expansion of TA as a way to address these issues. Thus, the main research question of this thesis is: In light of global challenges and worldwide effects of science and technology, how can we move towards a global TA? What are implications for this? For this, the following dissertation examines why TA seems to be especially suited for meeting these global challenges and, as an approach, aims to better align increasingly simultaneous and wide-reaching technology developments with societal needs and expectations. For this, chapter 2 introduces the overall setting in which science and technology (S&T) take place today. Globalization debates, also related to S&T policies, are described in order to understand the current challenges for any kind of assessment of S&T. New forms of knowledge production as well as several global initiatives and policy documents are examined in order to understand better the overall context in which a global level of TA would be set. Building on this, chapter 3 presents TA in its different forms and methods as well as possible impact. This is done to provide a general frame of TA, how it has developed by adapting to different aspects and how it is currently practiced, mainly in a European context. In a globalized situation, TA should aim to become more networked and flexible as a response to the worldwide challenges mentioned. In chapter 4 the issues of ethics and engagement as key elements of TA as well as of any society dealing with S&T are closely examined. Current discussions on global ethics as well as limits of engagement (also on a global scale) are discussed and provide a starting point for the country analysis of the following chapter. Chapter 5 then investigates the national contexts of TA in Germany, China and India. Interpreting key S&T documents and their connections to national values forms the basis of reflection. In order to gain in-depth insights, key actors from areas such as research, TA or policy were interviewed in China and India. Main aspects for analyzing the interviews are the societal setting of S&T, ethics and engagement, roles of TA as well as perspectives of a global TA. Following this, chapter 6 looks across the countries in order to better understand how engagement and ethics take place, also in relation to one another. Further, TA habitats in the different countries are reflected and compared, also as a way to discuss the normative aspects of TA in different contexts as well as to move towards more concrete parameters for conceptualizing a global TA. The concluding Chapter 7 presents models of and recommendations for further developing (global) TA in all three countries. This leads to further thoughts on how to move forward to a global level of TA, including fairly concrete recommendations for next steps. These center around the conceptual and methodological work necessary as well as what kinds of global TA projects could be useful to further advance it. A possible structure for a global TA is also highlighted as it may provide insights into how such a complex undertaking could be realized. Finally, based on the findings and insights of this thesis, some concluding thoughts are explored regarding further research and activities.

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Figures

Tables

Content

1 Introduction

1.1 Why a Global Technology Assessment?

> "Our species will survive neither by totally rejecting or unconditionally embracing technology – but by humanizing it; by allowing people access to the informational tools they need to shape and reassert control over their lives. There is no reason to expect technology to be disproportionately bad or good relative to other realms of natural selection […] We need to get good tools into good hands – not reject all tools because they have been misused to benefit only the few."
>
> (Raindance Foundation 1970)

This quote found in the journal "Radical Software" published by the artist and media activist group "Raindance" in 1970 points us to one of the key issues in our world, still today: that of technology, how it deeply forms our lives and how we, as individuals but also societies, can hope to shape it. The "tools" for this can be numerous and vary according to whom they serve, where they come from or how they are applied. One could say that what makes them "good tools" depends on whether they can help align needs and expectations of people, communities and societies within increasingly global and complex developments in science and technology. One such a tool can be Technology Assessment (TA), an approach which in its essence is concerned with providing knowledge on technology developments and what their implications for society may be. Emerging in the 1960s and 1970s in a Western context, it was created as a tool to predict consequences of increasingly applied technologies and as an early warning system on possible risks for policy makers (Grunwald 2010). Over time TA has evolved to include wider perspectives and today focuses on scientific, interactive and communicative processes for informing and advising public as well as political debates according to various aspects such as societal, ethical or environmental ones (Decker and Ladikas 2004; Grunwald 2018b). Traditionally, TA's frame is the national context; addressee being a specific parliament, a nationwide public or local stakeholders. The boundaries and orientation of the assessments seem fairly clear in this approach at least from afar: for instance, how is a new technology debated among different groups in a specific society, what are possible ethical concerns emerging from dominant national values and how can policy decisions be informed? Over the years, TA has developed and sharpened its methods and formats for assessing such issues and numerous TA institutions, especially across Europe, continue to refine these, mostly national, activities (Hennen and Ladikas 2019). Yet today, for TA, which is already a multifaceted undertaking, this is becoming increasingly complex in a globalized and highly interconnected world. In light of this, new challenges for TA arise, which, as an adaptive and problem-oriented approach, it should find ways to address.

So, do we now need a global Technology Assessment one can ask. In a world characterized by globalization, science and technology do not remain within national borders and their effects are simultaneous and rapid across societies. Further, global challenges such as climate change or sustainable development require responses on an international scale. With these developments increasingly defining and shaping our everyday lives and, to a large extent, science and technology developments, useful tools to manage and shape these are essential

(Member Group to Support TFM 2016). Hence, we seem to be at a crossroads: can the "tool" of TA be adapted to better include and meet these global challenges or should it primarily remain in national or local contexts? This thesis aims to argue for the expansion of TA (as an addition to the national) and attempts to explore ways it could be extended to a global level. With its rich foundation of experiences, activities, methods and formats to build on, TA can actually be valuable for this global context if adapted and expanded to diverse settings across the world. Therefore, it does seem time and worthwhile to think about adding a global level to TA; to enhance it with a specific global perspective regarding its approach and correspondingly its methods and applications. Important here is to also reflect on possible limitations of this global expansion due different normative foundations. This points to the overall intention of the present thesis: to follow up on research done in TA as well as experiences gained through its application and connect this to developments in other countries as well as overall to our increasingly globalized world. As argued throughout this thesis, it seems useful to do so since TA can offer valuable input and methods, which, if revised, can in turn help us deal with these global developments and challenges in more appropriate ways. This implies a better connection of science and technology with different and diverse societal needs and expectations while at the same time taking on an explicitly global perspective. It also entails, for instance, mutual learning and exchanges between various countries regarding their own issues with new technologies as well as how this relates to a global level. Further, it should aim to connect the local, national and global together in a comprehensive and networked way. This points us to novel aspects of this thesis: to re-examine TA in light of globalization and far-reaching effects of technologies, while still accounting for culturally-sensitive methods and approaches as well as tracing TA or similar activities in-depth in key countries. Reflections of these findings throughout this thesis make it an important contribution to TA itself, but also for uncovering what "good tools" we need to assess science and technology in our world today.

1.2 Design of Thesis

Research Question

In light of global effects of science and technology as well as global challenges there is an increasing need to find methods and frames for coping with, but also shaping these developments. Next to more or less established forms of national TA (Decker and Ladikas 2004), this calls for a searching of global approaches (as described and argued for in chapters 2 and 3 below). This thesis has its basis in the experiences and reflections on TA, which come from TA in practice. Over time, various forms of TA have developed, responding to challenges or critique, as described further in part 3.2. The frame and orientation of TA is based on the problem at hand, which then determines the methods used or the addressees targeted. From the increasing relevance of global effects and challenges comes a further problem orientation for TA: How to respond to these (new) increasingly global transformations?

The main overarching research questions of this thesis are therefore: **In light of global challenges and worldwide effects of science and technology, how can we move towards a global TA? What are implications for this?**

This implies local and national contexts in which S&T take place, but stresses the importance of scaling this up to a global level. In order to approach this, the thesis therefore empirically

examines different national contexts (also regarding science-policy foci and transformations) and how TA is understood here. The choice of cases builds on previous work on global ethics in S&T (Ladikas et al. 2015b), access in the country through close-knit networks and relevance of the countries as large S&T players with global significance. Other interesting aspects are the different political settings and cultural contexts these countries present and what implications this has for TA. This in turn may lead to very different forms of TA within the countries, yet through a wider reflection, communalities may also arise. Building on this, specific sub-questions for the national cases in Germany, China and India are posed: **What forms of TA(-like) activities can we identify in different contexts? What is the nature and extent of S&T debates in policy-making in different national contexts? What roles do ethics and engagement as potential common denominators of TA play? How is TA understood and practiced in the specific national contexts?**

Presumably, by understanding the national context and also identifying common denominators (ethics and engagement) of TA a link can be established to the global level. The **premise** here would be: **TA is relevant across borders** and the detailed understanding of TA in different contexts, its location within the system and the relevance of ethical considerations and engagement poses the possibility to find links to a global level. From this emerges the **overall aim** of this thesis: **to provide useful insights into an expanding of TA towards a global level,** in order to better meet current challenges. This includes providing possible ways forward regarding TA in specific contexts and connections to the global level. It also implies that certain challenges for a global TA arise, which concern methods, structures as well as concrete projects with a global perspective (as presented in chapter 7). The overall development and effects of globalization as described in detail in chapter 2 lead to more specific challenges for a global TA approach as shown in table 1.

Table 1: Overall Challenges and Their Implications for TA (own table)

Overall Challenge	**Challenge for TA**
Global effects of S&T developments	Development towards global TA level, including reflection on chances and limitations
Interconnectedness of S&T developments across countries/cultures	Culturally specific methods/approaches in connection with global level
Importance of considering ethics and engagement in S&T discourses	Incorporation of ethics and engagement in global assessments as common denominators
Differences in legitimization and contextualization of S&T policies and priorities in various countries	Differences in TA understanding and activities in various countries taken into account
National specifics of S&T developments and debates Responses on national S&T policy level	Framing of the assessment based on identification of national values and needs "Opening up" of TA for providing conditional, specific and adapted reflections and advice
Different level of inclusion of societal aspects in S&T developments in various countries	Capacity building, mutual learning and exchange for TA

Within the scope of this thesis some light can be shed on several of these challenges (underlined in table 1), even if not conclusively. Especially the in-depth case studies provide insights into the culturally, socio-politically specific approaches and understandings of TA in the national contexts. A reflection on these, including identifying communalities (e.g. ethics and engagement) can help find connections towards a global level. At the same time differences in the understandings of TA as well as the framing of assessments according to national contexts is also described in the cases. In light of varying forms of political structures and debate cultures, different links and connecting points of TA to this setting are described. This in turn helps uncover potentials of TA from the national (or even local) to the global level. The cases also provide insights into the national values and needs that in turn influence S&T policies as well as frame what aspects TA should address. Nevertheless, these aspects can only mark a starting point towards a global TA, which this thesis aims to contribute to. Ideally, this would further lead to mutual learning regarding different experiences in and methods of TA as well as shared assessments on specific technologies or forms of standardized formats and prototypes. Initial ideas on this are described in detail in chapter 7.

Approach and Case Studies

This thesis examines TA in **three national cases: China, India and Germany** as a basis for a global frame. Due to the well-established networks in China and India, it was possible to gain access to

normally fairly 'closed-off' actors; a key aspect for acquiring important insights into the understanding and uses of TA, the framing of ethics and engagement as well as reflections on global TA. This shows the unique role these networks enabled: as a type of 'trusted visitor' who could access the field for a brief, yet intense period of time and gain insights into understandings, practices and routines of TA in the specific national context (Flick 2017: 149). This also determined a large part of the selection process of the interview partners. The local networks and contacts in China and India were relied upon to provide the choices of the key interviewees. The desktop research done beforehand provided a sound knowledge basis of the overall structures, institutional contexts and positions of the interviewees that were chosen.

Next to the important role of access, the three countries were chosen due to the relevance of their S&T activities on an international scale, but also within their national context. China as well as India represent two highly important countries regarding international developments in S&T, also in the future. Further, they are also interesting due to their different political structures and how rapid economic and S&T developments are dealt with on a societal level, so the realm of TA. Both China and India do not have a 'tradition' of TA, yet we can find activities that relate to it. The case of Germany on the other hand was chosen because it has long-standing experience and institutionalized TA, providing insights into TA in a more established form of TA, with fairly clear roles within the political system and society.

Building on desktop research on important documents and papers, **qualitative interviews** were conducted in China and India. This was chosen as a useful method to gain first-hand knowledge on TA and the specific cultural, political and societal contexts, providing a basis for interpretation and reflection. It also enabled a certain flexibility in how questions were asked to different actors. In Germany, direct knowledge comes from myself as well as key European projects such as TAMI[1] and PACITA[2] (described in detail in chapter 3), which provide a substantial basis for analysis and reflections. In China and India, the definitions and understanding of TA varied among the interviewees and the countries, making the use of a qualitative approach useful because of possibility to adapt the questions and gain more substantial insights. During the interviews, questions on TA could be modified according to the interviewees' level of awareness or knowledge on TA. In this way, a qualitative approach offered more benefits than a quantitative one, also because it was possible to contextualize the questions according to the specific settings. Further, it enabled assessments of the setting (e.g. political, cultural or social) in which TA does or could take place. Also, since the TA community itself as well as the group of individuals in the case countries is fairly small, a qualitative approach seems more appropriate. The aim of the interviews, combined with desktop research, is to come to substantial accounts on the S&T setting in the countries, the situation of TA as well as issues of engagement and ethics. These accounts aren't aimed at proving a set hypothesis, instead they should contribute to the emergence of the assumption that TA is highly relevant in current times and across borders and that we need detailed insights into how it functions or potentially could. For the reflections across the countries the guiding question is therefore: why do TA(-like) activities take

[1] The project "Technology Assessment - Methods and Impact" (TAMI) (2002-2003) was a unique collaboration between important TA institutions across Europe and was aimed to define TA and create criteria for its methods and the impact it can reach. For details on the project results see: Decker and Ladikas (2004). Also see section 3.1.

[2] The EU funded project "Parliaments and Civil Society in Technology Assessment" (PACITA) (2011-2015) intended to enhance capacities and institutional foundations of knowledge-based policy making and was especially focused on parliamentary TA. For details see: http://www.pacitaproject.eu/

place or not in certain settings? This also gives the possibility to transfer insights of the specific interviews and contexts into more general, abstract connections and reflections. Identifying TA's (potential) location within the different systems and the relevance of ethical considerations and engagement poses the possibility to find links to the global level.

A next step requires the **comparison of these cases in an explorative way**, looking at what aspects were most relevant in the countries. Criteria for this comparison are not quantitative, for instance which country allocates more funds for TA activities, but instead are focused on the diverse understandings across the cases and where similarities or differences lie. Criteria for this are therefore fairly open and revolve around key aspects for TA (including engagement and ethics) and its development or lack of. These comprise issues of S&T priorities and challenges, the political system and surrounding culture or the openness of decision-making processes. Through this we can come to understanding the specific TA habitats in the individual countries as well as reflect on a wider level towards a global TA. In this way the cases have an instrumental character, serving as a means to gain needed in-depth insights into unique habitats for TA, including what future requirements may be (i.e. recommendations for the countries) as well as showing us how we can move to a more general global level. In a further reflection beyond the cases, this is done by discussing questions of different normative foundations of TA as well as other relevant national contexts in section 6.2. The cases and bringing them together offers substance for the argumentation that global TA is needed and how we can move towards it. As such, the cases make up the main research part of this thesis, while the discussions on the global level of TA is done as a next, reflected step.

Scope of the Thesis

The questions behind this thesis emerged from my own experiences working in TA projects and increasingly noticing the importance of the global level of S&T developments as well as a certain gap in TA to appropriately approach this. Traditionally coming from national demands for better insights for decision-making, TA is often focused on country specifics, regarding political setting, historical context and sometimes cultural frame. Yet, this limits assessments to a certain degree. The challenge here is to expand TA towards a needed global level, next to the national. This also defines the disciplinary scope of this thesis. At its core is TA: how it is understood in different national contexts and what this can mean for a global TA approach as a way to come to assessments of S&T at a global scale. By using TA as its frame of reference, this thesis specifically focuses on main aspects like engagement and ethics as well as activities that relate to TA. For the country cases India and China this was important as many activities aren't explicitly termed TA but can be regarded as such.

Of course, the question of a global level of assessing technologies touches on various aspects that go far beyond the realm of TA. This includes issues of global governance and overall political structures, with questions like: If we aim to govern S&T on a global level, how can this be integrated in existing political or institutional structures? Yet, the aim of the thesis is to provide a first empirical basis and reflections on a global TA. Since S&T developments are becoming increasingly globalized, it is important for TA to adapt. A comprehensive and complete description of the changes necessary on a global governance scale would go beyond the scope of this dissertation and encompass political science, issues of governance, economic analysis or organizational theory. Of course, a comprehensive TA should include such aspects in its

assessments, yet for this thesis, the starting point and focus is TA, as it has developed and is contextualized. As the frame is TA, the work here focuses on activities in this area, characterizes them and reflects on possibilities and limitations of more global TA approaches. In this sense, the descriptions provided here represent a first step towards a governance or structuring of a global TA. For this to be realized more research and experience is needed, which is discussed further in chapter 7.

Newer approaches related to TA, which should be mentioned, such as Responsible Research and Innovation (RRI) or Responsible Innovation (RI) aim to find ways to better develop S&T for example by inclusion of relevant stakeholders, also stressing the importance of ethical considerations and engagement (described further in section 3.2). TA and RRI have many overlaps, conceptually and methodologically, which are described among others by Grunwald (2011). Yet, TA can be regarded as the more established concept, also in an institutionalized way, making it more useful in terms of tracing its understanding, methods used as well as potential impact in different countries. Also, TA is located in the political domain, due to its basic aim of enhancing the ability of political actors to govern S&T developments. In this sense, TA is inherently concerned with S&T policies and (improved) decision making. RRI mainly addresses the processes of S&T development itself, so how actors involved (scientists, stakeholders, citizens) can become mutually more responsible resulting in 'better' technologies. Regarding global developments in S&T and the appropriate responses towards the assessment of these, TA seems better equipped. This also differentiates TA from other approaches such as Science and Technology Studies (STS). Both TA and STS acknowledge the wide effects of S&T within our societies today, yet STS is essentially an academic endeavor across several disciplines, while TA has a political dimension and prospective orientation (Simonis 2013: 35ff.) As the aim of the thesis is to strengthen capacities to deal with global S&T developments on a political and societal level, TA is more useful here as it can offer ways towards finding strategies to co-shape and possibility direct S&T developments. Also, as the focus of the thesis is on understandings of TA in China, India and Germany and its location within the national S&T system the issue of cultural specifics comes into play. Yet, the aim is not to conduct a cultural comparison among the countries with a focus on the value systems; this has been attempted regarding global ethics in S&T (Ladikas et al. 2015b). Even though different values or emphasis of S&T policies are described, the focus remains that of TA and its (possible) application in the national contexts as well as potentials for a global level. For this, insights from the case studies are compared, for instance how ethics and engagement are understood, in order to identify possible connections that can serve as a basis for global TA. The cases present very different levels of 'development' regarding TA and can therefore be useful to understand the various needs for TA and how they are contextualized nationally.

Structure of the Thesis

The thesis' main focus is on the case studies in Germany, China and India. They form the basis on which the question of a global TA framework is reflected on. This has a twofold approach: first, reaching a more in-depth understanding of the national contexts of countries, which don't have an explicit tradition of TA (China and India) can help uncover what might be needed in order to come to a more fruitful "TA habitat" (Hennen and Nierling 2015) in these countries. Second, the case of Germany is chosen in order to describe a country in which there is a long-standing tradition and institutionalization of TA, so a more established environment or habitat.

This cannot be focused only one-way, from the established to the emerging. As, for instance, the PACITA project showed, mutual learning goes both ways and established TA needs to continuously adapt, also by learning from emerging TA and its issues in other countries (section 3.2). This enables reflections on the individual countries surrounding expectations and demands as well as the specific contexts (e.g. structures, institutions and activities). This also gives rise to an important question in the widening of TA. As discussed in detail in section 6.2.2, TA is a concept coming from a Western democracy context, originally with explicit role to inform parliaments, it is sometimes argued that TA has a normative core, which defines it as a critical observer of S&T developments or policies (Hennen and Nierling 2015; Grunwald 2018a). Here the question is whether TA is at its core democratic (and can only really be applied in a liberal democracy) or if the basis of TA is actually the norms and values of a given society. This means it could be adapted to a largely different (from Western societies) political context, for example, in China, in which values such as harmony or progress are important. Or to a culturally different and highly diverse context, such as India, where issues of access or equality are highly relevant. In this sense the cultural norms would form the basis of TA, not necessarily the political (democratic) structure it originally came from. Still, it would also be essential to define boundaries (either political or cultural) outside of which TA cannot function in a meaningful way. This key issue is further explored through the case studies, enriching the insights regarding the development of TA habitats and reflected on in chapter 7 on a global level of TA. Based on the findings from the cases, we can gain overarching insights, for example that ethics and engagement are key parts of any S&T debate or TA and can therefore function as common denominators in different cases or contexts. From the cases we see that the national context remains important: for the cultural and political specifics, but also as an addressee of TA (e.g. national parliament or citizens). Yet we also find that the global is a necessary reflection level and that ways forward towards this exist.

Chapter 2 of this dissertation aims to introduce the overall setting in which S&T take place today. Globalization debates, also related to S&T policies, are described in order to understand the current challenges for any kind of assessment of S&T. New forms of knowledge production as well as several global initiatives and policy documents are examined in order to understand better the overall context in which a global level of TA would be set. Building on this, chapter 3 presents TA in its different forms and methods as well as possible impact. This is done to provide the frame of TA in general, how it has developed in Western societies by adapting to different aspects and how it is currently practiced. Newer TA developments are described in order to come to the current tasks facing TA. In a globalized context, TA should aim to become more networked and flexible as a response to worldwide challenges. In chapter 4 the issues of ethics and engagement, as key elements of TA as well as of any society dealing with S&T, are closely examined. Current discussions on global ethics as well as limits of engagement (also on a global scale) are discussed and provide a starting point for the country analysis of the following chapter. Chapter 5 investigates the national contexts of TA in Germany, China and India. Interpreting key S&T documents and their connections to national values forms the basis of reflections of interviews with key actors in China and India. Main aspects here are the societal setting of S&T, ethics and engagement, roles of TA as well as perspectives of global TA. In chapter 6 we look across the countries to understand better how engagement and ethics take place also compared to one another. Further, TA habitats in the different countries are reflected and compared, also as a way to discuss the normative aspects of TA in different contexts as well as

to move towards more concrete parameters for conceptualizing a global TA. The concluding Chapter 7 presents models and recommendations for further developing (global) TA in all three countries as a basis for finding similarities as well as differences between these settings. This leads to further thoughts on how to move forward to a global level of TA, including fairly concrete recommendations for next steps. This centers around the conceptual and methodological work necessary as well as what kinds of global TA projects could be useful to further advance it. A possible structure for a global TA is also highlighted as it may provide insights into how such a complex undertaking could be realized. Finally, based on the findings and insights of this thesis, some concluding thoughts are explored regarding further research and activities.

2 The Global Scope of Science and Technology

The context in which science and technology (S&T) take place today is complex, far-reaching and interrelated. This in turn has substantial implications for policy-making concerned with aligning S&T developments and societal needs and expectations. Globalization as well as different forms of science and knowledge production have influenced the way S&T are conducted and how they, in turn, need to be assessed. In light of this increasingly global context, Technology Assessment as a process aiming to contribute advice to decision makers as well as a wider public, needs to respond and take up the challenges that come with this situation. In this sense, TA, as already implied in the beginning of this thesis, should increase its focus on the global context, next to the local and national, in order to account for these developments. So, how can TA better adapt to a globalized world? This chapter aims to provide first insights into global changes relevant for S&T developments and surrounding policies. In this way it offers an outline of the current situation and key aspects, which are an important step towards uncovering better what TA's potentials, challenges and limitations are regarding a global level.

Overall, S&T are becoming more and more widespread in their development and effects. Technologies extend worldwide and influence the lives of people in very different countries or cultures, almost simultaneously. When looking at most developments (economic, cultural, technological, social, etc.) in our world today, the concept of globalization is inevitable in order to better understand how these actually take place. Studies on the increasing global scope of changes have emerged since the 1970s, focusing on various developments such as the rise of a global economy, global cultural practices, political processes on a global level, the worldwide movement of people including new forms of identities and communities as well as new social hierarchies and forms of inequality. The analysis of these global issues has been done in numerous areas ranging from social sciences, history to law as well as natural and applied sciences. Robinson identifies two general streams of research in this context: those examining specific problems related to globalization and those developing theoretical reflection on the concept of globalization itself. This array of studies shows the "highly conflictive nature of the process" (2007: 126). Still, some common ground on what globalization implies can be found: in general, social changes have become faster and the interconnectedness of people and countries has increased, making globalization multidimensional. As Giddens writes: "Globalisation can thus be defined as the intensification of worldwide social relations which link distant localities in such a way that local happenings are shaped by events occurring many miles away and vice versa" (1990: 40). Yet, whether globalization is a process or a condition, whether it is mainly economic, cultural or political remains contested (Robinson 2007: 127). The numerous theoretical discourses on globalization each focus on different aspects, depending on their assumptions and the conditions they examine. High interdependencies between developments show the complexities behind globalization and the study of it. In the following some of these debates are briefly presented in order to better understand how S&T are situated within this.

2.1 Globalization Debates

Often discussed in the context of globalization, next to and related to the substantial changes in the economic system ("global capitalism"[3]) are aspects of cultural globalization. This is interesting to discuss in the frame of this thesis as it can help us understand the overall setting and the interconnected practices that also shape S&T. This includes analysis of an accumulation of space resulting in networks of, for instance, global cities[4] that are at the strategic forefront of the world economy and sites of production, innovation or services. These aspects are also analyzed in theories on transnationality and transnationalism. Transnationality refers to new communities which form new social identities, independent from national reference points. Transnationalism "denotes a range of social, cultural and political practices and states brought about by the sheer increase in social connectivity across boarders" (Robinson 2007: 136). This focuses on the formation of transnational practices of actors on a global scale, connecting these as well as institutions worldwide. Linked to this is also the idea of a globalizing culture; meaning the idea of a culture that is making things more and more similar around the world. Ritzer (2007b, 2015) problematizes this in his accounts of how "nothing" is globalized and uses the example of McDonalds to show how the systematic ideas of the fast-food restaurant dominate more and more societies. For him, "nothing" (in contrast to "something") is "defined as a social form that is generally centrally conceived, controlled, and comparatively devoid of distinctive substantive content" (Ritzer 2007b: 36). He also distinguishes between "glocalization" so the unique integration of the local and the global as kind of "cultural hybridization" (ibid.: 12) (associated more with "something") and "grobalization", which involves imperialistic ambitions of companies or countries imposing certain things worldwide (spread of "nothing") (ibid.: 15) [5]. We can state that the globalization of culture forms the context in which technologies and science develop today, what world-wide implications they often have and how this effects policies around them. Useful in this context is the term "technoscapes" referring to "the global configuration, also ever fluid, of technology, and the fact that technology, both high and low, both mechanical and informational, now moves at high speeds across various kinds of previously impervious boundaries" (Appadurai 1990: 297).

This shows the complex situations in which S&T as well as their polices are located and how current ideas of political regulation, national borders or market rationality are not really equipped to shape or even fully understand these developments. These technoscapes are one

[3] Theories of global capitalism focus on the profound changes in the economic structure and aspects such as global production and financial systems, which go far beyond national or state systems. This means a shift from national production forms to interrelated and globalized ways of production. Critique is often voiced in these discourses stressing that the rise of this new global order is without boundaries or limits also in regard to social, cultural and even individual life. For an overview on these debates see: Robinson (2007: 130–132).

[4] This discussion points to the development of a few "global cities" (Sassen 1991; Zukin 1989) that are focal points within the world economy, are places where a "new creative class" (Florida 2012) gather, making them sites for leading firms in various fields. Issues of gentrification and increasing competitiveness among cities are criticized from various areas (e.g. academics, arts and culture, citizen organizations, sustainability, etc.). For detailed analysis on this see: Kagan and Hahn (2011); Solnit and Schwartzenberg (2002); Zukin (2011).

[5] Ritzer also gives strategies for coping with globalization tendencies. These range from action on an individual level (stressing the importance of the local) to wider movements such as slow food (Ritzer 2007b: 192). Another interesting account is Sennett's idea of "craftsmanship" as a way to re-establish a sense of self-worth, long-term thinking or the learning of abilities. This is a way of counter the forces of a globalized economy towards a more sustainable way of living (Sennett 2009).

of many 'flows' that form a "global cultural economy" (Appadurai 1990: 296) and generate "sets of symbols, meanings, representations and values" (Robinson 2007: 140) that travel worldwide. In this way, cultural transnational spaces are created, but not bound to national or local societal contexts. This of course is highly relevant when relating it to S&T developments and the aim of aligning these with societal needs and expectations.

As we can already see, there is a wide array of studies on globalization and its effects[6]. Here the aim is not to give a comprehensive overview, instead attention is drawn to a few aspects that appear helpful to understand the relationships between science, technology and society in the context of a globalized world. Globalization has effects on science, technology and innovation, either on their production (e.g. new technologies are often produced within globally generated knowledge) or their diffusion (e.g. innovations that are used throughout the world). In this sense, S&T are elements of globalization, on the one hand enabling it in the first place and on the other an effect of globalization. This becomes clear when looking at some of the main approaches within globalization debates, such as "The Rise of the Network Society" (Castells 2008). Technological changes such as new information technologies are a premise in order to form a global economy or "network society". Part of this global economy is the globalization of S&T, but in a selective way, meaning that "while there is still a concentration of the stock of science and technology in a few countries, and regions, the flows of technological know-how increasingly diffuse around the world, albeit in a highly selective pattern. They are concentrated in decentralized, multi-directional production networks, which link up with university and research resources around the world. This pattern of technology generation and technology transfer contributes decisively to globalization" (ibid.: 129). We see from this how interrelated globalized developments of S&T are with societal, economic and cultural changes, but also how S&T are parts of wider, unbalanced or even inequality developments. This points to the interrelatedness when looking at globalization: S&T develop and enable globalization developments, an increasingly globalizing culture offers a basis for the spread of certain patterns or practices worldwide, tied together in networks and all based on an increasingly globalized economy (Archibugi and Iammarino 2002; Castells 2008). This then leads to the question what this globalized world means for S&T in societies and on a global scale. Two aspects are important here: on the one side challenges have become global and require global governance responses (e.g. climate change), on the other, many S&T developments have wide-spread effects that cannot be assessed by only focusing on the local or national contexts. In short, globalization enhances the effects of S&T on societies and at the same time makes them more complex.

In this setting, it becomes more and more important to bring together understandings of globalization tendencies and how these relate to the changing relationships between S&T in societies also on a global scale. For this, nationally bound assessments and analysis, even if they include global aspects, cannot be sufficient to understand S&T developments today. Therefore, a wider approach for this changed situation is necessary. Regarding the understanding of how global S&T effects societies and how interrelated cultural or economic developments are with S&T, assessments of technologies and the policies surrounding them have to be broadened in order to better grasp these changes.

[6] An overview of globalization studies is given here: Ritzer (2007a)

2.2 Current Challenges of Science and Technology Policy on a Global Level

From the above we gain the impression that globalization and its implications for economic, societal or cultural aspects is a key element of understanding the overall situation in which S&T are placed today. In turn, this leads to the question of which kind of assessments and recommendations are needed in this globalized setting to better cope with these developments. And as S&T change, so should the policy-making surrounding them. The policies to shape, govern and align S&T with societal expectations need to be responsive towards these effects, which correspondingly means that TA, as a provider of policy advice and adherent of public debate, should take these into account as well.

In the following, science is understood as a "body of research [where] knowledge is the outcome of social processes and institutional guided actions of researchers" (Edelenbos 2004: 291). In this sense, science is "influenced by societal and individual values and norms […] and is therefore amenable to being shaped and informed by users" (McNie et al. 2016: 886). Therefore, it is insufficient to think of science as uncovering 'the truth' in an independent sphere untouched by the rest of society (Sarewitz and Pielke Jr. 2007), since it "is not the objective procedure by which facts are uncovered, but the way of life in which facts are made" (Edelenbos 2004: 291). Further, technology is understood in the following as modern and therefore science and research-based (Grunwald 2010: 19). Throughout history technology has been essential for survival and advancement and its placement within societies and access to resources or capacities has been key (Grunwald 2018b: 14). Important, also in the context of TA and this thesis, are the risks and benefits or the intended and unintended consequences of technologies, often within the same one. This ambivalence characterizes technology and its development, use and application (as innovation) within society (ibid.: 16ff.). This points us to the importance of uncovering the contexts and framings in which S&T take place, the values and societal settings in which they are conducted, funded or used as well as possibilities and limits. We see here that an approach such as TA, as described in the introduction (chapter 1) and in-depth in chapter 3, can be a useful tool to help understand and inform the shaping of S&T, i.e. policies. The policy-making surrounding S&T should take the embeddedness in society into account and often does so by linking the funding of science to desired outcomes or innovations that are 'good' for society. Based on Fischer (1997), van Enst et al. define the concept of policy as "a course of action designed to resolve or mitigate problems in the political sphere" (van Enst et al. 2014). Important to note is that the focus here is not on how (public) policy uses scientific knowledge to inform its decisions, for example on issues such as urban development, on which much has been written (Fischer et al. 2007), but rather on science policy, so policy decisions concerned with supporting and funding research, technology and science.

Challenges facing S&T policy-making today come from the increasing global reach of technology developments and as well as the scale of problems science is expected to tackle and the seemingly increasingly blurring boundaries between science and society. As diagnosed with the terms "Mode 2" (Gibbons 2000; Nowotny et al. 2003) or "science for a post-normal age" (Funtowicz and Ravetz 1993) knowledge production is increasingly "socially distributed, application-oriented, trans-disciplinary, and subject to multiple accountabilities" (Nowotny et al. 2003: 179). This means that ethical questions and (unintended) outcomes of technology developments cannot merely be answered by science itself, but need "extended peer

communities" (Funtowicz and Ravetz 1993) to reflect on values, interests and create a 'talking back' of society to science (Gibbons 1999). This new form also implies that knowledge itself isn't understood as a public good anymore, but more and more as intellectual property forming "a new language […] – a language of application, relevance, contextualization, reach-out, technology transfer, and knowledge management" (Nowotny et al. 2003: 185). Knowledge production is now more contextual and can occur differently across space. Scientific knowledge is no longer within the protected environment of science and its disciplines, rather "science can no longer not be validated as reliable by conventional discipline-bound norms; while remaining robust, science must now be sensitive to a much wider range of social implications" (Gibbons 1999: C82). This also changes the spaces in which science and technological developments are shaped. The formulation of problems that need scientific or technological solutions and the working out of how this should be done takes place in what Gibbons calls the "agora" which is "[n]either state nor market, neither exclusively private nor exclusively public, the agora is where today's societal and scientific problems are framed and defined, and their 'solutions' are negotiated" (ibid.: C83). This can ensure socially robust knowledge which firstly "is valid not only inside but also outside the laboratory. Second, this validity is achieved through involving an extended group of experts, including lay 'experts'. And third, because 'society' has participated in its genesis, such knowledge is less likely to be contested than that which is merely 'reliable'" (ibid.: C82).

The diagnosis here is that more and more legitimate actors are (or should be) included in the debates on science due to "the manifold uncertainties in both products and processes [that] require that the relative importance of persons becomes enhanced" (Funtowicz and Ravetz 1993: 752). This is also necessary because science is still meant to provide expertise for decisions but "particularly in the field of technology - scientific knowledge is necessarily incomplete, provisional and underdetermined with regard to the complexity of the problems of policy-making. Ethical questions growing out of scientific development as well as the assessment of risks for human health and environment cannot be reduced to scientific facts and be dismantled of the values and interests" (Hennen et al. 2004: 58), which then effects policy-making. Therefore, the "extension of legitimacy to new participants in policy dialogues has important implications for both society and for science" (Funtowicz and Ravetz 1993: 740–741). Yet, even though over the years there has been a growth of participatory formats aiming to figure out how to come to more robust decisions also becoming part of research funding programs[7] the inclusion of these extended actors as an integral part of science and research is still missing. As McNie et al. state: "Lacking […] has been any formal conception of research that acknowledges and fully integrates the role of use and users in knowledge production as part of its basic definitions and conceptualizations" (McNie et al. 2016: 886). In this light, if science, research and technology are meant to address and maybe even solve pressing challenges, it is essential to understand how boundaries between science and society are becoming more indistinct, for example by acknowledging concepts such as Mode 2 or post-normal science and to find processes and methods to cope with these developments. This of course is also relevant for policies dealing with S&T. As the boundaries between science and society become blurred, shown for example in the idea of the "agora" or the "extended peer communities", it becomes important to actively deal with this. McNie et al. describe this as "boundary work" which ensures

[7] E.g. Horizon 2020 Funding Program of the European Commission under the Responsible Research and Innovation (RRI) framework.

"that research responds to the needs of users while assuring the credibility of science. Boundary work involves communicating between science and society, translating information, and mediating and negotiating across the boundary" (2016: 890) and is also of relevance for S&T policy-making.

Overall, Mode 2 and post-normal science as images of the changing relationship between science, technology and society seem useful to understand (global) effects and entanglements and to think about more appropriate (policy) structures as a response. Even though the conceptualizations described above, for example of Mode 2, have been criticized for various reasons, such as lack of empirical basis (Nowotny et al. 2003), they still offer a starting point to think further about how S&T discourses take place within different societal contexts and on a global level and what this might mean for policy-making. Also, they point us to relevant issues of engagement and the inclusion of different ethical reflections regarding S&T developments, which are explored in detail in chapter 4 in this thesis. If nothing else, pressing current issues demand this: "The new policy issues of risk and the environment are global not merely in their extent, but also in their complexity, pervasiveness, and novelty as a subject of scientific inquiry" (Funtowicz and Ravetz 1993: 754). Further, we find "new 'general purpose' technologies such as ICTs [information and communication technologies], biotechnology, new materials, etc., [that] have been shown to intensify the science–technology interface and to be inextricably associated with the complex processes of organizational, institutional and infrastructural change" (Archibugi and Iammarino 2002: 99). This "globalization of innovation" [meaning the] increasing international scope of the generation and diffusion of technologies" (ibid.: 99), show the increasing need to frame S&T, next to the national level, in a global way.

2.2.1 Science and Technology Policies Today

As we see, "Mode 2 knowledge production" moves towards contexts of application, rather than an understanding of science as independent from its surroundings. Globalization developments present new complex connections between S&T and society. These changing relationships and their implications are also highly relevant for policy-making surrounding S&T. As Sarewitz and Pielke write: "Science policy decisions are not made in a vacuum but with some consideration or promise of societal needs and priorities. Thus there is a feedback between the (perceived) demand for science and the (perceived) characteristics of supply" (2007: 6). Even though the argument that science works best, if it is independent from societal demands or needs is still often used also in the context of funding, it is ultimately a strategic decision, often based on values or perceived needs and expectations, where to invest. Overall, "strategic decisions to focus public sector resources in particular areas of science have consciously and successfully linked research portfolios to technological advance and such societal outcomes as economic growth, agricultural productivity, and military power" (ibid.: 8). Yet, looking at decision-making as a rational process with causal connections isn't realistic (Hennen et al. 2004: 58). The supply of scientific knowledge as well as its societal demand is set in a complex and dynamic relationship (Sarewitz and Pielke Jr. 2007: 6). Therefore, if science policy is seen as the reconciliation of supply and demand, it must incorporate values, needs and interests into its decisions that ultimately into science. Connected to "extended peer communities" described above, as an important part of including various forms of knowledge on values, interests or ethical considerations, this means forms of engagement should be a part of policy decision

making processes. As Jasanoff writes: "What has to change is the *culture* of governance, within nations as well as internationally; and for this we need to address not only the mechanics, but also the substance of participatory politics" (2003: 238). Here there is a need to look closer at the processes within science policy itself. Since, much attention has been given to interaction dynamics between the decision makers and producers of knowledge as well as the need for innovation on the institutional level in order to enhance these interactions. Yet, "[v]ery little consideration has been given […] to science policy—that is, to the decision processes that strongly determine the priorities, institutional settings, and metrics of success for the supply of scientific research […]. Correspondingly, very little consideration has been given to the types of information or knowledge that science policy decision makers could call upon to improve the reconciliation of supply and demand" (Sarewitz and Pielke Jr. 2007: 10). Engagement could be one way of gaining access to specific, contextual knowledge for making decisions between supply and demand and designing research portfolios to reflect this. For instance, as we see in the cases described in chapter 5 below, S&T policies in countries like China or India are often not well aligned with actual needs and expectation of the public, subsequently because, as deducing from the case studies there, awareness of engagement or wider ethical reflections is lacking.

Regarding the developments described above, the question can be raised: What kind of approaches do we need for policy-making in light of these challenges, also on a global level? The complexity of the contexts in which science is done has implications for how it should be organized. As McNie et al. (2016) reflect, the divided understanding of fundamental, basic and problem-oriented, applied science isn't useful, especially regarding the complex interrelations described above and as a means to assess research. Yet, it is often still used in thinking about what research to fund resulting in more knowledge, but not necessarily useful information, in the sense of relevant, credible and legitimate (Cash et al. 2002) "resulting in missed opportunities of reconciling the supply of scientific information with the capabilities, demands, and needs of users" (McNie et al. 2016: 885). Because of changes in science and society, there new ways forward on conceptual as well as practical levels for science policy are needed[8].

Overall, the level of knowledge production is tied to the developments described above regarding Mode 2 or post-normal science and reflect the wider changes here. New forms of expertise ("extended peer com munities"), high levels of uncertainty or problem-orientation are important factors here meaning that policy-making as well as assessments need to be better adapted to cope with this. The field of learning and engagement and (boundary) knowledge exchange is a key point for science policy as it is concerned with reconciling supply of information and demands made by users by use of methods of informing, consulting or mediating. Here, the idea of "brokering" is interesting because it is about building relationships between various actors and networks. Generally, aiming to link science with society (supply with demands) means doing "boundary work" and in "some cases brokering is done by organizations that are designed to do this work" (ibid.: 888). TA comes to mind here as an approach which supports such work (as we see in chapter 3) and where, while constantly adapting to changing relationships and interfaces, this type of exchange and reconciliation will continue to be done.

[8] For this McNie et al. suggest a "typology to inform discussion, design and implementation of research" (2016: 887), which is aimed to give science policy practitioners and researchers a more holistic vision of what a given research program or project entails and whether or not it is aligned with project or programmatic goals.

TA is a field where policy, S&T and society come together and one where methods and tools can be developed and used to better assist negotiations within the "agora", as a kind of "honest broker" (Pielke 2011; Grunwald 2018b: 173ff.).

These changing conditions in which S&T and policies are situated also point us in towards the global level. Here, S&T related policies on an international level are often discussed in order to find ways of action regarding environmental problems, climate change and sustainable development (United Nations Development Programme 2001; U.S. Climate Change Science Program 2003; United Nations 2012)[9]. These problems require global responses and therefore the boundaries of national policies become apparent. Problematic here is that decisions behind science policies and research (especially on a macro level) are often made by actors and institutions that are far away from the connections between research and its possible uses. Often mentioned in this context is the need for science to inform policy as "global environmental changes are cross-scale phenomena that require assessment at all scales and integration across scales in order to inform policy- and decision-making most effectively" (Cash and Moser 2000: 109).[10] This also reflects in post-normal science and Mode 2, which stresses the complexity of the "organization of knowledge production necessary to address problems of decision-making, in contrast to older notions of autonomous – ''normal'' – scientific practice" (Sarewitz and Pielke Jr. 2007: 10). From this we see that we need boundary work to better align S&T policies with current societal challenges in a globalized context. TA can and should take on this role enabling the inclusion of, next to scientific assessment, reflections that can account for new forms of science as well as the complexity in which it is situated. This is examined further in chapter 3. Building on the previous descriptions of the issues related to S&T policy-making today, looking at current global approaches to S&T developments can offer insights into what can be and is addressed on this level.

2.2.2 Global Agendas for Science and Technology

As we have seen, globalization implies that effects of S&T reach in all areas of the world. And, in turn, issues such as climate change can only be tackled on a global scale. On a policy level, this means different agendas regarding S&T as well as innovation strategies can be found in different contexts. Looking at these can help us understand how S&T developments and challenges are framed on an international or global scale, providing insights into how the questions and issues described above are taken up here. These policies differ between countries and regions as well

[9] This is often related to innovation as a 'go-to' way to solve any societal challenges in a universal way. For a detailed description and critique on this, also the way this is translated into specific context, see: Pfotenhauer and Jasanoff (2017).

[10] There is an on-going discussion regarding climate science and the knowledge it provides for policy-making circling around climate scientists wanting to provide "useable knowledge for decision makers" and that it is mainly about "delivering facts to users"(Sarewitz and Pielke Jr. 2007: 10). As Sarewitz and Pielke criticize this "debate is oblivious to the sorts of insights […], which teach us that science is always politicized, and that the real-world challenge is to cultivate an inclusive and nonpathological process of politicization" (2007: 10). For this debate see also: Pielke and Sarewitz (2003) and Wigley et al. (2003).

as between the Global North[11] and the Global South[12] (Holizki and Wolbring 2016: 11). The policy papers or reports of each country or region typically focus on specific challenges as well as the key aspects of S&T and innovation on the national level, with the aim of setting strategies. Yet, as the case studies in chapter 5 show, one can find similarities across the different S&T and innovation policies in the countries regarding the framing of these policies along societal challenges and the need for S&T to address them. The basic idea of development and progress via S&T and innovation in these policies can be understood as a sociotechnical imaginary, which forms collective and stabilized visions which support advances in S&T development (Pfotenhauer and Jasanoff 2017: 788). Looking at an international level, many S&T policy documents can also be found, focusing on the global context of developments. For example, the European Research Council[13] aims to strengthen research in Europe and therefore funds highest quality research throughout the EU while corresponding with the funding framework programs. The "Strategic European Framework for International Science and Technology Cooperation - Communication from the Commission to the Council and the European Parliament" makes a strong connection (as many policy papers do) between the further developments of S&T and the economic, but also societal well-being of Europe. The report reads: "Deepening the European Research Area (ERA) through greater integration and cross-border coordination of research investments and activities will increase Europe's competitiveness and its attractiveness as a place to invest in research and innovation. Promoting European ICTs worldwide as a key driver of socio-economic growth will also contribute to the Growth and Jobs agenda" (Commission of the European Communities 2008: 4).

Further, S&T policy papers often connect advances of S&T and innovation to competitiveness, but also to achieving sustainable development on a global scale. On the European level we find statements such as: "The main objective is to contribute to global sustainable development and to foster Europe's S&T excellence, which is increasingly a basis for economic competitiveness at a time where EU companies are ever more facing competition from emerging economies" (ibid.: 5). Moving towards the global level we can also find this. The United Nations states: "We resolve to adopt science, technology and innovation strategies as integral elements of our national sustainable development strategies to help to strengthen knowledge-sharing and collaboration" (United Nations 2015: 53). Or: "We recognize the need to facilitate informed policy decision-making on sustainable development issues and in this regard to strengthen the science-policy interface" (United Nations 2012: 48). This is then often connected to issues of accessibility and inequality as well as technology transfer or capacity building. "We request relevant UN agencies to identify options for a facilitation mechanism that promotes the development, transfer and dissemination of clean and environmentally sound technologies by, *inter alia*, assessing technology needs of developing countries, options to address them and capacity building" (ibid.: 48). The Third International Conference on Financing for Development 2015[14] presented the

[11] Documents named by Holizki and Wolbring (2016) include: Commission of the European Communities (2008), Australian Academy of Technological Sciences and Engineering (ATSE) (2013); Government of Canada (2014). Other examples include: Federal Ministry of Education and Research (2010) or the Office of Science and Technology Policy in the U.S.A., which produces many documents and reports regarding specific technologies and implications for the country. (https://www.whitehouse.gov/administration/eop/ostp)

[12] Documents named by Holizki and Wolbring (2016) include: Cao et al. (2006); Agency for Science TaRS (2011); Department of Science and Technology (2014/2015).

[13] https://erc.europa.eu/

[14] http://www.un.org/esa/ffd/ffd3/

Addis Ababa Action Agenda (United Nations 2015), which identified the problem of "the persistent "digital divide" and the uneven innovative capacity, connectivity and access to technology, including information and communications technology, within and between countries (United Nations 2012: 51). Based on this the agenda regards the strong need for capacity building and therefore calls for the formation of a " Technology Facilitation Mechanism [which] will be based on a multistakeholder collaboration between Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders and will be composed of a United Nations inter-agency task team on science, technology and innovation for the sustainable development goals, a collaborative multi-stakeholder forum on science, technology and innovation for the sustainable development goals and an online platform" (ibid.: 55). This mechanism is an interesting case, also in the context of TA and its global level and is therefore examined closer in section 7.3 of this thesis.

This brief view of the documents and reports points us to the various contexts in which S&T and innovation is discussed on a global level. The interrelation between S&T advancements, tackling societal challenges, economic well-being in all countries and the responsibility of making S&T accessible on a global scale becomes apparent in these documents. They of course also include ethical considerations or reasoning: certain values (such as equality, justice, etc.) form a basis for formulating agendas and demands for what the future of S&T (policies) should look like. Here S&T is often seen as a way to tackle issues such as that of sustainability. Yet, challenging for a global approach is that cultural differences, specific value systems, historical contexts as well as diverse paths of developments also shape S&T within different societies. And that these can vary substantially. What a specific technology to solve a sustainability issue should look like can be very different according to the societal context (e.g. values, cultural setting, etc.). And how the policies to foster such technologies are framed (e.g. according to which needs and expectations) can depend on the socio-political system or cultural specifics in a certain country. For instance, in China a more top down oriented system will potentially mean that S&T priorities are set by experts, not a wider public. In other countries, such as Germany, established forms of TA or engagement can allow for a wider reflection to be included in policy-making. How this unfolds is further explored in chapter 5 and the implications reflected in chapter 6. Concluding, we can see from the accounts above, that due to globalization developments a global approach to assessing S&T seems necessary, yet there is the challenge of finding 'culturally fitting' ways to take the needs, ethical considerations and possible boundaries of S&T in specific contexts into consideration. This is a main challenge for S&T policy-making currently: to find ways to understand these specifics as well as to translate them to a more general level. Here an approach aimed at providing advice for decision- and policy-making in S&T can be a useful way forward. Technology Assessment as such an approach is therefore examined closer in the next chapter in order to identify its potentials as well as challenges for offering global assessments and perspectives for this current situation.

This chapter aimed to provide a backdrop of the current developments that increasingly shape S&T and the surrounding policies. The international documents regarding S&T show that these are seen as key factors in taking on global challenges. Yet, in light of globalization we need to find more appropriate ways to assess and ultimately govern these. As we have seen above, S&T are widespread and extend worldwide, effecting lives of people simultaneously by moving fluidly and at high speeds across countries and cultures. Based on this, national perspectives don't seem fitting anymore, also regarding S&T assessments. Here lie the challenges for S&T

decision- and policy-making, also in the context of newer understandings of knowledge ("Mode 2") and science ("post-normal"). These accounts then raise the question what kind of approaches are needed that better fit this overall situation. This chapter shows that aligning S&T policies with societal needs and expectations in a globalized world requires work that can include scientific aspects as well as reflections on societal issues, different kinds of knowledge and ethical consideration as well as overall complexity. A look at international policy documents regarding S&T developments also shows that policy is concerned with global S&T developments as a way to address challenges but also as something which needs to be tackled and harmonized with societal needs and issues of sustainability or (economic) well-being. This points us in the direction of TA, which, as mentioned above, may be a useful approach to addressing these issues.

3 Technology Assessment and Challenges

Globalization and its effects on S&T developments, new forms of knowledge production and challenges of aligning societal needs with S&T policies all imply an approach which can address these issues. We can identify policies across countries which place advancements in S&T and innovations at the heart of development and progress for their societies. Also, we find global initiatives, for instance on the level of the UN, focusing on sustainable development and stressing the importance of S&T in this respect. What we see here is that these policies and initiatives seem to center around needs and challenges of societies as well as a global community. This allows for the conclusion that assessments on S&T and policy decisions should be based on insights on the societal conditions of S&T developments and their implications worldwide. This also entails an understanding of the political, institutional and cultural settings as well as value and belief systems within a society in order to find ways to shape S&T accordingly. Further, it requires methods and tools that can help translate this to a global level. TA as a process, which is at the interface of society, S&T, policy, etc. seems to be uniquely placed as the area to further develop approaches dealing with global challenges of S&T developments and corresponding policy decisions. When looking at S&T discourses in policy, TA offers many insights based on wide experiences with interacting between policy makers, technology developers, citizens, etc. mainly on national levels. These interactions are an inherent part of TA and enable it to take on issues of shaping S&T developments, targeted to opening reflexive processes, and anticipating possible effects.

This chapter aims to describe the state-of-art of TA regarding methods and their potential impacts as well as past, relevant current developments and possible future directions for TA. Based on key projects like "Technology Assessment: Methods and Impact" (TAMI)[15] and "Parliaments and Civil Society in Technology Assessment" (PACITA)[16], which explicitly focused on TA itself as well as its European-wide implementation, this chapter provides a starting point of TA (e.g. working definition, impact, methods as well as different forms). It also initiates first reflections on newer developments of TA and implications of a global level. As we will see in the following, TA seems to be a useful approach regarding the effects of S&T developments and shaping them. Yet, for today's worldwide challenges, national TA needs to be complemented with an explicitly global perspective, which is able to include insights from various countries across the globe and scale these up. In order to move towards this global level, we should first examine TA in detail.

3.1 Technology Assessment: Methods, Impact and Internationalization

Technology Assessment emerged in the United States of America in the 1960s and 1970s and today forms an interdisciplinary research area oriented towards providing knowledge and option for better shaping (new) technologies and innovation. As a Western 'invention' it was originally aimed at predicting consequences of increasingly widely applied technologies by acquiring knowledge on options of technology developments for policy decisions (Grunwald

[15] See: Decker and Ladikas (2004)

[16] http://www.pacitaproject.eu/

2010). The idea was to have an early warning system that could identify possible risks and help minimize them. The first institutionalized form of TA was the Office of Technology Assessment (OTA) established 1972 at the US Congress with the goal to provide knowledge on S&T for political decision-making (Grunwald 2018b: 44ff.). As the creators of the OTA stated: "it is essential that, to the fullest extent possible, the consequences of technological applications be anticipated, understood, and considered in determination of public policy on existing and emerging problems" (United States Senate 1972). Even if OTA was shut down in 1995[17], this original form of TA as classical policy advice is still an inherent part of TA today and includes identifying impacts of S&T, understanding the causes and effects as well as providing alternative options for political action. In this role, TA serves as an information provider, focused on giving options for action, not actually taking action. Over time, TA was adopted in European countries, which used the term, but widened its understanding. Originally, TA was focused on technocratic solutions to technocratic problems, yet it soon became clear that to understand the implications of S&T in a comprehensive way, TA needed to include societal aspects (Hennen and Ladikas 2019). In this sense, TA took on a more active role including new objectives and methods to incorporate these complex and changing conditions. Today, TA is a wide area of problem-oriented research with many different 'streams', as described further below. Based on this, a working definition of TA, here is:

> "Technology assessment is a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology" (Bütschi et al. 2004: 14).

As this definition shows, TA is at the interface of S&T, society and policy based on its "initial and still valid motivation to provide answers to the emergence of unintended and often undesirable side effects of science and technology" (Grunwald 2011: 14). Further, TA aims "to reduce the human costs of trial and error learning in society's handling of new technologies, and to do so by anticipating potential impacts and feeding these insights back into decision making, and into actors' strategies" (Schot and Rip 1997: 251). Grunwald describes the beginnings of TA as a way to react to technological developments as a kind of early-warning system but in the 1980s becoming more and more a means of 'interacting' with and shaping technology (2011: 13). Motivations for TA changed over time and ranged from concerns of emerging technologies increasingly only being understood by experts, methods to overcome technology conflicts, shaping technology along societal values and demands, supporting innovations and the increased use of visions and metaphors in debates on future technologies (ibid.: 13f.). In general, TA can be distinguished according to "four partially overlapping branches of TA addressing different targets in the overall technology governance: TA as policy advice [e.g. like the work of OTA], TA as medium of participation, TA for shaping technology directly, and TA in innovation processes" (ibid.: 14).

A further way of describing TA is offered by Grunwald who identifies a "trinity of TA" in the various areas of action and based on the different actors involved. As he describes: "The actor constellations in these fields of TA practice show considerable differences with respect to the addressees of advice, the experts and expertise needed, stakeholders to be involved but also with respect to the expectations what TA should deliver and with regard to methods and

[17] For more on OTA and why it was closed see: Bimber and Guston (1997).

procedures required" (Grunwald 2018b: 51). From this come three distinctions for TA: as "policy advice", as part of the "public dialogue" and in the "engineering process". The longest established form of TA policy advice (e.g. Parliamentary TA, OTA) is focused on providing advice regarding different technology aspects and their relation to societal interests and political decision-making. It is usually adapted to the specific political conditions and includes aspects such as safety, issues of citizens' rights or setting priorities for research or innovation priorities. TA in public debate is aimed at coming to better decisions on technology by including a large spectrum of citizens and stakeholders. This improves the knowledge basis and ultimately leads to more robust and legitimate decisions. TA in the engineering process (such as in Constructive TA) means that TA is part of the development process throughout all stages. By the inclusion of TA, values, interests and possible consequences are part of the development of technologies with the aim of improving the quality. Parliamentary TA, constructive TA, participatory TA, Real-Time TA are all strands of TA that have developed over time. Several of these seem useful here, especially regarding how TA has developed to interact with various actors. The inclusion of multiple perspectives reflects in Constructive TA (CTA), which is based on the assumption that TA should be integrated into the seamless web of technology development, so the shaping of technology as mentioned above. CTA aims "to broaden the design of new technologies (and the redesign of old technologies). Feedback of TA activities into the actual construction of technology is crucial, and strategies and tools contributing to such feedback make up CTA" (Schot and Rip 1997: 252). Technology development itself is made up of very heterogenic social, cultural, economic, technical and scientific factors in which permanent course setting takes place. CTA therefore needs to continuously accompany this process by informing and reflecting to actively manage dynamic processes of technological developments. For this it makes use of socio-technical mapping, early and controlled experimentation or dialogue between innovators and the public but also technology forcing through regulation (ibid.: 255)

This 'opening-up' of TA to an active part of development processes is also an important part of Real-Time TA, which reacted to a situation where "technology assessment as a practice became lodged in institutions advising national parliaments. Resulting organizational relations not only compounded the problem of "science proposes, society disposes" by regularly requiring a political trigger for the initiation of TA activities, but they also isolated TA from the R&D enterprise itself" (Guston and Sarewitz 2002: 96). Therefore, Real-Time TA aims at closely integrating natural sciences and engineering with social sciences and policy research from the beginning. With this its "communication and early warning component [Real-Time TA] helps assure awareness about innovation among researchers and the public, and its technology assessment and choice component provides a mechanism for such awareness to be reflexively incorporated into innovation" (ibid.: 109). In this sense, Real-Time TA is a successor of CTA, yet differs in certain aspects. For instance, theoretically experimentation with new technologies isn't needed because Real-Time TA aims at already being part of the knowledge creation process itself by integrating reflexivity components such as focus groups. In order to see possible problems, it examines how knowledge, perception and values change over time. It also adds to the socio-technical mapping by including "prospective (scenario) analysis, attempting to situate the innovation of concern in a historical context that will render it more amenable to understanding and, if necessary, to modification" (ibid.: 98).

Experiences with participatory methods and processes in TA have become more and more important, not only because of developments such as CTA or Real-Time TA. Here a wide range

of formats with different actors can be found, which have been conducted for more than 20 years in the context of S&T. Regarding the thematic and spatial aspects of participation, TA can offer insights that rely on experiences through implementation. Participation in the context of planning processes, so regionally and locally grounded, is often regarded as successful. In contrast, cases of participation dealing with new materials (e.g. Nano) or more general topics of (future) technologies are often difficult to conduct. The assumption and motivation that "if technology could be designed according to social values […] problems of rejection or conflict would no longer occur at all" (Grunwald 2011: 14) is one that finds its expression in the use of participatory processes.

Over time, TA has developed many approaches that range from involvement of citizens, consumers and users, civil society, stakeholders, the media and the public throughout the different stages of technology development and governance. The underlying motivation is that including these actors leads to an improved knowledge basis according to values and ethical considerations and how different groups frame issues. For this TA has a set of interactive, participatory or dialogue methods that organize and facilitate these social interactions (Grunwald 2010: 15). From its beginning TA has included participation as "not simply some arbitrary method […] but an essential part of its conception […] as an attempt to implement or step toward democratic governance of technology policy" (Hennen 2012: 30). Important to note is that participatory TA is mainly conducted as a way of gaining knowledge rooted in social values and interests in a wider context of policy consultation and not as political participation in decision-making or agenda-setting itself. Because of this, often high expectations regarding the use of participatory TA methods for the democratization of science and technology policies cannot be fulfilled. This can result in a 'sobering up' of actors involved in these processes (e.g. citizens, stakeholders but also initiators and organizers) (Hahn et al. 2014). It also shows in critical aspects of participatory processes that include lack of impact, instrumentalization or the pushing through of acceptability. Yet, as in any form of consultation or inclusion, it is practically impossible to find direct links between the outcomes of participation and political decisions, as they only support and inform political decision-making. Further, any kind of assessment can be framed or understood differently by "power and justification strategies" (Hennen 2012: 35) and therefore is in danger of being instrumentalized. As a consequence, "studies on participatory TA [should] distinguish between the shortcomings of project management and the structural limits or deficits of the participatory procedure itself" (ibid.: 36). The question here becomes a basic one for TA: how to deal with outcomes (of participation or other methods such as vision assessment, scenarios or life cycle assessment) within the context of policy advice and consultation. On a more general level, a rise in demands and pressure for accountability of science results in wide requests for more transparency and participation in can be characterized as a "participatory turn" (Jasanoff 2003: 235) and is connected to new forms of knowledge production (as described in section 2.2 above). Here, the hope is to gain robust knowledge by embedding it in society and with this "opening up a process of technology choice" (Stirling 2008: 279) offering "'plural and conditional' policy advice (ibid.: 280). Participatory processes and methods are needed for "technologies of humility [that can bring forward knowledge on] the possibility of unforeseen consequences; […] make explicit the normative that lurks within the technical; and to acknowledge from the start the need for plural viewpoints and collective learning" (Jasanoff 2003: 240). Here, as we can already see from the definition provided of TA, it has an important role to play in this context.

The understanding of TA as a process for informing policy or public debate is broad enough to include the various concepts of TA, while focusing on its main aim: contributing to societal problem solving regarding S&T. In this sense, TA it doesn't actually shape technology, it only provides the advice for others to do so (Bütschi et al. 2004: 15). Further, this definition sketches the three main aspects or pillars of TA: science (so the knowledge of possible consequences), interaction (inclusion of stakeholders, etc.) and communication (as a means of opinion forming). This describes the general motivations of TA and how these have been further developed and realized in different forms of TA, always responding to what assessments of changing S&T developments and societal contexts may require.

Looking at the institutionalized forms of TA today we find various place in which these activities are taking place, mainly in a European context. Main ones include:

- Centre for Technology Assessment (TA-SWISS)[18], Switzerland
- Institute for Technology Assessment of the Austrian Academy of Science (ITA)[19], Austria
- Institute for Technology Assessment and Systems Analysis (ITAS)[20], Germany
- The Danish Board of Technology Foundation[21], Denmark
- Norwegian Board of Technology[22], Norway
- Parliamentary Office of Science and Technology (POST)[23], United Kingdom
- Rathenau Institute[24], The Netherlands
- Science and Technology Policy Research (SPRU)[25], United Kingdom
- Department of Science, Technology and Policy Studies (STEPS)[26], The Netherlands

On the European level we also find a TA office for the European Parliament named "Science and Technology Options Assessment" (STOA)[27]. Further, there is the European Parliamentary Technology Assessment (EPTA)[28] network, which brings together TA institutions for advancing TA as a key part of policy decision-making processes. Activities under the term TA are already spread in an international way, across Europe making it interesting for a global approach as further described in section 7.2. From these descriptions comes a certain common ground regarding aspects of TA: ranging from providing advice, accounting for societal contexts or being part of technology development. Looking closer at the specific methods of TA and their possible

[18] https://www.ta-swiss.ch/en/
[19] https://www.oeaw.ac.at/ita/en/home/
[20] http://www.itas.kit.edu/english/index.php
[21] http://www.tekno.dk/?lang=en
[22] https://teknologiradet.no/english/
[23] https://www.parliament.uk/post
[24] https://www.rathenau.nl/en
[25] http://www.sussex.ac.uk/spru/
[26] https://www.utwente.nl/en/bms/steps/
[27] http://www.europarl.europa.eu/stoa/
[28] http://www.eptanetwork.org/

impacts is a next step in better understanding TA and how it is practiced. This can further provide insights into communalities that are important when moving towards a global approach.

Methods of Technology Assessment

Based on the definition and descriptions above we can see that TA has the aim and experience to provide valuable insights into the complex and ever-changing relationship of S&T and society. Therefore, taking into account the diagnosis of chapter 2, a detailed look at TA's methods and tools can be a further step towards finding ways to deal with global challenges and worldwide S&T effects. Interesting here is to see how these methods and tools have been used and developed so far, in a mainly Western context, how they account for national specifics and whether, so the aim of this thesis, they can move towards the global level as well. The challenge here is to find an approach that can take up broader tendencies such as globalization and can also identify what these mean in a specific (cultural, historical, societal) context, as done in for the case studies in chapter 5. The methods of TA, which aim to uncover this, are therefore a necessary and important part for a global assessment approach.

Taking stock of these methods and their possible impacts is a complex undertaking; one that is documented in the central book "Bridges between Science, Society and Policy. Technology Assessment – Methods and Impacts" (Decker and Ladikas 2004), which is a kind of 'self-assessment and reflection' of TA and its practice in order to identify processes, criteria, institutionalization as well as a mission of TA. The book draws on the project Technology Assessment Methods and Impacts (TAMI), which ran from 2002 to 2003 and aimed to take stock of TA in Europe[29], by bringing together the main TA institutions and reflecting. This project is examined in detail in the following because it presents an important initial step in structuring TA activities across different countries in Europe. TAMI can be regarded as the first project to bring together a wide array of TA practitioners to reflect on their activities in a methodological way. Questions guiding this assessment of TA itself revolved around how goals can be reached with different methods or which methods are useful in various political situations. It aimed at providing a step-by-step framework to actually 'doing' TA. This methodology is useful because it provides an overall frame of TA and identifies and describes various methods and tools. Further it gives a 'process' of doing TA, beginning with understanding the situation (in terms of societal, political and scientific aspects) in which a certain S&T question is located and then setting goals. As we see in Figure 1 below, during the situation appreciation different dimensions need to be accounted for: issue dimension, political dimension, innovation dimension and the availability of knowledge (Bütschi et al. 2004: 19). This shows the complexity in which TA acts: which kind of technology, at what stage of innovation, within which political atmosphere including possible conflicting values in society. Following this situation appreciation, the specific goals of the TA project need to be set accordingly. These can be clustered according to scientific assessment, social mapping, policy analysis, agenda setting as well as mediation, the restructuring of political debates, the need for new decision making processes or policies (ibid.: 27). One TA project can commit to several of these goals, yet it is important that these correspond with the situation the TA project is set in. The project is then designed based on these goals and the desired impact. Here TA can resort to a number of methods and tools that have been developed over time. Overall, there are three general lines in which methods can be

[29] https://www.itas.kit.edu/english/projects_grun02_tami.php

clustered: scientific, interactive, communication. These methods have been developed in other disciplines or areas and have proven useful for the context of TA. Scientific methods come from natural or social sciences "applied to TA problems, in order to collect data, to allow prediction, to make quantitative risk assessments, to allow for the identification of economic consequences, in investigate social values or acceptance problems, to enable eco-balancing" (Bütschi et al. 2004: 31–32). TA also makes use of "Interactive, participatory or dialogue methods [that] are developed to organise social interaction in order to make conflict management easier, to allow for conflict resolution, to bring together scientific expertise and citizens, to involve stakeholders in decision-making processes, to mobilise citizens for shaping society's future, etc." (ibid.: 32). Further, "communication methods are used to communicate the corporate image of a TA institute, the TA approach, the TA process and product to the outside world in order to increase the impact of TA. On the other hand, communication is an important feature for the TA-Institute to keep in touch with the outside world and by that keep track with reality" (ibid.: 32). During the design of the TA project methods are selected. This is based on what methods justify the best outcome according to the aims as well as gaining high quality results for TA.

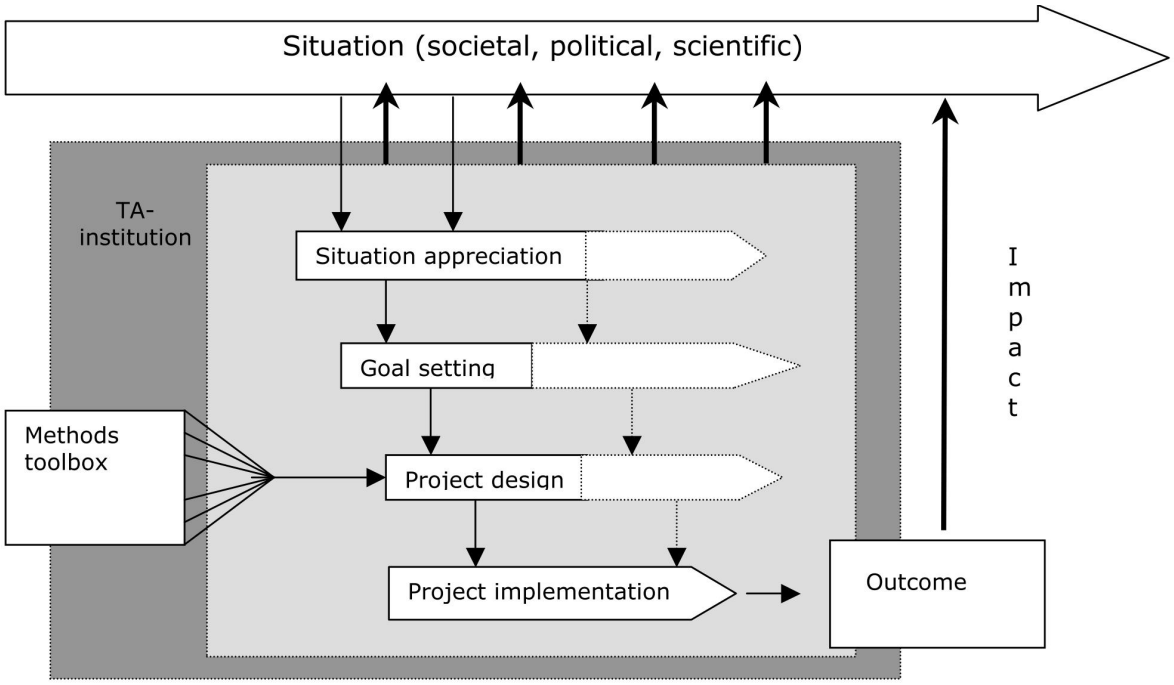

Figure 1: From Method to Impact (Bütschi et al. 2004: 16)

Following the ideal case design is the actual real world implementation, which might require changes or adjustments due to unforeseen circumstances, e.g. the TA project wasn't able to access a representative amount of citizens for a participatory event. The assessment of this is also tied to scientific, interactive and communication quality criteria that ensure that the specific nature of TA as a practice dealing with multi-faceted issues within highly complex settings is done according to overall criteria (ibid.: 33). Regarding the scientific methods, quality criteria here is tied to scientifically sound findings e.g. about technological developments. Due to the complex topics and questions of TA this also includes interdisciplinary approaches. Part of the quality of a TA project is if the different disciplines organize their work in order to reach useful results and scientific analysis. A further important aspect regarding the quality of scientific knowledge within a TA project is the reliability of the inputs. Relevant scientific knowledge is an

important factor because it 'protects' the TA project of being labeled as biased. Useful here are extended peer reviews or expert confrontation during which different arguments are weighed. For the methods of interaction, quality criteria include social and process fairness, transparency of the interactive process and argumentative quality. These are closely linked to the legitimacy, so how social values are integrated, of an interactive process and the whole TA project. Regarding communication methods used in a project, they should be flexible regarding the ongoing debate, keep track of social, political and scientific reality, try to embed outcomes in political decision making, disseminate results and to create synergies (Bütschi et al. 2004: 41) As Figure 1 shows with the ideal structure of a TA process and the interrelations of the steps described above, it becomes clear that TA is intertwined with its surroundings, such as the overall societal, political and scientific situation a technology is located in, which itself is subject to constant dynamic change. The TA institution itself, depending on its structure and mission shapes the 'kind' of TA that it does. Therefore, a process of TA must constantly account for influences from the 'outside' regarding the questions, aims, methods and recommendations it has.

A more recent model of TA, which also points us to the complexities and embeddedness of TA is proposed by Grunwald (2019) and exemplifies the different levels of TA, also referring to the impact levels developed in TAMI and described below (Table 2). Interesting in this model is that it points us to the cognitive and conceptual aspects of TA, next to the practice of "TA in action", responding outside needs (the societal, political, scientific situation) and reaching impact. As we see in Figure 2 inside the dotted lines, TA takes place on different levels, ranging from the interest of TA to support, strengthen and enhance reflexivity (cognitive interest) to the unfolding conceptual dimensions with concepts and methods regarding anticipation, inclusion and complexity (ibid.: 90ff.). This model shows us in more detail the understanding of TA as a scientific, interactive and communicative process embedded in the socio-political world and aimed at gaining impact regarding the societal aspects of S&T. For TA to be done "in action" it requires this basis of the cognitive and conceptual and unfolds in the "trinity of TA", as described above, in which TA can provide policy advice, be part of public dialogue as well as be embedded in engineering contexts. As we see, for instance in the case study in Germany in section 5.1, TA can be more or less established in these different areas and has various formats and methods it uses accordingly.

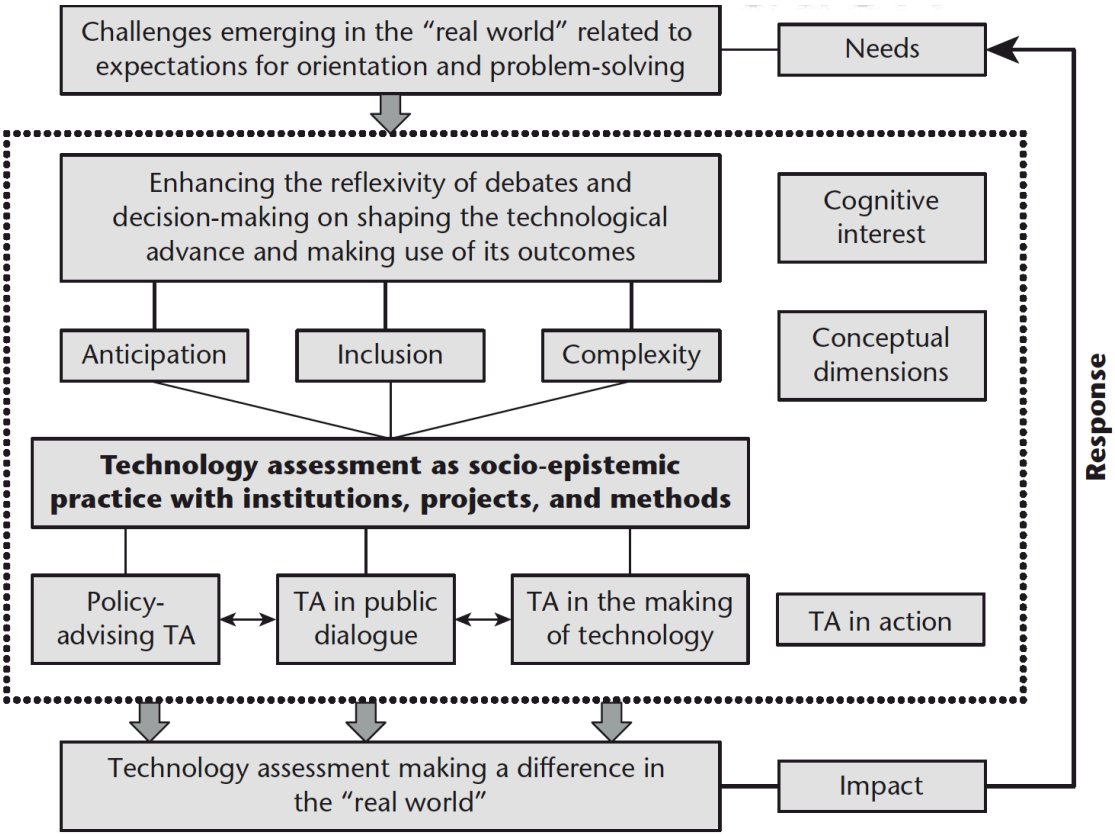

Figure 2: A General Model of Technology Assessment (Grunwald 2018b: 89)

Next to these aspects, this model also has consequences for how TA can be understood and which is also important in the context of a global level of TA. The (historical) basis of TA in Western liberal democratic thinking shapes the cognitive interest of TA to enhance reflexivity and "puts it into intimate neighborhood with democracy" (Grunwald 2018b: 97) In this way the process of TA normative and strongly connected to certain values (e.g. human rights, division of power). This of course can raise questions when expanding TA into other non-Western contexts and possible other normative foundations as discussed in part 6.2.2. This democracy implication goes along with others coming from this model such as not reducing complexity, but weighing options, thinking in alternatives as well as dealing with tensions between technology promotion and control (ibid.: 96ff.). What becomes clear here is that TA is not a simple endeavor as it requires a certain openness within a society to allow for these implications and their cognitive and conceptual precursors. Further, we can also identify certain normative criteria which define TA and its actions and which are important to reflect on when expanding TA globally, also regarding possible limitations due to socio-political surroundings or basic values. What this means for a global TA and next steps is explored in the cases presented in chapter 5 as well as the reflections in chapters 6 and 7.

Impact of Technology Assessment Activities

Next to the methods of TA as an important part for a global approach, the aspect of impact is significant as well. This refers to TA actually creating a difference in the "real world" (as shown in Figure 2 above). For a global approach this is also important as it is only actually useful if it is able to develop and use methods and tools, which achieve some level of impact in practice. And in order to trace this, there needs to be some kind of definition of impact, which provides

reference points. This also points to the usefulness of TA for a global approach. Here, the TAMI project also offers useful insights. The common understanding is that "TA has to make a difference in terms of the quality of decision making processes by adding comprehensive and non-biased knowledge" (Hennen et al. 2004: 61). In this sense, TAMI acknowledges that any discussions of TA will always also circle around the effects it has on its main space of action: policy-making. At the same time, it also recognized that a causal connection between 'rational' scientific knowledge and 'rational' decisions can't be made, but that the question of impact is central to TA, stating that: "The implicit expectation here is that decision making *with* TA leads to "better" (more rational, informed or legitimate) decisions than would have otherwise been achieved *without* TA. This is however based on an ideal concept of rational decision making (which to some extend ignores the reality of politics) and the impact of TA in this sense is hardly measurable. Nevertheless this concept is behind all discussions on impact since it is indeed connected with the traditional mission of TA" (ibid.: 61).

Based on this, a broader working definition of impact can be "any change with regard to the state of knowledge, opinions held or actions taken by relevant actors in the process of societal debate on technological issues" (ibid.: 61). Still, the actual evaluation of impact remains difficult. Even this wide definition of impact makes a tracing of effects of TA challenging, as these aren't necessarily visible or clear and might even take some time to actually develop. TAMI attempted to better the "understanding of what and under which particular condition can realistically be expected as a contribution of TA to policy making as well as public debate" (ibid.: 61). For this a typology of impacts was developed (Table 2 below), which relates dimensions of impact to dimensions of issues of TA. Impact is understood by TAMI as the application of knowledge or information making the dimensions of impact (raising knowledge, forming attitudes/opinions and initializing actions) a kind of continuum ranging from increasing awareness to actually intervening in or changing agendas. The project provided a detailed list of various forms impacts which are connected to the methods and tools of TA (Bütschi et al. 2004: 16ff; Cruz-Castro and Menéndez 2004: 121). For example, forming attitudes by setting the agenda in a specific political debate can be done by interactive methods such as a consensus conference. A Delphi method or a risk analysis may help show the technical options and contribute to a scientific assessment which raises knowledge of a certain technology. Along the continuum it seems that raising knowledge and forming attitudes is the somewhat easier mission, actually initializing actions, e.g. passing new legislation, is probably not something that is only left to TA, or that can be directly traced back to TA activities. Instead, methods from all three dimensions (scientific, interactive, and communicative) may need to come together over a longer time frame in order to actually induce this 'higher' level of impact.

Table 2: Typology of Impacts (Cruz-Castro and Menéndez 2004: 121)

IMPACT DIMENSION ISSUE DIMENSION	I. RAISING KNOWLEDGE	II. FORMING ATTITUDES / OPINIONS	III. INITIALISING ACTIONS
TECHNOLOGICAL /SCIENTIFIC ASPECTS	SCIENTIFIC ASSESSMENT a) Technical options assessed and made visible b) Comprehensive overview on consequences given	AGENDA SETTING f) Setting the agenda in the political debate g) Stimulating public debate h) Introducing visions or scenarios	REFRAMING OF DEBATE o) New action plan or initiative to further scrutinise the problem decided p) New orientation in policies established
SOCIETAL ASPECTS	SOCIAL MAPPING c) Structure of conflicts made transparent	MEDIATION i) Self-reflecting among actors j) Blockade running k) Bridge building	NEW DECISION MAKING PROCESSES q) New ways of governance introduced r) Initiative to intensify public debate taken
POLICY ASPECTS	POLICY ANALYSIS d) Policy objectives explored e) Existing policies assessed	RE-STRUCTURING THE POLICY DEBATE l) Comprehensiveness in policies increased m) Policies evaluated through debate n) Democratic legitimisation perceived	DECISION TAKEN s) Policy alternatives filtered t) Innovations implemented u) New legislation is passed

TAMI chose to use the term impact because it reflects best the expectations that practitioners, addressees and observers have, so by which TA is 'judged'. This is in line with TAMI's aim of advancing the discussion between practitioners of TA and its clients regarding the relationship between methods applied and impact achieved and fostering self-reflection. What is clear is that the relationship between TA methods and the effects they might have is complex and depends highly on the situation, context and time frame. Overall, the TAMI project focused on understanding the aims, methods of TA and also measuring the impact of TA activities as a basis for furthering the debates among practitioners and addressees of TA. It understood TA as social problem-solving in which a technology itself isn't directly shaped by TA, but the policy-making surrounding it is advised regarding different options. The TA institution is the place of TA activities, and the main addressees are policy-making actors. With its European view of TA, TAMI was very focused on socio-political structures that are based on government as a central actor as well as institutions and activities that are actually 'labeled' as TA. It wanted to build on methods that have been established over time and identify 'ideal' conditions for TA and what is needed for it to actually contribute to policy-making. TAMI can therefore be used as a starting point, which took stock of TA activities and systemized them in order to enable better discussions between TA practitioners and addressees. But with growing global developments in S&T, as well as international levels of policy-making and societal changes occurring beyond

country borders it can be helpful to expand the TAMI findings. TAMI itself touched on this point when discussing impact and defining it as "making a difference" (Hennen et al. 2004: 61), in order to improve dialogue between practitioners and clients of TA. It therefore didn't aim at "gathering data and/or empirically exploring the effect of a TA procedure in its environment" (ibid.: 61), yet regarded this as an important step. This becomes relevant when trying to understand better the possible global dimensions of TA and scaling it up to better meet global challenges. For example, a parliamentary oriented TA is useful when analyzing the national situation and which measures may be important, yet it is limited regarding the global effects or context and how this needs to be assessed. Exploring the different contexts in which TA-(like) activities show, in which contexts and with drivers, methods but also what are drivers and possible barriers for TA can follow frames and models described above, but should be widened to a global scope.

The scientific assessment shown in Table 2, for instance, has universal claims. It can be applied in any context producing the same results and are important for TA studies to be regarded as credible and non-biased. But when put in a socio-political context, the framing of these scientific assessment and their outcomes can be very differently interpreted and therefore mean different things for policy-making processes. This touches on the interactive and communication dimensions of methods within TA mentioned above. What kind of interactive, participatory method is useful for a specific context can vary greatly. Not only can the stage of technology development influence this, but also the societal context. Within Europe alone there are very different traditions with participatory methods within representative democracies and recent demands to include citizens or stakeholders in decision-making becoming more and more. On an international level each country will have different traditions, political, social contexts that require different approaches. Therefore, choosing the kind of interactive method doesn't only depend on what the aim of the TA project may be or what questions it asks regarding a specific technology, but also where it will be used; the overall situation. This is also relevant for communication methods. Therefore, taking into account the context of a TA project, so the situation appreciation as described in Figure 1 above, should also include a *cultural* dimension, next to issue, political, innovation and the available knowledge. It could be said that this cultural dimension lies beneath this and contextualizes the methods and impacts.

Regarding different cultural settings relevant for TA, the European funded project "Parliaments and Civil Society in Technology Assessment" (PACITA)[30] which ran from 2011 to 2015 is highly relevant. This project marked the first comprehensive attempt to systematically look at TA in a more international context, specifically at Parliamentary TA (PTA) activities or the lack of these in various European countries. The overall aim was to increase capacities and mutual learning and better the institutional foundations for establishing TA. PACITA was an important project regarding more recent internationalization attempts of TA, focusing on the European context. A motivation of PACITA can therefore be described as: "More than ever, technological change is being driven by and is itself a driving force of globalisation. Therefore, it is logical that the assessment of new technological developments also adapts to the international or European level through networks and cooperation" (Peissl and Barland 2015: 72). By looking at countries that mostly lack TA activities or institutions the project was able to identify barriers but also possibilities for developing TA. Using experiences from countries with more established TA, such

[30] All deliverables and further information on the project can be found here: http://www.pacitaproject.eu/

as Germany, Switzerland or Denmark, countries lacking this, such as Portugal, Belgium or Czech Republic, were analyzed. Important, especially for the context of this thesis and for coming to a global TA, were the insights regarding the needs, demands and existing institutional structures for introducing TA. This has effects on the 'location' of TA in the national policy and S&T systems. For instance, Hennen and Nierling describe the Parliament as the main addressee of a TA in countries like Ireland, Portugal or Wallonia (Belgium), since here activities of the Parliaments have already begun. A new kind of TA "network model" is needed in countries like Bulgaria and Lithuania, since there is very little experience with TA. This network model can raise awareness of an unrecognized need for TA by addressing S&T issues in society and with decision makers, hereby demonstrating the relevance of such activities. In countries like the Czech Republic and Hungary, with traditional institutions like the national academies, TA must be integrated into these already existing structures (2015: 53ff.).

Overall, this shows relevant findings regarding the (further) development of TA in various settings. This ranges from established TA countries, in which new TA methods or approaches may be needed, to emerging TA countries, in which TA should be adapted to the specifics of the national context and existing activities in different ways. In general this can be described as a "TA habitat", which is made up of structures, institutions or processes (ibid.: 54). This corresponds with the findings in the TAMI project, which stress that the "three main categories of influencing factors [are]: Institutional Setting, Technology Policymaking Culture, and Structure and State of the Innovation Process" (Hennen et al. 2004: 77). In general, "TA has to be responsive to the given policy context and the expectations and demands expressed in the countries explored" (Hennen and Nierling 2015: 56). This also means that there are certain challenges which can include TA's role to stimulate public debate in the light of an overall unawareness of democratic relevance of S&T policies or TA's role as an unbiased actors able to bring democratic decision making into S&T policies as well as remaining independent of pressures of economic developments or innovation competitiveness. Deriving from these challenges is a foundation in basic democratic understandings also of TA, which can be in contrast to the need to be responsive to given policy contexts and institutional settings in different countries with other political systems. In reflections on the PACITA project and its findings this was only touched upon (also due to the basic democratic structure in all European countries examined): "'being responsive' to national expectations should not imply giving up a certain (normative) core of TA as a concept" (ibid.: 56), as TA should remain critical to S&T policy-making and shouldn't give in to each demand by decision makers. This of course plays a more prominent role when looking at a global level of TA, which necessarily goes beyond Western contexts. What this implies for TA and where possible limitations lie is therefore discussed in detail in sections 6.2.2 and 6.2.3 of this thesis.

Overall, the PACITA project itself marked an important step towards creating and strengthening networks and cooperation between countries regarding the development of TA on national levels. As it mainly looked at Parliamentary TA, it remained somewhat limited to this role of TA and its addressee, even if it did also look at other relevant activities and actors. Additionally, it shows the importance of context, even in fairly similar settings (at least politically). From this however comes the need to also look at TA outside a fairly homogeneous context like Europe (regarding structures or values) in order to better understand what its roles may be: "The further exploration of the question what the societal features of the 'TA habitat' actually are and to what extent these are developed in a particular national context must be regarded as a

desideratum for further research on the role and function of TA in public knowledge production" (Hennen and Nierling 2015: 54). In this sense, tracing how (policy) decisions are made in different contexts and "empirically exploring" (Hennen et al. 2004: 61) how this is important in order to develop a (TA) framework is the next step after TAMI and PACITA. This should acknowledge blurring boundaries between science, technology and society, cultural contexts and the global dimensions of developments and issues as well as account for different national habitats. This must be based on more general theoretical reflections as presented in chapter 2 as well as previous work that has been done (such as in the TAMI or PACITA project) while extending it to new contexts. It should also take into account newer discussions on TA and surrounding approaches that may be relevant.

3.2 Newer Technology Assessment Developments[31]

The projects TAMI and PACITA are especially relevant in the context of TA and its internationalization. TAMI (still) offers useful measures of impact as well as methods to achieve it and as such a basis of how TA is done and a way of 'assessing the assessment'. Yet, as mentioned above, new questions arise when impact measures and methods are used in contexts outside of the fairly similar (political and cultural) settings of Europe or the USA. This is also relevant to the PACITA project. It examined the TA habitats of European countries and found similarities and differences mainly in the context of Parliamentary TA and in Western settings. Here issues of adaptability arise when TA moves onto a global level, with potentially larger socio-political differences. As the globalization of S&T described in chapter 2 shows, this represents a growing and pressing challenge for TA, which needs to be addressed. Further, newer discussion on TA or related concepts revolve around ways of including 'futures' in hermeneutic assessments as well as including relevant stakeholders throughout the development processes such as in Responsible Research and Innovation (RRI) or Responsible Innovation (RI). These developments are described in the following as they represent current discussions important for TA and show how TA aims to adapt to changing contexts and challenges. Hermeneutic TA being a development coming from TA itself, whereas RRI or RI, while including many aspects of TA, is a development in its own.

Over time, TA as a practice has developed in a way that it doesn't only react to developments in S&T, but aims to predict and even shape these (e.g. CTA); adapting to challenges of shaping technology next to providing advice on their implications. TA has broadened its scope, from providing advice as a mandate from parliaments to using methods that enable the inclusion of various kinds of knowledge within development and innovation even transformation processes. For doing this, TA practitioners increasingly emphasize the inclusion of various stakeholders (as described above in participatory TA, CTA or Real-time TA), but also the importance of looking at the future, or 'futures', as a way to understand current decision-making: "Debates about the future are an essential medium of modern societies' self-understanding and governance" (Grunwald 2014a: 1). Grunwald identifies a lack of considerations regarding futures within TA and focuses on their importance in how we understand societal developments happing today and what decisions result from this. This is shown in Table 3 with different 'levels' of prognoses,

[31] Parts of this section on Responsible Research and Innovation have been published under: Hahn and Ladikas (2014)

bases on different levels of knowledge. Grunwald's argument is that the open spaces of futures play an essential role in how S&T are governed and should therefore be included in TA. He describes: "In such cases beyond the mode 2 approach knowledge about the future could be used arbitrarily by representatives of political-societal positions, substantial values and specific interests to enforce their particular positions" (ibid.: 7). This means that there is a certain danger for these futures to be used and to legitimize already made decisions, by using these futures as a way to show inevitable developments. Therefore, if TA wants to remain open regarding providing an array of possible options then it should also find a way to assess the futures that are being used in current debates on S&T. TA should find ways to deal with these open spaces of futures and "offer to improve the conditions of an open, transparent and democratic deliberation and negotiation […] we are talking about another mode of governance of closing and deciding to which I would like to refer as "deliberative choice"" (ibid.: 7). A current challenge for TA is the uncovering of these futures and their role for framing debates and decision making. Further, this is connected to a democratization of these debates, as a hermeneutic TA would describe and open up these futures also for wider parts of society. In this sense, hermeneutic TA can be seen as part of TA as a democratization project, which is based on the idea that all relevant actors within a society should be enabled to take part in the shaping of S&T. This of course raises questions of what a current form of TA can look like in other socio-political or cultural contexts and whether this Western based view of TA as deliberative choice is appropriate for other countries or how it could be adapted.

Table 3: Hermeneutic Technology Assessment (Grunwald 2015: 67)

	Prognostic	*Scenario- based*	*Hermeneutic*
Approach to the future	one future	corridor of sensible futures	open space of futures
Spectrum of futures	convergence as ideal	bounded diversity	unbounded divergence
Preferred methodology	quantitative, model-based	quantitative or qualitative; participatory	narrative
Knowledge used	causal and statistical knowledge	models, knowledge of stakeholders	associative knowledge, qualitative arguments
Role of normative issues	Low	depends on case	High
Orientation provided	decision-making support, optimization	robust action strategies	self-reflection and contemporary diagnostics

A further relevant approach in this context is that of Responsible Research and Innovation (RRI) or Responsible Innovation (RI), which have had several implications in the sense that they take up many ideas, methods of TA and in the past years has been increasingly funded through the European Commission (EC)[32]. RRI can be understood as a European policy concept that takes up elements of TA, yet the relationship between the two isn't clear: does RRI 're-new' TA or should TA critically assess RRI? RRI poses a newer development which is relevant for TA, even as a way to reflect on its own processes and methods. Further, it does represent newer discussions on the relationship between science and society and how this should ideally be shaped, at least in

[32] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation

Western societies (Wong 2016). One of the most commonly used definitions of RRI is provided by Schomberg: "Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (Schomberg 2012: 50). This description of RRI already poses many questions on how to actually realize RRI in research and innovation processes. In this complex setting, further conceptual reflection and inclusion of 'practical' knowledge from different contexts is needed to better outline how a global perspective of RRI can be realized. RRI needs to be adapted and re-contextualized according to specific local but also global discussions on S&T and innovations and, for example, their ethical implications, in order to come to robust governance structures. Overall it seems, "There is 'an emerging Zeitgeist for 'responsible innovation' that may intuitively feel right, but which exhibits a lack of clarity in terms of definition, practice and, at a policy level, motivation" (Owen et al. 2012b).

At the moment, a main area of RRI is the policy context, especially on the EU level[33]. Funding initiatives provided by the EU (e.g. Horizon 2020) up until now provide constant development of RRI in practice and an immense sum of empirical data ranging from industry, research organizations to education are to be collected[34]. To help develop a framework for RRI activities in Europe, the European Commission wants an improved coordination with the Member States without a legally binding initiative, which involves actions such as setting incentives for RRI, national and disciplinary Codes of Conduct for RRI activities and development of standards on RRI. RRI can therefore be regarded as a fundamental and cross cutting theme for research policies in Europe, at least for now. In this context, the RRI framework provided by the EC sheds light on the main aspects of RRI. These are divided into different key dimensions or pillars: engagement, ethics, gender equality, science education and open access (EC 2012). These can, despite the fact that there is no standard definition of RRI, offer clarity about RRI since the dimensions themselves refer to discussions, measures and activities already going on in different areas. For example ethical guidelines for science and technology[35], strategic initiatives for gender equality by the European Union[36] or open access requirements in funding programs[37] offer important references and even tools to support the implementation of RRI. In the policy context, RRI can also be seen as a 'reaction' to increased demands of accountability of research and technological developments and 'science's new social contract with society' (Gibbons 1999) in which scientific knowledge needs to be "socially robust" (ibid.) and produced in participative and transparent processes. The notions Mode 2 or science for a post-normal age reflect complexity and diversity and how accordingly knowledge is formed. RRI aims to speak to these newer developments and attempts to shift how science, research and society interact. Yet, RRI implemented as a policy concept can also lead to certain tensions, such as the discrepancy between fundamental participation claims within research and innovation processes and the

[33] For an overview of the emergence of RRI in the EU context see: Saille (2015)

[34] It remains to be seen how RRI will develop further in the European funding context and if as a concept it will prevail. Newer tendencies for instance revolve around Open Science. Yet, even though the term may change, the conceptual approach to bring together science and society in a useful way will remain relevant.

[35] http://en.unesco.org/themes/ethics-science-and-technology

[36] http://ec.europa.eu/justice/gender-equality/

[37] http://ec.europa.eu/research/openscience/index.cfm?pg=openaccess

possible (mis-) use of RRI as a way to push through existing technological developments (Saille 2015: 163).

Even though RRI is largely shaped by policy documents and funding processes it has also gained academic attention, especially regarding its conceptual shaping. And even though we find several conceptualizations and descriptions of RRI (Schomberg 2012; Stilgoe et al. 2013; Grunwald 2014b; European Commission 2013) overall RRI as a concept remains rather blurry. First outlines frame RRI according to four dimensions which are anticipation, reflexivity, inclusion and responsiveness, with different techniques and approaches as well as implementations assigned to each of these dimensions (Stilgoe et al. 2013). Further, three emerging features of RRI can be identified within the discourse which themselves can be regarded as innovations (Owen et al. 2012a). "Science for society" deals with the actual purposes of science and innovation and how RRI democratically opens up new areas for public values on science and innovation, making RRI an inherently political program. "Science with society" means the integration and institutionalization of reflection, anticipation and deliberation as a framework for RRI. "Reframing responsibility" explicitly links research and innovation to responsibility which includes a collective approach to issues of responsibility. Owen et al. also point out that the clarification of purposes and motivations for RRI must become clear on a policy level and therefore ongoing discussion on the aims are necessary. Otherwise, "RRI risks becoming a new label for business-as-usual, it also risks being used instrumentally, to smooth the path of innovation in society, and/or to achieve precommitted policies" (2012a.: 757). Building on this, it can be argued that if RRI is actually implemented thoroughly in different contexts, it can have far reaching effects. In this way "Impact may be achieved only when disruption has taken place to establish institutional, scientific and governance habits and routines. This is important in terms of maintaining and enhancing a reflexive and critical disposition, both in science and technology studies of RI and more broadly as RI begins to move across borders" (Macnaghten et al. 2014: 197). This would mean, that if RRI is followed through there would have to be fundamental shifts, e.g., in institutions and among actors towards an openness of regarding uncertainty and plurality and other 'ways of doing business'. This would in turn mean that the responsiveness of individuals or institutions is based on the acceptance of uncertain and unclear solutions or 'ways forward'. Also the question remains how spaces for experiments and reflection can be created especially within established institutions or processes? As an emerging concept, which has more and more actual implications, it therefore seems important to reflect conceptually on RRI especially regarding its central issues, how it is and can be operationalized and what implications it can have. This includes aspects such as the understanding of innovation and responsibility within RRI but also the meaning and implementation of participatory elements as well as conditions of transferring RRI into economical contexts.

For TA and the context of this thesis, RRI can mainly be regarded as a newer (policy) approach that takes up essential questions of TA, many of its methods (such as participatory ones) but also includes other aspects (such as open access or gender). The more conceptual levels of RRI, e.g. anticipation or reflexivity, are also key parts of TA. RRI is therefore relevant for TA (and its potential challenges) as it represents a current 'zeitgeist' with various activities in numerous RRI

projects across Europe[38], which in turn has implications for TA. Discussions on whether RRI is a critique of TA (van Lente et al. 2017) or if TA should rather be a "light-house" for developments such as RRI" (Nentwich 2017) are underway and it remains to be seen what future, beyond EC projects, RRI will have and how much it will influence TA. Nevertheless, RRI does show a response to a continuous need for improving the interactions between S&T and society, towards finding approaches and new forms of, for example, engagement and it therefore relevant for TA. The questions that arise when a popular approach such as RRI is pushed can also concern the global level. Some initiatives in EU projects have been taken towards expanding RRI to other countries outside of Europe[39], which in turn raise questions such as the values (e.g. democratic, liberal) RRI depends on or whether these can vary in different countries (Wong 2016). For RRI, as well as for TA, going towards this global level therefore means thinking about what this implies in different national contexts. This presents a key challenge, not only for RRI, but more importantly, for a global TA.

3.3 Current Challenges for Technology Assessment

By looking at global developments as well as the various forms and methods of TA, a first basis for a global level of TA becomes clearer. TA with its large experience in assessing the relationship between S&T and society, including methods, approaches and impacts provides a background on which further developments can be based. New methods such as hermeneutic TA as described above, open TA up towards finding ways to incorporate complexity and help uncover decisions or values behind processes or developments under changing circumstances. Insights from projects such as PACITA show the need for TA to adapt to specific national situations and needs, demands but also structures, resulting in different forms of TA such as a network for mutual learning or its integration into existing structures. This all shows that TA is uniquely fit for the task of developing a global approach for S&T assessments and due to globalization and wide spread effects of S&T should attempt to do so. This also coincides with a certain evolution or "metamorphoses [through] societal trends and research directions [which] have made their mark on TA [and] have led to TA's conceptual and methodological diversity today" (Grunwald 2018b: 47).

Knowledge produced by TA is often used in a conceptual way, meaning raising "awareness of the complex consideration with different fields of policy making, interconnection of the problem under possible effects not being taken into account and change in the policy makers view on priorities for political action" (Hennen et al. 2004: 59). Building on this, TA should take into account the different, alternative and diverse perspectives and dynamic processes described above. TA situated on a national level (e.g. parliamentary TA) does take globalization or new forms of science into account, but translates this into the national context. Looking towards the global level then raises the question what forms of TA are needed for this. Scaling TA up to a global level also means to look for common ground: Which aspects of discussions can be found in all countries or cultures dealing with S&T developments? As we see above, certain elements

[38] A list of several RRI projects, though not comprehensive, can be found here: https://www.rri-practice.eu/participants-and-networks/affiliated-networks-and-related-projects/

[39] For example the project Responsible Research and Innovation in Practice (RRI Practice) examines RRI in research funding and conducting organizations worldwide, in countries such as China, India, Brazil, U.S.A. or Australia. For more information including outcomes of national case studies see: https://www.rri-practice.eu/.

such as the including and shaping of public debates on for instance ethical aspects of S&T are key parts of TA. The challenge for a global level of TA here would be to incorporate common denominators such as ethics and engagement as a basis for a global perspective, which is described further in the following chapter 4. Developments such as RRI show that engagement and ethics are becoming more and more important for assessing and shaping S&T. At the same time, it is important to look at how TA (or TA-like activities) are understood in different countries and how they may differ according to specific social, political or cultural contexts, as done in the case studies presented in chapter 5. The challenge for TA here would be to take different TA understandings into account and connect culturally specific methods and approaches to the global level.

Accounts on the shortcomings of TA[40] and possible new forms can be found especially related to sustainable development. This also points to a global level, since, as we remember from chapter 2, sustainability is a key issue in global initiatives. TA has the potential to help prioritize and identify more effective or sustainable S&T policy decisions. But, the critique here is: "conventional forms of TA often fail to deliver on this potential, particularly in the developing world. They provide inadequate accounts of the social, technical and ecological complexities and uncertainties at stake, and pay insufficient attention to the power relations that often drive directions of technological change" (Ely et al. 2011: 10). From this we can conclude that new forms of TA are needed, ones that "position technologies within dynamic pathways of change at the system level, recognise alternative understandings of these systems by different groups within society and attempt to build resilience in the face of pervasive uncertainty" (ibid.). These new models of TA should adapt to the world around them; they should combine participation of decision makers with citizens and technical experts. Moreover, they should be "virtual and networked rather than being based solely in a centralised location such as an office of technology assessment. They [should be] flexible enough to address issues across disciplines and […] increasingly transnational or global in their reach and scope" (ibid.). This in turn can enable an opening of the output provided by TA to wider policy discussions as well as bringing wider inputs into the assessment[41]. For Ely et al. the global level of new models of TA comes through the inclusion of an array of organizations throughout the world, which, beyond national borders, can be included in TA activities and useful in numerous countries and contexts. In this way, new models of TA remain focused on institutional or organizational contexts, but go beyond: "Instead of the old model of a country-based, government-led, 'glass and concrete' technology assessment office, a redesigned conceptualization of these activities has been proposed; one that is more transnational, networked, virtual and flexible than its predecessors, and crucially that combines citizen and decision-maker participation with traditional subject-matter-based expertise" (ibid.: 21). This exemplifies a further challenge for TA: opening up towards more flexibility and exchange while providing advice through different forms, which can in turn be adapted to specific conditions.

[40] More general shortcomings and critique, especially of parliamentary TA can be found related to the first Office of Technology Assessment (OTA) established 1972 by Congress in the U.S.A. Critique here is that OTA lacked objectivity, was slow in assessing, had a limited view of consequences (focusing more on economic ones than on ethical or social effects) or lack of stakeholder involvement (Ely et al. 2011: 17).

[41] One example of a wider inclusion and taking action regarding technology development especially in the developing world is the Appropriate Technology Movement. See: Hazeltine and Bull (1999), Pearce (2012) or http://apptechdesign.org/

A global level of assessment and corresponding policies seems to be needed. A first experiment in this direction were the World Wide Views initiative coordinated by the Danish Board of Technology, described in detail in part 4.2.2. The main aim was to enable citizens' debate on policy related issues in the area of sustainability in multiple places across the world on the same day. The results were voted upon and then presented to policy-makers on national and international levels. Critical regarding this method is whether it was able to incorporate and deal with the many cultural differences by using a standard format of questions and discussions. This points to some of the difficulties of an international approach: what methods or formats could have the potential to be used in various cultural contexts? What are intercultural denominators that allow for common ground (e.g. ethics and engagement)? The challenge for TA here would be to frame its assessments according to the specific assumptions, different problem orientation as well as scope. Further, this would include capacity-building and mutual exchanges in order to come to specific approaches that can also function on a common (global) level. In order to understand this and to move towards a possible global framework of TA, a starting point can be to empirically examine how TA or TA-like activities are understood in different countries, all with specific political or institutional settings and cultural contexts. As the developments described above show, there is an increasing need to identify methods and settings for TA that can better cope with changes occurring. The first step towards this is to find common ground for TA taking place in different settings. A possible basis for this are ethical considerations, which take place in some form in any society dealing with S&T as well as engagement, which, understood in a fairly broad form, is also part of how S&T developments take place within a society. These possible common denominators, ethics and engagement, can be a first step towards forming a global level of TA.

TA, its methods and possible impacts as well as current and future challenges were the main focus of this chapter. In light of the global scope of S&T described in chapter 2 and its societal implications, this chapter has shown that TA is a useful approach for dealing with challenges arising. TA is essentially about contributing to problem-solving and providing options for decisions regarding the relationship between S&T and society. Different approaches of TA (e.g. Constructive TA, Real-Time TA) have responded to various challenges over time (e.g. different forms of knowledge beyond experts needed), continuously adapting it to the situation at hand. This is also done in order to improve the impact of TA, which as described above, can happen in different ways. The projects TAMI and PACITA provide valuable insights here, regarding the method and impacts of TA but also its internationalization, at least on a European scale. Newer developments effecting TA to a certain degree, such as RRI, present further challenges for TA to reflect on its roles. This chapter illustrates that TA is able to adapt to changing settings and therefore a useful approach for dealing with the global scope of S&T.

4 Ethics and Engagement in Science and Technology

Science and technology activities take place within societies and, at the same time present normative visions of what an ideal society should look like. They reflect current challenges (such as an increasingly ageing society) and address solutions towards these (such as robotics in care systems). As such, S&T also present the ethical ideals and beliefs of a given society, which in turn are continuously negotiated, by different actors engaging in debates. Consequently, ethics and engagement are essential parts of any TA, which ultimately aims to better align S&T and society. In the following chapter, these two aspects, ethics and engagement, are described on a more general level as well as in the context of (global) TA. As we have seen in the previous chapter, TA is about providing knowledge to better align S&T developments with societal needs and expectations. The inclusion of these into the assessment of S&T requires forms of engagement as well as understanding ethical considerations or debates. The assumption here is that ethics and engagement are therefore not only key to any TA(-like) activity, but also can be found in some form in any society dealing with S&T developments. Hence, they could be a useful foundation for a global level of TA. This also provides a basis for the case studies in Germany, China and India (chapter 5), in which ethics and engagement are traced in order to gain insights into their different understandings in the specific country contexts as well as how they should ideally take place. This is especially interesting in India and China which don't have explicit TA histories, yet presumably have some forms of ethical reflection and consideration or inclusion of a wider public in their S&T priority setting. This can therefore enable a step towards identifying the potentials of TA in the countries as well as its (possible) locations.

4.1 Ethics and Science and Technology

Ethics is a long-standing discipline concerned with systematizing and debating arguments for good and bad behavior or morality. It covers moral philosophy and has numerous areas of focus across all parts of our societies. Broadly, three different areas of ethics can be defined: meta-ethics, which is focused on the root and meaning of ethical principles or universal truths, normative ethics (e.g. virtue ethics), which examines the content of moral judgements and norms of right and wrong as well as applied ethics (e.g. business ethics, bioethics, animal ethics), which looks at what one is obliged to do or permitted to in a specific situation. Applied ethics uses concepts and tools of meta-ethics and normative ethics and in general the three often overlap[42]. In the context of this thesis, the academic, philosophical endeavor of ethics isn't the main focus, even though professional ethics can play a role in form of ethics committees on a specific technology. For the question of a global level of TA, how wider ethics debates on S&T developments take place within societies and who is involved in them seems to be a useful starting point. Looking at the academic realm of ethics with meta-ethics, normative ethics or applied ethics can give us insights into systematic arguments for or against something. Yet, as this embodies a general historically Western approach[43], it may limit the possibility to uncover what kind of ethical reflections or debates are taking place in other countries, like China or India,

[42] http://www.iep.utm.edu/ethics/

[43] Of course, we can also find ethics in other Non-Western traditions, such as Confucian thinking. This is explored in detail in section 6.2.2 regarding normative foundations of TA.

which in turn has implications for a global level as discussed below in 4.1.1. Further, looking explicitly at the academic discipline can also limit the openness to wider and often more intense ethical debates on S&T taking place in different contexts (Ladikas et al. 2015a: 3ff.). As the focus of this thesis is TA, an understanding of ethics that allows for these (public) ethical negotiations to be included seems useful. As we have seen in the previous chapter, TA aims to contribute to public opinion-formation in an interactive manner. In order to do so, TA must also be able to understand ethical debates taking place in society.

When looking at debates on S&T in societies it becomes clear that these can be highly contested and diverse areas of negotiation among many different actors. Whether we want a particular technology to be used and if yes, then how, are reflections of the specific cultural, historic, value-based as well as economic situation in a society at a given time. This is the realm of ethics; which, it can be assumed, is a main aspect of any kind of S&T discourse and decision-making process worldwide. S&T developments don't take place in an empty space: they reflect current values and are embedded in local, national, even global contexts. On the level of policy, S&T can play a role in carrying certain understandings of what a 'good' or 'prosperous' society should look like. This is often reflected in political demands for developing S&T in order to become a more innovative, economically affluent or creative society. Looking at almost any strategy paper by a national government will show this connection (as done in detail in the case studies in chapter 5). These of course are normative claims that, for instance, tie together an economically ever-growing society with strides in S&T. We also find ethical considerations that often show in (strong) reactions regarding S&T developments in certain countries ranging from Genetically Modified Organisms (GMOs), to human enhancement, robotics in health care or research on human embryos. We see that whether the discussions on certain technologies or research provoke very drastic reactions or whether it is simply about developing a technology that actually takes into account its context, the debates surrounding these developments are ethical ones, conducted by various actors within society. This can be termed as 'lay ethics' or "lay morality" (ibid.: 3). Lay here refers to non-professionals in ethics such as citizens, individuals effected by certain technologies or stakeholders. We can assume that lay ethics is a part of any S&T development in any society at least to a certain degree. For TA, this means this ethics is also an essential part of its conception. As TA is concerned with S&T and the public debates surrounding them as well as what this means for policy or decision making it must take ethical considerations into account. Ethics can therefore be seen as a kind of 'common denominator' in S&T discourses, also on a global level.

Since globalization developments have intensified the effects of S&T worldwide, it is necessary to think about an approach to understand and assess this situation. Here we can see a starting point to begin thinking about a global level: because S&T developments take place within a given society, some level of ethical considerations are inevitable. TA has, as discussed in section 3.1 above, incorporated ethical reflections (including those of stakeholders or lay people) from its very beginning and is therefore in a unique position to also inform a global approach on this. In this way, it is essentially about the interrelations of ethics, S&T developments and what this means for decisions made in society. Within the TA process ethical considerations are incorporated in various levels: for example, the situation appreciation takes into account the context a certain technology is set in. Here the possible ethical debates surrounding this development have to be taken into account. Also, methods of TA, such as engagement, aim to explore ways to understand and take up ethics of stakeholders, laypeople, etc. and then use this

as a part of the assessment. In this sense, we can say that without ethics there cannot be TA. In an increasingly globalized world TA must find new ways to deal with the complexities and uncertainties of S&T and what this means on a global level. This is essential if TA wants to be part of shaping technological change in ways that are better incorporated in society and in turn more robust. Newer TA approaches such as participatory TA or constructive TA aim at dealing with changing situations of S&T development, a next and wider step would be to scale up to the global level in order to face challenges of the global reach and scope of S&T. Looking closely at specific ethical considerations may help find a common ground on which a global TA could be based. Yet, it also means finding a useful (working) definition of ethics and ethical debates, which can accommodate the diversity and complexity of the discussions. Here we can find two especially useful contributions to the debate on ethics of S&T on a global level: The Global Ethics in Science and Technology project and a report written by the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) advisory group of the UNESCO, which are both described in the following.

Understanding the global level of S&T was the main aim of the Global Ethics in Science and Technology (GEST)[44] project, which focused on Europe, China and India and the ethical debates surrounding S&T in these areas of the world. Therefore, it can offer a useful starting point to understanding ethics in relation to S&T. An assumption is that S&T are sources of progress but at the same time of conflicts in societies (Stemerding et al. 2015: 99) and that some form of ethical debates take place in all countries with research and development. This makes ethics of high importance to TA, especially since debates on the ethics of S&T as well as innovation have increased "in the sense of both greater intensity and a wider plurality of voices. In addition to the standard expert perspectives, more and more lay people have found a common voice to express their opinions" (Brom et al. 2015: 9). The effects and consequences of S&T have become more apparent, also through globalization tendencies that increase the scope of technological developments. Social values are challenged by the 'disturbance' of new values through scientific views (Ladikas et al. 2015b: 15). A larger number of people in society is now involved in ethical debates; on questions of which paths are required for the further-development of S&T and which ones are too irresponsible to take. Often these debates are made up of ethical, economic, social or religious issues, making the "meaning of the term 'ethics' is at best debatable. What is an ethical consideration for some people might be considered an economic matter by others […] in many instances it is even more difficult to separate opinion from dogma, or belief from religious prescription" (ibid.: 3). Furthermore, in these debates lay people have become more and more important as a legitimate part of the discussion, evidence of this can be seen in the increase of engagement processes especially in European countries[45]. Next to 'expert

[44] The EC-funded project Global Ethics in Science and Technology (GEST) ran from 2011 to 2014 and aimed to analyze the ethical debates around S&T in Europe, China and India. It focused on the technology areas of food technologies, nanotechnology and synthetic biology (Ladikas et al. 2015b).

[45] For example, the inclusion of stakeholders is increasingly a part of science funding programs (Horizon 2020) and on a national level we find many examples of engagement: in Germany the Ministry of Research and Education (BMBF) has supported several project such as the Citizens Dialogues on Future Technologies/Topics (http://www.buergerdialog-bmbf.de/index.php), in which hundreds of citizens across Germany gave recommendations for research programs of the ministry. Other initiatives include projects on Citizen Science which aim to include lay people as part of the research process. Regarding contested technologies (in Germany for instance the search for a repository for nuclear waste), the inclusion of ethical considerations through engagement is becoming a more common practice. This is described further in section 5.1.3.

knowledge', ethical issues regarding S&T are voiced and through this continuously changing belief systems.

On a policy level, we find documents dealing with the relationship between S&T and society, so ethical considerations that revolve around changes in how science is conducted and for which overall goal. For example, a report by the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) group of the UNESCO[46] deals with issues of globalization and S&T, tensions between public and private interests as well as global challenges (e.g. climate growth or growing populations) and what these mean for ethics of S&T. A reshaping of science and its policies is taking place, for example due to "divisive globalization [that] integrates the world without equipping it with broadly shared worldviews on background ethical principles and virtues that can be relied upon to produce practical consensus" (World Commission on the Ethics of Scientific Knowledge and Technology 2015: 21). As the report states: "Science does not function in isolation from other global trends that are tending to reconfigure and in some respects sharpen inequalities. A challenge for ethical thinking is thus to interpret general principles in light of social settings that hamper equitable benefit sharing" (ibid.: 9). Science ethics is defined here as "the principles according to which scientific activity should be conducted and to the mechanisms by which conformity to such principles is promoted, fostered or ensured. An ethical approach to science shows that the quest for knowledge and understanding incorporates essential ethical values, such as integrity, truth and respect for reasoned argument and evidence. The criteria for what counts as "good science" are, in part, ethical. Such values are universal in the sense that they command broad acceptance, at a general level, across disciplinary, national and cultural boundaries. They have, indeed, been explicitly recognized in international normative instruments" (ibid.: 4). We see here a more general understanding of what it means to conduct "ethical" science, which includes aspects of global standards regarding integrity or global access to scientific information. Issues here are possible divides in geographical terms but also regarding capacities, disciplines, in competitive ways or even among different actors (e.g. policy makers, academics, etc.). The report draws a direct line between ethical reflection of developments of S&T, human rights and failing to give the "right to participate in science, on the basis of fair opportunities, and to enjoy the benefits of technology as well as to assess their risks, [which] constitutes a *prima facie* injustice as does, at a systemic level, failure to promote an institutional framework within which the right is likely to be realized" (ibid.: 10). Here the report identifies that science ethics, even though discussed in various contexts[47], is limited regarding newer developments such as globalization and the issues resulting from this. Based on this there are areas which require new ethical thinking and

[46] COMEST is an advisory body of the UNESCO set up in 1998. It is made up of eighteen scholars from scientific, legal, philosophical, cultural and political disciplines from various regions of the world and appointed by the UNESCO Director-General. Additionally, eleven *ex officio* members representing UNESCO's international science programs and global science communities are part of COMEST. It aims to provide decision makers with ethical principles for different areas such as robotics ethics or bioethics. For further information, see: http://www.unesco.org/new/en/social-and-human-sciences/themes/comest/

[47] Examples here are: "Recommendation on the Status of Scientific Researchers" United Nations (1974), which recognizes the ambivalence of S&T developments enabling vast prospects for the benefit of humans but also the possible threats of using scientific knowledge against human rights. It therefore states that accordingly policies should be developed that help realize the benefits while avoiding the risks. The "Declaration on Science and the Use of Scientific Knowledge" World Conference on Science (1999) also ties "good science" to the advance of humankind and as an essential part of resolving global challenges (e.g. public health, reduction of poverty). Here, the commitment of scientists to high ethical standards based on international human rights is stressed.

institutional developments. These include the bridging and reduction of knowledge divides, encouraging integrity with responsible research and sustainable innovation, assessment and management of risks, enabling public engagement and consultation and supporting ethical and institutional frameworks in order for benefits of S&T to be shared. Concrete suggestions of the report are an open access model for science, codes of conduct, ethics education, consultations on S&T by citizens, valuing of local and traditional knowledge as well as clarification of the status of researchers for allowing consistency between the institutional arrangements of science and the mutual ethical standards for use (World Commission on the Ethics of Scientific Knowledge and Technology 2015 : 22). We see here, that including ethical considerations in S&T is a complex undertaking which touches on many aspects and issues. Further, it becomes clear that there is an awareness on the policy level to find ways forward regarding ethical considerations on S&T and how these can actually be incorporated in policies and help to take on the challenges of a globalized S&T world.

The aim here is to focus on S&T developments and how ethical considerations (as well as engagement) of various actors play a role. And further, on the role of ethical reflection for policy-making of S&T. This is done as a basis to identify similarities but also differences between countries. As ethical debates are inevitable in societies dealing with effects S&T and therefore an inherent part of TA, this is a necessary step towards a global scope of TA. This context also requires a focus on a wider conception of ethics, beyond the 'professional' forms of committees or boards. Therefore, in the following, the differences in ethics approaches are discussed further.

4.1.1 Towards a Global Ethics?

The academic study of ethics is a wide field, which can offer a starting point for thinking about which criteria, values or standards are important in decisions on S&T. Ethics as an academic exercise presents arguments which can be applied universally. Yet, the question here is whether this academic view of ethics can be useful for looking at how 'ethical' considerations and debates actually take place within societies including all actors and how they deal with S&T developments. Generally, the academic field concerned with ethics aims to look at, note and categorize questions of ethics. There is a large body of literature and tradition of ethics as a philosophical or academic study also in relation to S&T[48]. As an academic discipline, ethics systematically deals with moral phenomena, such as 'responsibility', 'rights', 'values'. It is a method to find justifications that then claim universality. Different to a policy document such as the Universal Declaration of Human Rights of the UN[49], which is normative, ethics as a discipline provides a systematic account with deduced arguments. Descriptive ethics (dealing with the "pure description of ethical beliefs", normative ethics ("systematical approaches to answer moral questions, aiming to provide reliable means to distinguish good actions from bad actions" or meta-ethics (regarding "questions such as: Can any of the normative ethical approaches claim universal validity?" (Ladikas and Schroeder 2005: 405) are all streams of thought in this academic field. If we regard challenges such as globalization, which intensifies effects worldwide and the increase of public debates for example over S&T developments, we can question if taking this

[48] For an overview of ethics regarding emerging technologies such as biomedical applications, human enhancement, information technologies or robotics see: Sandler (2014)

[49] http://www.un.org/en/universal-declaration-human-rights/

academic field into account is enough to cope with this, especially on a global level. Specifically, when relating S&T developments to their societal effects, it seems necessary to widen the scope of ethics to include various actors. In order to trace which 'kind' of understanding of (global) ethics is useful here, whether understood in an academic frame, within policy or as something done by society as a whole, several approaches are looked at in the following in order to frame the approach in the case studies and overall in the thesis.

Adding the term 'global' to ethics "means "relating to the whole world," so global ethics should mean ethics in its individual guises (descriptive, normative, meta) with the addition that it applies to the whole world" (Ladikas and Schroeder 2005: 405). When looking closer at the academic discourses on ethics, the limits of a global approach become clear. Normative ethics, for example, by means of the categorical imperative says that one rule has validity in various contexts. Yet for a global scale this clashes with cultural traditions or systems that don't have this approach, where context or the relationships between the actors are essential to make an ethical decision. Therefore, it doesn't seem possible to find a general principle for action. Meta-ethics seems to be the realm in which questions of global ethics are apparent. But, also here we find difficulties of universalization, "an all-time favorite question being: Are human rights a Western invention based on nonuniversalizable deontological thought? Or are they the moral basis for human flourishing and happiness worldwide and therefore worth fighting for? A lot of work needs to be done in global meta-ethics, but it is unnecessary to add the word global to ethics in this context. Meta-ethicists were always interested in either (a) universally valid answers or (b) a proof that item a is impossible" (ibid.: 405). This then turns the focus of global ethics to a wider field, beyond an academic exercise, because in "their essence, descriptive and meta-ethics have to be global and to add more normative ethical systems to the existing jungle will not make a qualitative difference without attempted meta-ethical answers" (ibid.: 405f.). The way to define global ethics is then to move out of the academic context into the area of how people debate 'ethical' decisions. "When somebody says: "Have you considered the ethics?" or "One could question the ethics of such and such agreement" or "What are the ethical implications of your undertaking?", they are not talking about the academic study of moral principles" (ibid.: 406)[50]. Following this, a useful definition can be: "Global ethics is not a field of academic study, it is an activity: the attempt to agree on fundamental conditions for human flourishing and to actively secure them for all" (ibid.). In this sense, ethics as an activity becomes something, which is done by societies and its actors as a whole. This wider description of ethics seems more useful also in the context of S&T as it adds a normative level while still remaining open to various cultural or historical specifics. It includes the negotiation-aspects of ethics: the challenge to find common ground to agree upon. Based on this, certain challenges for global ethics can be identified, which include global inequalities which almost cannot be resolved, lack of global decision making bodies with actual authority to enforce as well as powerful cultural differences in moral perspectives (e.g. agreement on conditions of human flourishing), difficulties in defining moral perspectives that depend on social customs, economic and political

[50] A further term in this context could be that of "global ethos" as coined by Küng (2001). This ethos is derived from basic similarities of different religions and philosophical-humanistic approaches worldwide. A basic consensus on norms and values independent from culture, religion and nationality exists and is needed in order to deal with global challenges. An example of this is the common rule that one should treat others as oneself wants to be treated. In this thesis the term ethics or lay ethics is used because it represents specific discussions, which are directly related and in the context of S&T as well as TA (also see description of the GEST project below).

situations or historical injustices (Ladikas and Schroeder 2005). Certain ways towards a situation "more conducive to human flourishing" are presented such as better intercultural dialogue to uncover cultural communalities supporting cooperation and understanding and even solidarity on a global level. The goal here would be "to reach a common understanding of terms and concepts that denote each culture's moral codes and behavioral prescriptions" (ibid.: 411). Further, trust building in order to overcome injustices of history can help networking and communication by means of a transparent and honest approach and in turn help foster intercultural dialogue. Also, the addition of ethics reviews to ongoing discussion can help for example bring ethical considerations into policy decisions. This can also be done within discussions on S&T, which are complex and could benefit from common terminologies. Here, we find ourselves on the level of policy.

Generally, within the area of public policy, reflections on ethical behavior in the face of changes of public services by different types of organizations and actors is increasing. This can be interesting here since it takes up the relationships between society, policy but also cultural differences in the context of processes such as globalization and translates this into (ideal) practices. Regarding ethics in public policy and management, the focus can be on the practices of ethics in policy making fighting corruption (even asking if there can be a common understanding of what it actually is), protecting integrity (e.g. ethical leadership), but also whether "a 'global' ethics is possible" (Lawton et al. 2016: 327) as a form of global standards. When discussing this Lawton et al. draw on the 'classic' discussion between a "universalistic ethics" and "ethical relativism" (ibid.: 327), the latter stating that "ethical principles or judgements are relative to the individual or culture, and that is does not make sense, therefore, to pursue the goal of a universal ethics" (ibid.: 328). In this sense, ethics are relative and there can be no independent way to judge the behavior of others, instead certain things are 'preferred' to others. Yet, it is also pointed out that there are approaches to synchronize these culturally particular ethical practices with a universal ethic. The need for this global frame comes from globalization processes, which since the "1970s the situation of philosophical ethics has changed in so far as the need for a global or universal ethics has been widely recognized" (Apel 2000: 139). Yet, the "great problem of our situation of globalization has to be faced, which is determining the moral and juridical conditions of a multicultural society, which today has to be realized at least on the planetarian level, but also as a paradigm of coexistence cannot even be avoided in most of the constitutional states" (ibid.: 140). It is therefore important to find a concept of universal ethics in response to globalization, but which "should be more than just an agreement on a certain enumeration of words for values (or even norms) that can be made the subject of declaration, although such a declaration could be very useful and even politically influential, as has been shown by the UN declaration of human rights of 1948. [...] But should it not be possible, furthermore, to formulate the procedural principles of discourse ethics as a rational frame of possible agreement [...] with regard to common duties and responsibilities" (ibid.: 153). Identifying these commonalities can be done by empirically looking at different discourses on ethics. These communalities can be found to some degree between global actors in international treaties, conventions or agreements. These form core values that can be explicitly addressed or implicitly presumed. Looking at a number of international treaties, agreements and programs one can identify an "emerging global standard for public ethics", which is made up of core values such as right to self-determination, freedom (of information, autonomy of economic and political choice) honesty of government (accountability), trust as

well as stability (and predictability) (Yoder and Cooper 2005: 316). Further, Bossaert and Demmke (2005) look at EU member policies regarding ethics and integrity and the attempt to develop a European Code of Ethics. They find that even though there are differences in overall ethical understandings the requirements for ethical behavior for civil servants are similar. Also, the more traditional values for civil servants (neutrality, confidentiality, etc.) have stayed the same over time (Lawton et al. 2016: 333). Yet, "new values such as transparency, diversity, sustainability and flexibility have also been added to the classical values. As it seems, the future will be dominated by more value conflicts and newly emerging values" (Demmke and Moilanen 2011: 30). This can be seen in the large increase of countries defining transparency as a main public service in the last decade. So, it could be that over time some ethical problems could be resolved while new ones come up (ibid.: 30), creating challenges for civil servant and more generally, policy-making. As a way to understand public values worldwide, Jørgensen and Sørensen look at codes of conduct, which can be found in many countries, focusing on the role of the state and the public sector (civil servants) and can be termed "codes of good governance" (2012: 73). By analyzing 14 country-specific codes of good governance they identify "a set of apparently global public values: Public interest, regime dignity, political loyalty, transparency, neutrality, impartiality, effectiveness, accountability and legality [which] match with the international code from the UN and the model from the European Council and the conceptions of good governance launched by OECD, IMF, the World Bank, UN and EU. Consequently, we may have identified a set of global public values" (ibid.: 96). This can be seen as a "step towards an explication of a global normative context" (ibid.). Closer examinations of values as well as actual practices and behaviors could show to which degree these expressed public values remain superficial and which ones shape daily actions. Overall, these analyses examine the public sector, policy management as well as the roles of civil servants. Within these discussions, for example regarding New Public Management, there are accounts of convergence processes, in that tendencies for countries to become more similar in structure, processes or performance (Lawton et al. 2016: 331). In this sense, looking at these developments shows the emergence of global values and policies. Therefore, these studies, even though focused on a specific area of public policy, show us that aspects of global values can be identified and are worth looking at closer.

As we can see, it seems that discussing global ethics is a complex undertaking done in several areas in academia and policy in response to an increasingly globalized world. Of course, the question arises whether global ethics should even be pursued at all; ethics could also remain in the realm of academic discussions according to well-established methods and arguments. Globalization and S&T developments may have their effects worldwide, but each culture or country will deal with these in their own way, according to their specific value system. Yet, we can already see some difficulties with this approach. Globalization forces and S&T developments will strive on and it seems limited to only deal with them on a national or even local level. Even national ethical considerations include the global context. This can be seen in discussions on competitiveness and whether or not to pursue a specific technology, which often take place between the arguments: 'if we don't do it they will' or 'it is important for our competitiveness and well-being'.

Further, if we give significance to universal values such as human rights, transparency or sustainability then we have common responsibilities, for which we should find ways of dealing with. Global ethics in this sense can provide a space for discussing which directions we want to

take. Here, it seems that understanding ethics as an activity or a process is the useful way forward, since as such it can take into account different cultures or value systems. At the same time, universal values such as human rights should be agreed upon, across national borders. This seems to be the difficulty of a global ethics approach: it must find emerging global values, which can be identified when looking at local or national understandings. A meta-approach to this would clash with specific ethical reflections in a certain context. For global ethics this means that 'translation' efforts need to be made. In some countries the focus may be on accessibility as a key value of this society, in others it might be equality. These also presuppose each other and influence the ethical reflections of these societies. For example, accessibility and equality are closely related, yet finding out what they actually mean 'in practice', how they are prioritized and what this means for global ethics is a challenge for cultural-sensitive translations between countries. Understood as an activity or process, global ethics is also ever-changing. Therefore, moving towards a global ethics approach also means finding ways or spaces that allow for deliberation and change.

For TA aiming to include a global scope, it seems necessary to understand ethics in this broad way: as an activity which is conducted by various actors across society. As we have seen, TA is a process aiming to "contribute to the formation of public and political opinion on societal aspects of science and technology" (Bütschi et al. 2004: 14). In this sense, the inclusion of a wider definition of ethics, not restricted to the academic one, is necessary in order for TA to actually take all relevant discussions and deliberations into account. TA must be able to uncover and incorporate the ethics considerations of a wide array of societal actors, such as lay people, interest groups or industry, which it has done through various methods and then help inform policy-making. Further, as we see that these wider forms of ethical debates take place throughout all societies dealing with S&T, they form a basic condition for a global approach, including similarities and differences.

4.1.2 Ethics and Global Technology Assessment

The increase of ethical debates regarding S&T developments require a closer look at how these are shaped and influenced by other aspects, especially for TA. Further, understanding the dynamics here can help inform policy-making towards a global level. By uncovering these debates, new forms of inclusion can be identified and applied in order to inform and even shape policy-making. This points to the complexity of ethical debates on S&T that take place in a certain society (or area of society) at a specific time in history, on the basis of particular values and ideas. A working definition of ethics or ethical debates useful for TA, that is non-disciplinary and locates it in the public area of social interaction made up of different forms of expression could then be: a "common platform for deliberation and discussion of values in society that is based on perceptions of right and wrong, is influenced by cultural norms, and aims at informing policy making" (Brom et al. 2015: 9). In this understanding, ethics is tied to the culture of a society, which is expressed in dominant values, the historical context as well as official structures of governments or private concerns. For TA, ethics as a common platform is especially useful because it is aimed at understanding and forming opinions of S&T within society. This of course is somewhat in contrast to the disciplinary definitions of ethics that focus on universality of arguments dealing with moral phenomena. Yet, as mentioned above, this disciplinary focus would limit the possibilities of a problem-oriented approach such as TA, which needs to account

for various aspects of ethical considerations in complex and uncertain situations. TA needs to be able to include ethics as a basis for providing orientation knowledge regarding how S&T could or even should develop. This means TA must also understand the (public) discussions surrounding S&T in order to provide policy advice or input for decision making and therefore requires an applied view of ethics.

Building on this broader sense of ethics, Figure 3 shows how ethics becomes part of policy-making in S&T and is therefore useful to examine in this context. Ethical debates can take on formal or informal forms. Formalized meaning ethical debates have a specific structure in which they take place. Here we find advisory bodies for S&T policies but also quasi-government organizations, where ethics is debated in a "reflective, formalized and disciplined manner" (Ladikas et al. 2015b: 4). On the other side we see ethical considerations being negotiated in 'informal' ways by lay people; through "lay morality", ethics is integrated into policy-making. This reflects the current values a society has, which can be identified in official documents that structure society such as its constitution. Cultural contexts and history form the background of ethical views, making these other important factors when understanding the arguments of ethical debates in different countries. Private, business-related and also civil society organizations' concerns should also be included in this, as they also try to influence policy-making via ethical debates (ibid.). Analyzing formal and informal ethics debates means looking at the specific structures as well as values systems. This is done knowing that it can only be a glimpse of specific ethical debates and the related arguments and decisions. This is important because it "point[s] the way towards a common approach to ethics that can be followed at a global level with a global audience" (Brom et al. 2015: 11).

Figure 3: Incorporation of Ethics in Science and Technology Policy (Ladikas et al. 2015a: 4)

In order to examine ethical debates on nanotechnology, food technologies and synthetic biology in the three regions of Europe, China and India the GEST project developed a comparative framework (Figure 4). This takes into account that the "nature of expectations, tensions and conflicts will vary, not only in relation to the contents of particular fields of science and

technology, but also according to particular socio-economic conditions, cultural contexts and values in the different global regions" (Stemerding et al. 2015: 100). The aim here being to identify similarities and differences between discourses on technologies as well as regions in order to understand where these come from and how they develop. This can enable comparisons between the countries, between technologies as well as uncovering the discourses as storylines which are translated into S&T policy-making. The framework also allows to see these processes in the context of and mediating between 'professional' ethics (in form of committees) and lay morality (lay people's views on S&T). Through this, the intention is to come to "more responsive and robust practices of anticipatory governance of science and technology" (ibid.). Therefore, the framework focuses on societal discourses as central to the storylines of specific technologies (e.g. the case studies in the project).

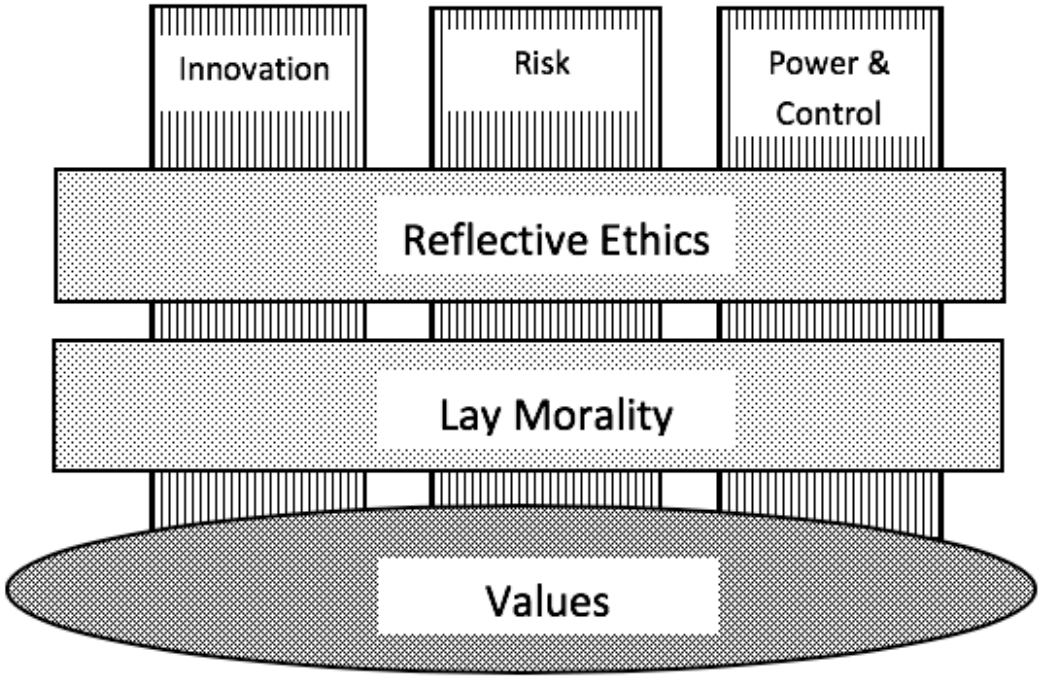

Figure 4: Crosscutting Science and Technology Discourses (adapted from Ladikas et al. 2015b: 102)

Within the framework three content-related discourses are identified: innovation, risk and power and control. Reflective ethics and lay morality are cross-cutting in that they form the way the discourses on innovation, risk and power and control are perceived in ethical analyses as well as broader public debates. The guiding questions of the comparative analysis in the project therefore revolved around how the S&T discourses were translated into S&T policy-making and how this is facilitated by institutionalized ethical reflection and public deliberation. The context of different histories and cultures shape of ideals, experiences, values as well as concerns that play a role in S&T discourses. The framework looks at the similarities and differences between the discourses and their specific contexts. Of course, these are hardly straightforward or easily differentiated. Yet, "by drawing these distinctions, our framework can serve as a valuable investigatory searchlight that may help us define relevant storylines in our case studies for comparative analysis" (Stemerding et al. 2015: 102).

Regarding the context-related discourses, the one around innovation focuses on the possible benefits of investing in S&T. It takes up societal goals and challenges (economic competitiveness, progress of society) as well as specific ones such as climate change or energy supply. Innovation discourses are mainly conducted by scientists, industry and government and revolve around values such as "market freedoms, progress, self-reliance, sustainability, social justice (including access) and equality" (Stemerding et al. 2015: 103). For instance, looking at strategy papers of government bodies such as ministries can reveal much about this discourse as innovation is related to societal or economic progress and affluence. Next to the innovation discourse we find the emphasis on possible risks that may come through S&T developments. This risk discourse often regards health, the environment and individual rights and next to physical harms focuses on 'non-physical' one such as wider societal impacts. The values of this discourse include "safety as a citizen right (i.e. the right to protection), harmony, dignity, precaution, social justice and sustainability" (ibid.: 103). Actors involved in the governance of risk (scientists and government and regulatory agencies) are active in this discourse as well as civil society organizations. Debates on S&T also include aspects of power and control; so how is a technology controlled (by whom), who is responsible and who participates in decisions. Arguments from the innovation discourse (e.g. competitiveness through S&T) can useful to support the importance of economic power. Therefore this discourse is based on an "entire spectrum of values related to innovation and risks, including market freedoms, self-reliance, citizens' rights (to protection and choice), harmony, sustainability, global justice (access) and equality" (ibid.: 104). Here we find civil society organizations and similar voices as actors next to the ones involved in innovation and risk governance.

Cross-cutting discourses that relate to innovation, risk and power and control are reflective ethics and lay morality. The former is more institutionalized and deals with ethical considerations of S&T developments, emphasizing possible tensions between advancements in S&T and the possible societal consequences. Actors are public ethics bodies as well as TA institutions that support debate or function as policy advisors. Within research funding programs we also find a focus on ethical, legal and social issues of S&T. A less formal version of this discourse can be found in "modes of ethics deliberation, such as the media or art" (ibid.: 104). Lay morality is discourse, which has become important since more and more actors of society have become involved in debates on S&T. These individuals or groups don't necessarily bring scientific expertise into the discussion, yet "believe or are persuaded that their voices are as valid as those of the experts in the field of science or ethics" (ibid.: 104). TA tries to take up these discourses by involving lay people in discussions on S&T and incorporating their views into policy recommendations. Lay morality can be communicated through public debates or controversies or public consultation formats and is often initiated by civil society organizations. The values presented in this discourse relate to the ones of the innovation, risk and power and control ones.

For a global TA approach these overall findings show that there is an increasing need to find ways to deal with (potential) conflicts and tensions of S&T, to find more robust ways to design policy-making based on analysis of various discourses and to incorporate values, interests or cultural considerations into governance. The GEST framework presented above shows possible ways for TA to deal with this. Looking at the origins of values and belief systems show differences but also similarities is important in order to "understand the impacts of [S&T] development and how society should help develop frameworks and institutions to address [these] continually"

(Chaturvedi et al. 2015b: 165). For policy-making, the mainstreaming of socio-ethical analysis is important but not easily achieved. Using universal values or guidelines can be seen as an imposition or difficult to contextualize. Therefore, an analysis of the values that can be accepted as well as an understanding of the contexts and practices is necessary for TA. Mainstreaming in this sense doesn't mean to reproduce the same structures everywhere. Instead, "the modalities of mainstreaming have to develop, taking into account the science and technology contexts, the relationship between science and technology and society, and the diversity in stakeholders in either country" (ibid.: 168). This in turn means that analysis of the discourses in the specific country regarding a certain technology is required since it "is not possible to suggest a one-size-fits-all approach or solutions based on that" (ibid.: 171). Based on this, the cases the GEST project make several suggestions for ways to mainstream ethics in S&T policy-making, which go in the direction of a global level and can already be found to some degree in certain countries. These include establishing common global deliberation platforms, capacity-building for mutual structures on ethics policy advisory (institutionalization of ethics), development of common social impact indicators for S&T, development of comparative systematic public perception databases via common surveys, promotion of common templates of public engagement (ibid.: 172). These can also be relevant to a global TA, as is shown in section 7.3. All of these points are ambitious since the levels of their realization are different in each country. Important is that these recommendations allow for comparisons as well as finding acceptable ways for coming to common or adapted approaches in each country context.

The findings described above mark an important step regarding the interplay of ethics, values; their basis in culture and how these influence policies of S&T. Therefore, they are useful for thinking towards a global TA approach. If we see ethics (understood as an activity) as an essential part of TA, then the findings above can also show us how TA or TA-like activities are practiced in different countries. The GEST project focused on China, India and Europe, already providing insights to a large area of the world. It would be interesting to 'test' the findings against a wider scope, trying to account for a more global approach. This could, for example, regard the different discourses described above. In Europe we seem to find a predominance of the risk discourse as opposed to the stronger innovation discourse in China and India. Here, an approach, which (on a more quantitative level) asks about these discourses in other countries could be useful to understand better the tensions between risk and innovation arguments and compare them. As a challenge for global ethics (Stemerding et al. 2015: 109) (and TA) these tensions must be balanced, while taking into consideration country specifics. Therefore, also in-depth accounts of the specific (cultural, policy, socio-economic) settings of countries would be necessary.

Generally, as we see, an applied view of ethics seems to be the best approach for moving towards a global level of TA. As GEST points out, there are ways towards mainstreaming in the sense of finding methods to understand the relationships between S&T in a certain society and scaling this up to a global level, including global platforms for deliberation, capacity-building, common impact indicators or public engagement. A basis for this is a common and wide understanding of ethics and how it shapes discourses and decision-making regarding S&T. This can enable finding spaces for common collaborations without neglecting the specific cultures or value-systems in a given country. This balancing of mainstreaming and taking into account country specifics is essential in order to prevent cultural misunderstandings and to still find common ground. Due to the increasing global scope of S&T and ever-faster developments this needs to be pursued if societies want to be capable of actually co-shaping S&T according to their

values, at least to a certain degree. As argued above, TA can and should take this up: as an approach dealing with the relationships between S&T and societies it has suitable methods as well as ways of measuring impact (see section 3.1), which could be further developed and applied in various contexts. In light of the pressing issues of S&T in a globalized world it seems necessary to go forward here.

Globalization, its effects and technological developments require a wider approach to ethics, beyond the academic study, but also on a more global level. In this context, Jonas describes the changes of modern technology so far-reaching that they need a new kind of ethics. Ethics can no longer only concentrate on the local and interactive, if S&T simultaneously effect someone on the other side of the world. Therefore, "with certain developments of our powers [like those of modern technology] the *nature of human* action has changed, and since ethics is concerned with action, it should follow that the changed nature of human action calls for a change in ethics as well" (Jonas 2014: 38). He continues: "Modern technology has introduced actions of such a novel scale, objects, and consequences that the framework of former ethics can no longer contain them […] the old prescriptions of the "neighbor" ethics – of justice, charity, honesty, and so on – still hold in their intimate immediacy for the nearest, day by day sphere of human interaction. But this sphere is overshadowed by a growing realm of collective action where doer, deed, and effect are no longer the same […] and which by the enormity of its powers forces upon ethics a new dimension of responsibility never dreamt of before" (ibid.: 39). We can see from this again that a wider understanding of ethics is more useful in the context of global S&T developments because this enables to go beyond the academic exercise of building systematic arguments claiming universality. Understood as an activity, ethics can include specific cultural, economic, etc. aspects as well as lay people's evaluations of a certain technology. TA aims to include this when looking at S&T in the context of society. Yet, with developments such as globalization we need to be equipped with and require "both new thinking and new ethically based institutional responses" (World Commission on the Ethics of Scientific Knowledge and Technology 2015: 21). TA, with its basis in ethics (and engagement) has the potential to provide this in form of a global approach.

A way forward here can be to first understand the cultural dynamics in specific contexts (e.g. countries) and then come to a global TA approach which is networked, flexible and able to address global issues (Ely et al. 2011: 10), while taking complexity into account. As Ladikas et al. write: "The incorporation of ethics in policy-making does not happen in isolation, as if ethics were a stand-alone concept. Ethics is inextricably connected to culture, and this affects its expression in a multitude of respects: dominant values, history and official governmental structures all influence the expression and direction of ethics debates. At the same time, private concerns […] influence ethics debates by promoting moral arguments over certain world-views and policy choices" (2015b: 4). We see here ethics, as a (negotiation) activity which takes place within society, is a key component of a global TA approach. As shown, frameworks to understand and assess this are useful to find common ground as well as differences. In this way, the framework and the findings of the GEST project show how TA 'is done' in different countries regarding different technologies.

Further, we see that ethical reflections often include some form of engagement or inclusion of stakeholders or a wider public. Because it is about deliberation and discussion of values within a society, ethics in some way has to involve people actually conducting the reflection. Yet, even

though we find strong overlaps between ethics and engagement, there are also differences. If we look specifically at TA then ethics is an underlying activity, which is part of the entire TA process, in basically all aspects. The situation appreciation in any TA project needs to account for the societal or political contexts (which are also determined by ethical considerations). The goal setting, project design and its implementation are influenced to a degree by normative, ethical aspects. Of course, these aspects should be similar in any TA project in any context. Yet, what they look like in practice (e.g. which aspects are especially important) depends on the societal context and therefore the ethical reflections surrounding it. Engagement is an essential part of TA (also in order to understand ethics), yet it is mainly a method used as part of the assessment, in order to involve actors within agenda setting or decision making; to communicate, consult or participate.

As we see, ethics and engagement are closely linked. If we conclude that ethical reflections are an essential part of S&T discourses worldwide and that it is therefore important to understand these, then we also must understand the kind of engagement that happens surrounding these. Engagement is a way that enables an understanding of ethical reflections of different actors in society. In this sense, we cannot look at one without the other. Yet, ethics seems to be more encompassing because it plays a role in any kind of consideration, discussion or decision-making regarding S&T within society. Still, a closer look at engagement and its role in S&T decision-making and which role it plays is key for a global TA approach to move forward.

4.2 Engagement and Science and Technology

Involving the wider public or stakeholders in questions of S&T developments is a means to include their ethical reflections and to find ways to shape S&T according to societal contexts. Public engagement or consultation by governments or industry regarding new technologies has become popular since the 1980s and 1990s in Europe and the U.S.A. Since then we can find increased demands for inclusion here, which aim to take various kinds of knowledge into consideration. This moves away from an understanding of S&T as giving the tone and society going along; only needing to be informed about what new research experts have explored now. In the past, actors of S&T (such as scientists or policy makers) have mainly been concerned with creating credibility of science, so establishing information that is believable and can be trusted. Yet, increasingly issues such as salience (so how relevant knowledge is for policy-making) as well as legitimacy (concerned with the fairness of knowledge production and to what degree it takes values, concerns and perspectives of different actors into account) have become important. In turn, there is a growing demand to find ways to enable this (Cash et al. 2002: 2). For instance in the context of Nanotechnology, engagement has been used early on in the development phase to include various stakeholder perspectives (Powell and Colin 2008). Several engagement events in this area were organized by governments (e.g. ministries)[51] as well as industry[52] in order to

[51] In Germany for example the "Technologiegespräche mit Bürgern" (Technology Conversations with Citizens), which have been on-going since 2012 and aim to bring together experts and citizens to discuss issues surrounding Nanotechnology. These are organized by the German Ministry for Education and Research and can be regarding as a communication platform for informing citizens. See: http://www.werkstofftechnologien.de/veranstaltungen/technologiegespraeche-mit-buergern/

[52] The NanoDialogues of the German company BASF can be named here. This continuous stakeholder dialogue was concerned with communication of potential benefits and risks of Nanotechnology. They also aimed to find a

find ways to engage the public early on in the development phase. Today an increasing trend in S&T policy-making, especially in Europe and the U.S.A., is to include a wider public in decision making processes. This connects to developments described in chapter 2, and sheds light on new relationships between science and society; the basic notion being: wider forms of knowledge are necessary to make more robust and accepted decisions. With globalization developments and the wide effects of S&T that change our common or dominant understandings, there arises a 'cultural' challenge in dealing with this situation, in which there seems to be a greater need to form reflexivity, awareness-raising and debate in order to reach more accountability and transparency (Leach et al. 2007: 6). As Jasanoff writes: "Many therefore see this epoch as a proving ground for new political orders whose success will depend, in part, on our learning to live wisely with our growing capacity to manipulate living things and our equally growing uncertainty about the consequences of doing so" (2005: 14). Due to the wide effects of S&T new forms of knowledge production and governance become necessary. This also reflects in the many publications on the evaluation and outcomes of engagement case studies that can be found in various areas[53] Additionally, this situation is somewhat ironic as the more difficult it becomes to govern S&T due to global developments, we increasingly turn to deliberation and participation for answers (Stirling 2008: 263).

Engagement or participation can take on many forms ranging from smaller focus groups to large-scale consensus conferences[54]. Including stakeholders or the public is aimed at finding better ways of dealing with the uncertainties and risks of (emerging) technologies and to include the "plurality of value-based perspectives" (Zhao et al. 2015: 39). Due to their potential vast impacts on society, many S&T developments are political and consequently should be discussed in a public sphere. Regarding biotechnology, Jasanoff makes this point clear stating that development "efforts are political in the sense that they centrally concern the production and distribution of societal benefits and risks; they are cultural in that, by intervening in nature, biotechnology forcefully impinges on social meanings, identities, and forms of life" (2005: 15). Technologies are often connected to "controversies about risk and benefits and ethical disputes about human dignity, the common good and questions of responsible research" (Zhao et al. 2015: 40). This connects to ethical considerations that have become increasingly open to a wider range of actors. Because these considerations are about negotiating different values and beliefs the "emphasis on 'perceptions of right and wrong' pertains to the need to acknowledge the importance of public perceptions in the debate, regardless of their origin (e.g. religious vs. secular)" (Ladikas et al. 2015b: 3). Further, beyond "ethical and normative reflections, decisions made without public support tend to provoke a loss of empirical legitimacy that may be expressed in confrontation, disruption and public distrust" (Zhao et al. 2015: 40). With the rise of engagement we see a growing importance of voicing opinions of "groups or individuals that

framework for the responsible use of Nano. The first two dialogues (2009/2010 and 2011/2012) were focused on the German context, the other dialogue (2014/2015) involved stakeholders on the European level who identified issues of transparency, responsibility and uncertainty and useful tools to deal with these (BASF SE 2016). http://www.nanotechnology.basf.com/group/corporate/nanotechnology/en/microsites/nanotechnology/dialogue/index

[53] See for example: Arnstein (1969); Irwin (2006); Stirling (2008); Wynne (2007); Webler and Tuler (2002); Knapp et al. (2013); Hahn et al. (2014); Irwin et al. (2013)

[54] For an overview of the most common methods and a detailed description of how to conduct them see: Elliott (2005). Also, the OECD provides a general handbook for policy makers on participation: Gramberger (2001).

do not necessarily claim any particular expertise in the scientific subjects under discussion, but are nevertheless persuaded that their voice is as valid as those of the experts" (Ladikas et al. 2015b: 3).

Despite the trend towards more engagement or public participation, there is still a lack of clarity of the terms. Overall, public participation can be understood as "the practice of involving members of the public in the agenda-setting, decision-making, and policy-forming activities of organizations/institutions responsible for policy development" (Rowe and Frewer 2005: 253), yet this is still vague in the sense of what involvement actually entails. Therefore, a closer look at how information flows between citizens and the initiators is helpful. We can then identify different descriptions: "public communication, public consultation, and public participation" (ibid.: 254). Engagement is the more general term that includes all three distinctions, "these concepts in combination are referred to as public engagement, and the methods intended to enable this as engagement mechanisms (generically) or engagement initiatives or exercises (specifically). Mechanisms intended to enable one of the three forms of engagement [are] labeled […] communication, consultation, and participation mechanisms" (ibid.: 254). Arnstein (1969) designed a typology or "ladder of citizen participation", which is often used in identifying the level of participation. Ranging from citizen power to non-participation, from manipulation or informing to delegated power or actual citizen control. With this ladder, the hope is to understand better the powers and motivations behind participation efforts and what they actually mean especially for the "have-nots" in society. Newer forms of this, such as a public participation spectrum provided by the International Association for Public Participation, also group the public's role in engagement processes, ranging from informing, consulting, involving, collaborating to empowering. This also defines the promises made to the participants (e.g. we will keep you informed or we will implement what you decide) and the overall aims of the process[55].

Often the issue of effectiveness of engagement exercises is debated. With the increase of their implementation, questions of how these formats fit into decision-making processes, but also in wider terms into representative democracies or other government forms have intensified. On a procedural level the issue of effectiveness is about two aspects: "the first concerns the fairness of the mechanism/exercise, and the second concerns the competence/efficiency of the mechanism/exercise in achieving its intended purpose—whether that is educating the public, achieving a good consensus, eliciting views, or some other aspect of the process or outcome" (Rowe and Frewer 2005: 262). Yet, it remains a key issue of engagement to find ways to include the outcomes in wider decision-making processes, if engagement efforts aren't to be reduced to mere discussion exercises. The meaning of the outcomes of engagement as well as the roles of the citizens, policy makers, stakeholders, etc. involved are often unclear, which leaves the actual impacts open as well (Hahn et al. 2014).

Also important when looking at engagement is Citizen Science (CS), which has recently gained increased attention, especially in Europe, in discussions on engagement of citizens in science,

[55] The spectrum can be found here: https://www.iap2.org.au/Tenant/C0000004/00000001/files/IAP2_Public_Participation_Spectrum.pdf

also from the side of S&T funding[56]. It mainly refers to research conducted by lay people according to scientific standards, often together with professional scientists. Within CS there are numerous initiatives throughout the world that include citizens on different levels. The use of new technologies (e.g. information and communication technologies) also supports these efforts. Irwin (1995) writes about these practical initiatives and links them to scientific citizenship and how this can shape policy-making (e.g. agenda setting). Often connected to Citizen Science are real-life laboratories, which are initiatives that aim to actively transform everyday practices in collaborative efforts between citizens, researchers or policy-makers, as described further for the German case in section 5.1. Also, organizations aim to bring together CS projects to enable a common understanding, in order to increase the use and credibility of CS. The European Citizen Science Association (ECSA) functions as a platform connecting various actors in the field[57]. Critique of CS is often voiced regarding data quality or confidentiality, but also possible conflicts of interests, especially political objectives (Nature Editorial 2015).

From this we see that engagement and participation of citizens or stakeholders in S&T is constantly changing and adapting. Different goals can define these processes, from the information of citizens to their actual inclusion in decision-making and priority setting. How this plays out in practice also ranges according to the surrounding socio-political systems, as we see particularly in the case studies presented in chapter 5. Further, critical aspects of engagement processes can pose questions regarding actual use, transparency or how they can fit into existing structures and systems. For TA and its global development this is relevant because it shows which issues need to be addressed and possibly resolved in different contexts when seeing engagement as a common basis.

4.2.1 Global Level and Critique of Engagement

Overall, we find many engagement processes that remain in a local or national context, focused on technologies and their specific implications. One notable exception is the consensus conference World Wide Views[58] organized by the Danish Board of Technology Foundation and conducted in many countries at the same time. As such, this process had an explicitly global scope. The topics of climate change as well as biodiversity were chosen as issues that affect people across the world and therefore require a global form of engagement. Further, World Wide Views aimed to provide citizens' recommendations for these issues to the UN Conventions dealing with them. In general, the focus was on reaching consent: after being informed on the topic all participants were asked the same questions and voting across all the locations. The basic idea behind this was for citizens to learn about the main issues of climate change or biodiversity, then to deliberate and finally to vote on recommendations. In this sense, the World Wide Views can be regarded as a "consultative participation format" (Knapp et al. 2013: 54) with the goal of reaching a global political scale. Of course, such a process bears the question whether it can take the cultural specifics into account. The design of World Wide Views came from a

[56] One example is the German Ministry of Education and Research funding large projects dealing with and aiming to increase the networking of Citizen Science initiatives. An outcome of these efforts is the Platform for Citizen Science: http://www.buergerschaffenwissen.de/en

[57] http://ecsa.citizen-science.net/

[58] The website of World Wide Views provides information on method, outcomes, etc. http://wwviews.org/. For a detailed account on development, implementation as well as outcomes on both topics see: Danish Board of Technology (2009, 2012)

European TA context (Danish Board of Technology Foundation) in which the practice of discussing S&T or policy issues in such a format is very common. Also, the discussion questions were designed according to this context and then translated from English. Yet, it could be better to have more general questions enabling the translations to be more culturally or language specific (Knapp et al. 2013: 55). On a methodological level, the question here is whether this procedure can actually live up to its global application. For instance, how do questions on biodiversity translate from a highly industrialized country to one where certain groups are much more in touch with nature and possibly more effected? World Wide Views did bring together a wide array of stakeholders on national and international levels and was able to give citizens a voice in the political procedures, that will affect their lives considerably (Knapp and Hauser 2011: 79). Yet, the question remains whether engagement on a global scale is actually about finding one format for all (and consensus) or if it is more about identifying relevant questions and issues and then designing appropriate formats that are specific for the context in which they're applied. Of course, comparison is better possible if the processes are the same. Yet, it is unclear what 'value' a comparison or consensus can have, if the format cannot develop its potential in all contexts.

We can also relate this to what can be criticized as a kind of artificial participation. As Bogner writes: "this form of lay participation, which is organized by professional participation specialists and carried out under controlled conditions, rarely is linked to public controversies, to the pursuit of political participation, or to the experiences of people directly affected" (2012: 507). This can be seen as a kind of lab experiment which is in contrast to more bottom up participation as protest, which forms when people see the controversies or risks of a technological development as a form of criticism. Yet, invited or 'lab' participation is on the rise, as examples of initiatives to involve the public in discussions on nanotechnology show. The effect of this kind of participation is paradox, it doesn't result in gains towards rationality that are hoped for nor are the reasons for this to be found in the shortcomings of the participants. Rather the structure of the process hinders this. This is because "lab participation is characterized mainly by its decontextualization, that is, these deliberation experiments are carried out in a contained environment and bear practically no relation to the world outside" (ibid.: 511). These processes are separate from institutional location; they remain abstract and isolated from political and social contexts. As S&T become more encompassing, understanding their effects cannot be limited to a lab setting, instead this needs to be done with and within society. For instance, real-world laboratories can be a means for this; as a way to apply S&T developments in a concrete context under actual conditions. A critique of more 'artificial' lab participation can then be: "*While society at large is becoming a laboratory in which knowledge is produced, public participation is retreating from society into the lab*" (ibid.: 522). With the increase of engagement demands and implementation it is necessary to also take this critique into account, since otherwise the involvement of different actors becomes frustrating and essentially ineffective. For a global TA this is relevant because finding 'meaningful' forms of engagement for different contexts is a key aspect and can only be done if critical issues are taking into account.

In general, main critique points of engagement that are often voiced revolve around in-effectiveness, in-transparency, 'artificial' settings or questions of pushing through of already agreed upon S&T agendas and unclear location within decision-making processes (including in institutional and political structures). Often, studies on public engagement on S&T "conclude

that the issues put to the public are limited, that the actual involvement of the public is marginal and that institutional actors resist engagement by insisting that both science and innovation should remain unquestioned and beyond serious democratic control" (Irwin et al. 2013: 120). It is in this situation that claims for more engagement, also from the policy side, are made, often without clear notions of how and to what end. Powell and Colin (2008) provide recommendations regarding 'meaningful' engagement which include regularity of these events and institutional commitment, open-endedness of the process, capacity-building for all actors involved, increased funding as well as systematic institutional mechanisms for on-going engagement.

Even if claims for engagement are often ambivalent regarding the actual reasons, motivations or goals for engagement, the increased demands for it make it relevant, especially on a policy level. A perceived "widespread sense of public unease with 'science' which has manifested itself in Europe over recent decades" (Felt and Wynne 2007: 81) often drives the calls for more engagement in the agenda setting and decision-making of S&T. Further, the past assumption seems outdated that "technically complex decision making [would take] its color more from the nature of the issues than from features of national culture or politics. Policymakers everywhere, so the reasoning went, would be compelled by the same scientific, technical, and economic considerations; policies would therefore converge, and little insight would be gained from comparing national approaches over time" (Jasanoff 2005: 17). This coincides with the idea of the deficit model of the communication of S&T to the public (Layton 1993), which assumes the public is deficient in its understanding of S&T developments due to ignorance of the science behind them and therefore has irrational fears about what might happen. So, the assumption is that by providing more information on a certain technological development, the acceptance of it in among the public will increase. Yet, this relationship isn't so clear cut; we find critique of the deficit model especially from science communication, since there is "ample reason to consider it quite implausible that the well-informed and poorly informed citizen go about the business of making up their minds in the same way" (Sturgis and Allum 2004: 58). Even if increased engagement and science communication has made many efforts to unravel it, this deficit model still lies at the basis of many decisions and understandings of the relationship between S&T and society. This of course neglects any idea of different forms of knowledge that are legitimate and important in shaping S&T developments. In a report regarding the governance of science for the European commission this predicament is described: "Although it has become common in European policy circles to reject deficit model explanations of public resistance to innovation, that model nevertheless continues to be reconstructed in sophisticated new forms […]. One could say that while the public is rhetorically given more rights to participate in technoscientific developments, at the same time the idea of the public is often framed in more restrictive ways. Implicitly, upstream public participation is welcome so long as it complies with the innovators' demands" (Felt and Wynne 2007: 78).

We find an increased demand for engagement or citizen participation in the area of research funding, such as in the Science with and for Society program of the European Commission[59]. Especially when looking at ideas such as Responsible Research and Innovation (RRI) or Responsible Innovation (RI) we find a shift towards including stakeholders or citizens throughout the entire research and innovation process (Schomberg 2012; Owen et al. 2012a; Macnaghten

[59] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society

et al. 2014). According to the European Commission one of the main pillars of RRI next to ethics, open access or science education is engagement[60]. We see here a normative connection made between involving stakeholders or citizens and coming to 'better' technologies; ones that aim to fit the needs of society. Engagement is an essential part of reaching this goal. This of course also resonates with TA. On the side of policy as well as the public we find the need for processes that can help make S&T more 'responsible'. When "thinking about research today, policy-makers and the public inevitably focus on the accountability of science. As the relations of science have become more pervasive, dynamic, and heterogeneous, concerns about the integrity of peer review have transmuted into demands for greater public involvement in assessing the costs and benefits, as well as the risks and uncertainties, of new technologies" (Jasanoff 2003: 236). Perhaps the emergence of a concept such as RRI on a policy level is the best indicator for these new demands. As a fundamental and crosscutting program for research policies and funding in Europe it aims to anchor engagement in S&T development on a wide level. Even though RRI is a Western undertaking, debated mainly in Europe and in the U.S.A., it has global claims in the sense that the "need to harmonise current science and technology developments with the wider society's aspirations is evident in every advanced economy and one could even argue that there are shared societal objectives in incorporating ethics and societal values into S&T policy across very different global policy contexts" (Hahn and Ladikas 2014: 17).

The European Commission strategy policy paper "Options for Strengthening Responsible Research and Innovation" makes connections to the global level of RRI by stressing that challenges (such as climate change) require a encompassing approach as well as seeing Europe as the space where guidelines can be developed and implemented and then worldwide: "The development of such guidelines and standards present the opportunity for Europe to set global standards for Responsible Research and Innovation which necessarily entails global markets" (European Commission 2013: 22). We see clearly here that the idea behind RRI is inherently international, since it aims to be used on a European level while expanding globally: "To avoid fragmented approaches in the Member States that are incompatible with each other and therefore hinder the development of RRI in the European Research Areas and the Single Market for products and services, European RRI standards should be developed. These standards may then be leveraged on the international level, to achieve impacts on the global level" (ibid.: 34). Further, we see the importance of engagement for forming a (global) framework for RRI which "would firstly require a dialogue process that brings together all relevant actors that are currently involved with shaping the debate on RRI […] including the definition of intermediate goals that can serve as reference points for establishing a specific standard on RRI management" (ibid.: 35). We see the procedural importance of engagement as a way forward in forming a 'roadmap' for RRI as well as its relevance as an essential part the implementation of RRI in specific technologies but also when debating societal goals of S&T. Because of its funding especially on a European level and resulting relevance (also in concrete applications and projects), RRI marks an important program regarding engagement also on a global level. And as we have seen in section 3.2, RRI and TA are related regarding overall aims of shaping S&T developments according to society.

[60] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/public-engagement-responsible-research-and-innovation

A further relevant document in the context of engagement on a global level is the UNESCO "Science Report: Towards 2030" in which we find many references to engagement of citizens, for example in Citizen Science projects (United Nations Educational Scientific and Cultural Organization 2015: 7). The report concludes that global challenges require scientific approaches or solutions that should include a wider range of society, also globally. As report reads: "Meeting this challenge will require the engagement of peoples from diverse cultures and their leaders; it will demand global responses for which neither the scientific community, nor the policy world, nor the general public is well-prepared" (ibid.: 12). The report further stresses the importance, especially regarding the widespread effects of S&T, of remaining open towards different kinds of knowledge or creativity, also for policy-making. The possible added value of this requires "careful monitoring and evaluation of the difference the codesign and coproduction of knowledge between academics and non-academics makes to the practice and effectiveness of policy" (ibid.: 14). As we see, there seems to be a common notion from various sides that engagement of stakeholders or the wider public is a necessary development, especially in a situation of globalization, complexity and increased direct effects of S&T throughout the world. Moreover, engagement, at least to some degree, seems to be an accepted approach when finding ways to govern S&T developments, also on a global level (e.g. UNESCO report). Yet, as we also see, there is still much unclear about how to go about this. The specifics of individual engagement efforts as well as how to incorporate their outcomes on a wider (even global) policy level remain unclear. Nevertheless, we can see a growing (global) demand arising from policy, academics, funding as well as the public itself to engage in assessments and decisions regarding the shaping of S&T. Further, we can also identify these tendencies, even if not always explicit, in countries like China and India, as described in sections 5.2.4.4 and 5.3.4.4. The challenge, especially on a global level, is to find ways forward that take cultural, societal and political specifics into account and also allow for a basic understanding of the legitimacy of engagement. It seems TA can offer possible approaches here, since it is concerned with the relationship of society (e.g. citizens), policy and S&T. And as we have seen, similar to ethics, engagement is a fundamental aspect of TA. If we argue that TA can be useful to find appropriate policies and governance of S&T on a global level, then engagement is key for this as well.

4.2.2 Engagement and Global Technology Assessment

For TA, engagement has always been a key aspect. Since it is concerned with providing knowledge for informed and reflected decisions on S&T, it requires the inclusion of different kinds of knowledge. Engagement is how TA can gain insights into possible risks or benefits of S&T for specific groups or to understand how S&T developments can be shaped to be better in line with societal wishes and ideas, all providing a basis for advice. Further, engaging with various societal actors is a means to inform them on issues, possible risks and potentials of S&T. Therefore, engagement is more than just a method, it is a key component of 'doing TA' (Hennen 2012: 30). We find streams such as participatory TA but also constructive TA (described in 3.1), which focus on engagement as an essential part of the TA process itself.

If we look more specifically at engagement in S&T decision-making and the relationship to TA, we find that there is also critique of these processes. As mentioned above, developments such as that of "lab participation" (Bogner 2012) are important to take into account, since the increased demand for and implementation of engagement should be critically reflected, also by

TA itself. This then goes beyond the TA process, which may include engagement methods in order to gain insights for its assessment. It encompasses engagement used as a way to actively shape policies or priorities in S&T. As TA's aim is to contribute to this, it should also continuously reflect on why demands for engagement come up, how it is realized and for which reasons. Further, critical aspects such as unclear aims of the engagement initiative, difficulty of involving certain groups, dominance of scientific rationality or uncertain use of the outcomes in decision-making (Irwin et al. 2013: 119) play a role in almost all engagement processes. This is of course of high relevance for TA. It is important to note that participatory TA is often conducted as a way of gaining knowledge rooted in social values and interests in a wider context of policy consultation and not as political participation in decision-making itself. Still, often there are high expectations regarding the use of participatory TA methods for the democratization of science and technology policies, which frequently cannot be fulfilled. This can result in a 'sobering up' of actors involved in these processes (e.g. citizens, stakeholders but also initiators and organizers) regarding their expectations of actually changing or influencing decisions. This conflict also shows in the critique of participatory processes that includes lack of impact, instrumentalization or pushing acceptability. It is practically impossible to find direct links between the outcomes of participation and political decisions, as they only support political decision-making. Also, any kind of assessment can be framed or understood differently by "power and justification strategies" (Hennen 2012: 35) and therefore is in danger of being instrumentalized. As a consequence, "studies on participatory TA [should] distinguish between the shortcomings of project management and the structural limits or deficits of the participatory procedure itself" (ibid.: 36).

Stirling (2008) also takes this up and calls for an opening up of appraisal of governance of S&T. He distinguishes between appraisal (informing) and commitment (forming social concrete choices for governance of S&T). Regarding (participatory) TA this opening up leads to pluralistic and conditional policy advice (Bogner 2012: 513) which has the ability to address alternative questions, highlight ignored issues as well as marginalized perspectives, looks at different and new options and takes uncertainties into account (Stirling 2008: 280). Yet, "those comprehensible pleas for openness and pluralism have often remained programmatic declarations so far" (Bogner 2012: 513). Within the increased demands for engagement, TA should take this into consideration and critically reflect on its own methods as well as on the implementation of engagement in S&T decision making. TA should promote engagement in S&T, yet it should also take into account that "there can be no automatic presumption that [participatory processes] will necessarily be sufficient, or even always positive, in their effects. Attention should extend to a more diverse array of process and conditions, involve the practice of specialist analysis as well as participatory deliberation, and focus on appraisal as well as decision making itself" (Stirling 2008: 287f.). The combination of processes and methods should support and complement engagement as a way to deliberate possibilities of S&T developments next to other approaches.

Looking at current discussions on engagement, we see that the actual inclusion of these efforts in policy remains unclear. Demands for involving citizens and stakeholders by means of various methods are high, yet the effects are difficult to trace. However, even though the critique of engagement (e.g. lack of impact, transparency or pushing through of already set agendas) is important, it should be taken into account that the current situation of globalization and S&T developments and their wide political, social, cultural and economic effects require some form

of wider inclusion. This form should open-up debates and possibilities regarding S&T governance: “Only in this more open-ended fashion may we realistically hope to achieve a richer, wider, and more vibrant empowering of human agency in the deliberate social choice of technological futures” (Stirling 2008: 287f). TA is in the unique position to take up this challenge as it is essentially about the interactions between society, S&T and policy. Further, streams of TA such as participatory TA or constructive TA have experimented with forms of engagement and how they can be situated in different scenarios and inform policies. Since TA relies on engagement to uncover and incorporate (ethical) considerations of a wide range of societal actors (lay people, interest groups or industry) it must find fitting forms for various settings. This also shows the importance of culturally but also technology or innovation specific engagement processes. The kind of engagement method used varies, for example according to the phase of innovation (e.g. early stage or ready for market), the actors involved or the political setting. Similar to the requirements of a TA project, such as scientific quality, design of the interaction processes about S&T consequences or diffusion and communication of results, engagement processes within TA have to meet these criteria as well. To do this, these processes should be clear in their actual aims and motivations and open-ended in their outcomes, at least to a certain degree. This fits to what Grunwald describes as the “four partially overlapping branches of TA addressing different targets in the overall technology governance: TA as policy advice, TA as medium of participation, TA for shaping technology directly, and TA in innovation processes” (2011: 14). Here we see the close connections between participation or engagement and all other areas TA is concerned with. For TA it is key to find ways to incorporate engagement outcomes into the policy-making process since, “effectiveness of technology assessment rests not only on the process and outcomes themselves, but also on responsiveness and openness on the part of both government and wider governance actors, and on the availability of resources to enable the outputs of TA to be considered and acted upon” (Ely et al. 2011: 12). This means that TA has to act two-fold: as a (co-)designer of appropriate engagement processes as well as a kind of ambassador for the value and benefit of these processes for decision-making on S&T.

On a global level, TA seems to also be the concept that can take this up. Not only should TA continuously develop applicable forms of engagement, it should also try to do this for a global level regarding methods as well as possibilities to connect outcomes to appropriate existing structures (e.g. UN or UNESCO). The challenges of our time, as argued in chapter 2, require some form of global responses and global assessments. Engaging “with different actors, mak[es] it more likely that assessments attend to their priorities and questions and take on board their knowledge. This produces more analytically robust technology assessment outputs and helps to anticipate otherwise unforeseen constraints” (ibid.: 10). This is the subsequent challenge for TA, since more “conventional forms of TA often fail to deliver on this potential, particularly in the developing world. They provide inadequate accounts of the social, technical and ecological complexities and uncertainties at stake, and pay insufficient attention to the power relations that often drive directions of technological change” (ibid.: 10). Therefore, a new form of TA becomes apparent, especially when looking at a kind of engagement, which goes beyond countries and is able to incorporate a wider collection of organizations and actors as a part of TA, which can then be used in multiple countries and contexts.

Overall, from the previous, we can identify that ethics and engagement are key factors of TA and therefore are also useful to form the basis of a global TA approach. Further, we find indictors of ethics and engagement in S&T decision making on a global level, making them potential

'common denominators' for a global approach. This makes them both highly relevant in the context of this thesis. Of course, ethics and engagement are not without issues and critique, as we have also seen above. Ethics in the context of this thesis needs to be defined in a broader way in order to incorporate different ethical considerations that reflect values based on cultural norms. Also, engagement processes are in high demand (in certain areas of the world), but can unfold different critical issues when applied, such as in-transparent aims, difficulty of inclusion into existing structures or artificial conditions. Yet, based on the aspects described above, it still seems worthwhile to look closer at how ethics and engagement are used and possibly institutionalized in different contexts around the world. Looking at TA(-like) activities as the sphere where ethical considerations on S&T take place, also through engagement or at least deliberation, can help better uncover how this actually takes place in different contexts and compared, how this is done possibly in similar ways worldwide. Jasanoff points to the use of comparison of debates (regarding biotechnology) and states: "Comparison among national and regional debates surrounding biotechnology should therefore help us identify and make sense of the wider political realignments that are taking place around us at this moment. Comparison may even help us decide which courses of action we wish to follow, as individuals or as political communities" (2005: 15). This can also enable an understanding of possible global ethics - ethics understood as an activity - and connected to it engagement in S&T and how they take shape in decision making processes (or not), and which role TA can play here, also connected to a global level. In the case studies in chapter 5 as well as the further reflections in chapter 6, this is attempted for China, Germany and India.

This chapter was dedicated to examining the potential of ethics and engagement to function as possible common ground for S&T debates in various countries. This can be a first step towards a basis of a global TA, as ethics and engagement also make up essential parts of it. It was argued that ethics understood in a broad sense to include lay debates seems to be a useful way forward in order to account for different forms of knowledge and reflection which play a role in decision-making today. Also, this wider form of ethics is useful in order to uncover how these debates take place in different countries. Engagement, its forms as well as critical aspects, were described as well in order to understand how its takes place as well as important issues to address. Overall, ethics and engagement take place in any society dealing with S&T developments, even if in very different forms, explicit or more subtlety. Of course, as the accounts above show, there are critical issues and difficulties of implementing ethical debates or engagement processes in different socio-political setting. Yet, it still seems worthwhile to examine how countries deal with challenges arising through globalized S&T and increasing effects on their societies with a focus on ethics and engagement. This is taken up in the next chapter, which looks at these factors as well as TA(-like) activities in different national contexts, namely in Germany, China and India. This is done as a way to gain an in-depth understanding of how these countries deal with S&T developments, how they are framed according to societal challenges, which role engagement and ethics play as well as how TA is understood. These cases therefore provide us with valuable insights regarding possibilities and implications towards a global TA.

5 Tracing Technology Assessment

As we have established in the previous chapters, the expansion of TA to incorporate a global perspective on S&T developments seems highly relevant today. Globalization and worldwide challenges require methods that can help us answer to these developments and better shape our responses, especially regarding S&T. For TA, which can already rely on a basis of wide experiences regarding the relationship between socio-political contexts and S&T, seems uniquely fit to extend its efforts to this global scope, yet also requires new forms and approaches moving forward. A global level of TA requires insights into the specific cultural, political and societal settings of various countries worldwide. As stated above, these can help form a basis for a global level of TA, by identifying communalities as well as specifics to the national contexts. They can show us if and how S&T developments are prioritized, framed and aligned with societal needs and expectations. For a comprehensive global TA this should ideally be done for all countries worldwide dealing with S&T developments. Yet, for the scope of this thesis, cases were chosen to show first steps and insights towards a global TA. As such, they aim to provide points of departure for further work towards a global level. Therefore, the case studies in Germany, China and India function as examples of how TA is understood in very different countries, ranging from established and institutionalized forms to emerging or lacking aspects of TA. National debates on S&T and their connection to specific values as well as the development of a country can uncover how priorities are contextualized and where TA could offer insights. Further, possible areas where TA could be located in the national settings are explored, also with help of the interviews with key actors in the Chinese and Indian context. This functions in a twofold way: as a more in-depth examination of national specifics for TA as well as providing insights into the national perspectives regarding a global level of TA. This is a challenging task since in China and India TA is not as established as in Germany and understandings vary, as we see in the following, which is also due to the level of TA integration into the different national settings. Still, we may also find communalities, especially when looking at wider ethical debates or forms of engagement and inclusion.

The structure of the case studies is derived from the accounts above on the increasingly global level and implications of S&T and TA's challenge to take this into account. For each country, the national settings regarding their specifics for S&T policies, connections to values as well as issues surrounding ethics and engagement are described. The interviews provide the basis for a reflection on the societal aspects of S&T in China and India, the understandings and roles of TA, ethics and engagement and a national perspective of what a global level could look like. Reflecting the overall findings across the cases, as done in chapter 6 can help us come to more specific recommendations (section 7.1) for the countries as well as ways forward in our strives towards a global TA (section 7.3).

5.1 Technology Assessment in Germany[61]

The following examines TA in Germany, with a focus on existing advisory structures as well as examples of topics and projects of TA. In Germany, the assessment of technologies is established regarding the term TA, methods as well as its political embeddedness. Parliamentary TA as well as institutions specifically dedicated to TA make the German case interesting as it can provide insights as well as reflections on experiences with recognized forms of assessment. Further, this chapter describes key aspects of TA, ethics and engagement in the German landscape. Building on this the German perspective of potentials of a global TA is presented, in which German can take on an important role as well as incorporate reflection on its own practices by learning from other countries (with no explicit forms of established TA). Germany is especially relevant in the context of this thesis as it offers a case of a country in which TA became institutionalized over time and this fits into the specific political setting. This can provide insights for tracing TA(-like) activities in countries like China and India, which show potentials of an emerging TA, but also several barriers such as lack of awareness of societal implications of S&T or disperse forms of public debate, as examined in sections 5.2 and 5.3.

5.1.1 Overall German Setting

Germany is the country with the largest population in Europe, in total about 82 million and covers an area of around 360.000 square kilometers. It has a population density of about 230 people per square kilometer, making it one of the most densely populated countries in Europe[62]. It boarders with nine countries and is located in central-western Europe. It maintains a social welfare system including universal health care and laws on environmental protection as well as universities free of tuition. After World War II followed a time of rapid reconstruction and development in (West-)Germany. A lasting period of low inflation and industrial growth lead to an advanced social market economy. Germany is the worlds' fourth largest economy by nominal GDP (an estimated $3,7 trillion) and ranks fifth according to purchasing power parity ($4,2 trillion)[63]. Despite the social welfare system with redistribution measures, the wealth is distributed relatively unequal (for European standards), which results in a Gini coefficient (scaled from 0 to 100) of 29.5 in 2016 which ranks 13th in the EU (Gini coefficient in the EU 2016 was 30,8)[64].

The German "Grundgesetz" (Constitution) was established in 1949 by the occupying Western Allies with amendments made in 1990 under the reunification of Germany. The Constitution regulates the basic political structure of Germany: a federal parliamentary republic in which the federal legislative power is assigned to the parliament (Bundestag) as well as the representative body of the regional states (Bundesrat). Power is divided between these federal and state levels as well as between the legislative, executive and judicial. The political structure in Germany is also influenced by the European Union, of which West Germany was a founding member. This

[61] Large parts of this chapter have been published under the title "Technology Assessment in Germany" (Hahn and Scherz 2019).

[62] http://www.germany.travel/en/travel-information/germany-at-a-glance/germany-at-a-glance.html

[63] http://www.imf.org/external/pubs/ft/weo/2017/02/weodata/weorept.aspx?pr.x=19&pr.y=20&sy=2015&ey=2022&scsm=1&ssd=1&sort=country&ds=.&br=1&c=134&s=NGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC&grp=0&a=

[64] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di12&lang=de (in German)

is especially relevant regarding legislation, which shows in the form of laws passed by EU institutions. For example, regulations are passed and can be implemented without additional national measures; others, like directives require national implementation actions. Germany has been part of the Eurozone since 1999 and is a member of the United Nations, the NATO, the G8, G20 and the OECD.

Article 20 of the Grundgesetz states that Germany is a democratic and social state, in which all state authority is derived from the people. This sovereignty of the people means that any form of state power must be legitimized by its citizens (e.g. by elections). This is extended to the right of every German to resist any person trying to abolish the constitutional order, if there is no other possibility. This outlines the importance of resistance, which is an inheritance of Germany's past dictatorship under the Nazi regime. The Constitution also defines the roles of different government institutions with a strong emphasis on distribution of power and decision making. The Bundestag is elected by German citizens and performs the legislative process as well as providing parliamentary scrutiny regarding the work of the government. Members of the parliament also decide on the federal budget. This system also gives considerable power to the 16 German states and through the Bundesrat they participate in the legislation process.

The official head of state is the Federal President, yet he or she has mainly a representative role with a deliberate distance to party politics. All federal laws must be signed by the President. The head of the government is the Federal Chancellor, who is elected by the members of the Bundestag for a four-year term. The German Cabinet is the main executive body of Germany and consists of the chancellor and cabinet ministers. The Bundestag itself is also elected for four years, a party must have at least 5% of votes or at least three directly elected seats in order to be eligible for the parliament. In the 19th German Bundestag (from October 2017) there is a total of 709 MPs.

The German economy is the largest in Europe; in 2017, the GDP increased by 0.6%[65] compared to the year before. Foreign trade is of great importance to the German economy, with a positive trade balance of €249 billion in 2016[66], the highest in the world. S&T are closely tied to economic growth and stability from the political side, which also shows in a continuous rise in funding for public research mainly via the Ministry of Education and Research[67]. In 2013 the budget of the ministry was €13.7 billion, in 2017 it was €17.6 billion[68]. The research and development funds of the German economy were about €62.5 billion in 2015, together with public funding this means about €90 billion for research and development (in 2015) and about 3% of the GDP. This corresponds with European strategies of spending about 3% of the GDP for R&D per year (Bundesministerium für Bildung und Forschung 2017: 9).

[65] https://www.destatis.de/EN/FactsFigures/NationalEconomyEnvironment/NationalAccounts/NationalAccounts.html;jsessionid=7090DDAB6540CAA1C0098669A11104A1.InternetLive1

[66] https://www.destatis.de/EN/FactsFigures/NationalEconomyEnvironment/NationalEconomyEnvironment.html

[67] Other Ministries include mainly: Economy and Energy as well as Defense (Bundesministerium für Bildung und Forschung 2017: 17)

[68] https://www.bmbf.de/de/der-haushalt-des-bundesministeriums-fuer-bildung-und-forschung-202.html

5.1.2 Science and Technology Policy Setting and Values

The European context is very relevant for Germany's national S&T structures; e.g. 30% of all R&D funds from the European Commission go to Germany (Bundesministerium für Bildung und Forschung 2017: 9). On the national level the main government decision-making body for S&T is the Ministry of Education and Research (BMBF), which, next to professional training and apprenticeships, funds research across all areas. The Ministry is made up of different departments which are separated according to thematic areas such as digitalization, European and international cooperation, key technologies, health technologies or sustainability research[69]. The BMBF provides the basic funding for the large research organizations across Germany such as the Helmholtz Association, the Max Planck Society and the Fraunhofer Gesellschaft. In the area of research, the BMBF develops strategic lines described in the High-tech Strategy (HTS), which sets the main priorities for several years. This document shows close ties between societal well-being, innovations, prosperity and competitiveness. As mentioned, in 2017 the federal government spent €17,6 billion on research and development, marking an increase of 9 billion Euro from 2005 to 2017 (ibid.). With this increase also comes a higher need for legitimization. Therefore, a close connection to societal challenges facing Germany is made in the context of technology advancements. This is often not only a question of technological but of socio-technological innovations, which should at the same time guarantee the success of the industry location Germany. Further, finding responses to these challenges is more often seen as a mutual undertaking, in which S&T must be embedded in societal settings. For example, over the last decades demands for citizen or stakeholder engagement have risen to the level of decision makers in Germany. This implies that decision making structures as well as the funding and conducting organizations in research, science and technology increasingly frame their activities in the context of societal challenges.

Overall, in public research, S&T in Germany can be located within different types of research institutions which include universities, non-university research institutes, federal as well as state institutions[70]. Four unique national research organizations make up a large part of German S&T activities. These are: The Helmholtz Association, which is committed to long-term research goals; The Fraunhofer Gesellschaft, which is largely focused on applied research for private and public enterprises; The Leibniz Association, which conducts basic and applied research; The Max Planck Society, which is mainly committed to basic research, often in natural and life sciences. In the context of the assessment of S&T, the BMBF itself has a division which is dedicated to funding research on the social relevance and the chances as well as risks of technologies and innovation. The Innovation and Technology Analysis (ITA)[71] of the BMBF focuses on innovation and multiple dimensions of future developments, addressing issues such as possible ecological or economic outcomes of S&T, societal and ethical debates or which legal questions may arise. In this way the BMBF funds inter- and transdisciplinary research in the wider field of technology and its societal, ethical or economic implications. Explicitly, ITA also supports participatory processes as a way to include citizens in the assessment of S&T. The explicit goal mentioned here is to make decisions in S&T policy comprehensible for citizens. The projects conducted in the ITA framework can be regarded as technology assessment and a balancing of chances and

[69] https://www.bmbf.de/en/political-staff-and-organization-1403.html

[70] https://www.research-in-germany.org/en/research-landscape/research-organisations.html

[71] https://www.bmbf.de/de/innovations-und-technikanalysen-ita-937.html

risks, even though ITA as such has an overall very positive understanding of innovation (Grunwald 2018b: 19ff.). Through funding these projects, the ministry itself gains advice for future decision-making. Here we see that reflections on possible (societal) effects of S&T are an integral part of priority setting in the context of S&T, which in turn is influenced by general values.

Overall, the S&T setting in Germany is framed by underlying values, which determine priorities as well as which S&T developments are desired or not. The protection of individual liberty and dignity is a main objective in the German Constitution. The first article of it states that: "Human dignity shall be inviolable. To respect and protect it shall be the duty of all state authority" (Federal Ministry Justice and Consumer Protection). Issues of human and civil rights make up many articles of the Constitution and cover topics such as the right to freely develop one's personality and the right to life and physical integrity or the freedom of speech and the press. Further, Article 5 guarantees freedom of arts and sciences, research and teaching. In principle Germany's democracy is not just a formal one (guaranteed by the Constitution) but also represents a system of values in which the free democratic basic structure is an inviolable norm[72]. These values correspond to European ones, such as citizens' rights, equality, justice, freedom, solidarity, which are the main principles of the Charter of Fundamental Rights and the European Union Treaty of Lisbon, as well as sustainability (Schroeder and Rerimassie 2015: 53ff.). Here we can see the embeddedness of Germany and the European Union, also in a formal sense, as the principles of the EU treaty also regulate the national levels.

Regarding S&T priorities and underlying values the main strategic document for S&T in Germany, the High-Tech-Strategy, is key as it presents the broad vision of research, science, technology and innovation for the next years[73]. The HTS is also referred to in the coalition agreement of the government (2014-2017) and presented as the main document to lead research and innovation, also mentioning the importance of research on the social implications of S&T. The HTS from 2014, which currently still frames activities, gives the thematic frame in which public funding and stimulation of innovation take place in Germany. It therefore provides a good representation of the strategic priorities in Germany and their connection to underlying values. The main challenges and topics the current HTS addresses are: digital economy and society, sustainable economy and energy, the innovative workspace, healthy living, intelligent mobility and civil security (Bundesministerium für Bildung und Forschung 2014: 5). These are regarded as holding high innovation potential as well as dealing with global challenges and future well-being. As such, these foci tie the need for research and innovation to future prosperity and quality of life in Germany. Here, we witness the close connection of the development and (public) funding of S&T and the societal goals of enhancing well-being, prosperity and growth.

A further important part of the HTS next to the thematic priorities is the emphasis on the process itself. Here the underlying values of a democratic, ideally open society can be found. Next to the procedural aspects of providing a creative ground for the flourishing of innovation, the HTS

[72] This has developed based on the historical context of the Weimar Republic, in which the even basic rights in the constitution could be changed with two thirds majority, which then gave way to the National Socialist Party taking power in 1933.

[73] The Ministry provides an English version of the strategy from 2014 here: https://www.hightech-strategie.de/de/The-new-High-Tech-Strategy-390.php. The High-Tech-Strategy as a strategy tool has been implemented for around 10 years.

highlights the need for widened ideas of innovation: "We are emphasising an expanded concept of innovation that includes not only technological innovation but also social innovation – and that includes society as a central player" (Bundesministerium für Bildung und Forschung 2014: 4). The more conventional focus on enabling better transfer between science, research and industry is expanded, at least in the vision of the HTS, to include various actors of society: "We are promoting innovations and future technologies not for their own sake but for their ability to provide clearly recognizable social benefits. Within our innovation culture, we are integrating processes for identifying and assessing the societal opportunities and risks that are tied to the introduction of new technologies" (ibid.: 10). Next to core elements of the HTS such as networking and transfer, increasing innovation strength or providing an innovation-friendly framework, issues of transparency, communication and participation are also addressed. Here the inclusion of citizens and stakeholders is seen as a way towards "better" innovations that are broadly accepted within society. This rests on an understanding of participation for the support of innovation and as a way for the "Federal Government […] to promote development of a participatory, innovation-friendly culture, with the help of new initiatives and formats. For example, it plans to enable interested citizens to help shape innovation policy and it plans to improve its information provision regarding new technologies" (ibid.: 45). The move towards more inclusion, although often vague in the question of what useful formats are and how they can be incorporated in the political system, can be seen as a way to increase the legitimacy and acceptance of policies and S&T itself. The basic assumption is that assessing the risks and opportunities of new technologies cannot only be left to experts; it requires a wide range of actors. This can be understood as a form of lay morality or ethics as described in section 4.1, in which a public discourse or deliberation on the risks or benefits but also the boundaries of S&T take place. Yet, when looking at the HTS, it is often unclear what role participation should play: it ranges from a way to gain acceptance on a specific technology to it being an integral part of transdisciplinary research and transformation processes. This of course is highly relevant for TA, which is often seen as having a main role in facilitating participation. Apparent in the HTS are the underlying motivations for driving research and S&T development as well as calls for engagement. Well-being, prosperity as well as Germany's dominant position in the light of global competition are referred to throughout the document. These can be related to main values that lead many of the S&T debates in Germany. These include the fundamental rights of individuals and their dignity, as stated in the first paragraph of the German Constitution as well as freedom, citizens' rights, justice, equality, which are fundamental European values (Schroeder and Rerimassie 2015: 53ff.).

Further, sustainable management is considered one of the priority tasks of the future. The HTS describes the way we produce and consume should be more resource-efficient, environmentally friendly, socially acceptable and thus more sustainable. Research delivers insights how human activity affects the climate and complex ecosystems. Over the past decades the German political landscape has been highly influenced by sustainability or sustainable development, which has also shaped debates in the context of S&T[74]. This is often connected to the idea of responsibility

[74] An example is a Helmholtz coordinated project from 2003, which developed an integrative sustainability concept focused on providing rules and reference points, flexible enough but also robust, for actual use in practice (e.g. in areas such as mobility, living and building, food and agriculture (for publications see: https://www.itas.kit.edu/english/gze.php). A more current project is one on sustainability management for non-

(e.g. for future generations) and as such also determines the priorities of S&T. For example, the energy transition or the highly contested discussions on nuclear waste disposal are often debated the context of sustainability. This can be seen as a specific characteristic of Germany, as the value of sustainability has become important in regards to the wider understanding of responsibility also in S&T (Ladikas et al. 2017) as well as created concrete measures, instruments and tools (e.g. for industry standards). Also, it has brought to life numerous local or regional initiatives that aim to re-shape how development or progress are understood[75].

This all frames the way in which S&T developments are debated and governed in the German setting. Generally, in Europe and in Germany, the discourse on possible risks of S&T is predominant over that of innovation, which relates to the importance individual's rights and their protection and safety. This is different to other countries such as China or India, in which the discourse on innovation is stronger (Stemerding et al. 2015: 109) as discussed in section 4.1.2. Debates and discourses on S&T developments and implications for individuals and society can take place in more professionalized ways, but also in form of dialogue formats or public controversies. Discourses of reflexive ethics often take place in established committees, such as the German Ethics Committee, which is institutionalized in form of a specific law as a legal basis for its work. Lay morality, so the debates by actors with no specific scientific expertise, but with a claim to be heard, forms another important space for debates on S&T. In Germany, as seen in documents like the HTS, this area is increasingly gaining importance, also for policy. By stressing the significance of participation and the inclusion of citizens and stakeholder within the decision-making process, there is a certain overlap between the procedural level of institutionalized ethics and the ethical debates of lay people. Further, values such as individual rights or freedom call for the inclusion of ethical contributions of a wider scope of the population. Of course, the actual inclusion of this into the existing system remains challenging in Germany, as in many other countries. These newer formats seem to present a kind of 'disruption' to the established representative democratic system. The underlying value of the individual's rights, also understood as being heard regarding decisions on S&T, often forms the basis for demands of engagement. This also extends to the debate of values themselves, which are balanced and weighed in discussions on desirable or undesirable S&T developments. As in any society, values or normative framings are not set in stone and don't directly result in action (or non-action). Instead they are socially debated and conflicts can occur. Especially in the context of lay morality, debates and disagreements between different groups are an essential part how priorities are negotiated and then defined or changed.

Political decisions in Germany are often characterized by a balancing of values. These can revolve around the protection of individual rights or the well-being of the general public or a larger group. Different poles are particularly evident when it comes to ethical issues in S&T developments. For instance, a large scale infrastructure project may have negative effects on individuals due to land use, yet can claim to be necessary for the good of general public. The balancing of these different underlying values or effects of S&T developments can also be seen

university research centers (LeNa) from 2016, which developed a framework for Helmholtz, Fraunhofer and the Leibniz Association (https://www.itas.kit.edu/english/2016_055.php).

[75] One example of this in the context of TA is the project "Quartier Zukunft", which is a local urban initiative to make a city quarter more sustainable in a wider sense. This includes transdisciplinary activities regarding consumption patterns, or economic and social aspects. http://www.quartierzukunft.de/en/

as a value in itself. As described, this is an essential part of the value system in Germany and frames many of the debates on S&T. This can also be traced in one of the main areas in the HTS. Civil security, which includes topics like security research, cyber and IT security and secure identities, has become central because societal and technological developments such as the wide-spread use of the Internet or increased global networking have raised issues for the public as well as for policy. The protection of privacy and individual freedom become key issues for the government and policies in the light of ever evolving technological advances. In Germany, we can see the link between the S&T priority of civil security and the research or development needed for this and the basic values of rights and freedom for citizens. The HTS makes this clear: "The Federal Government's aims in this area include helping to safeguard individual freedom. Solutions in this area also help enhance citizens' security and quality of life – and they help to strengthen the civil security sector" (Bundesministerium für Bildung und Forschung 2014: 28). Efforts can further be tied to the value of equality since another objective is to protect privacy and freedom in the Internet in order to also ensure opportunities for all persons to participate. This also shows how values are used for argumentation (and legitimization) of funding certain S&T areas. Furthermore, we see the importance of societal use or application of research and technologies in funding and policies. Naturally, this is an ongoing issue that depends on negotiations and debates among a variety of actors.

Another example of S&T debates that shows the underlying values in Germany is the development of service-robots, especially in the area of care. An ageing society and demographic change in Germany are dominant societal challenges, which bring about debates on technical solutions. This means that S&T priorities are, for instance, focused on developing robot systems and including them in the daily lives of people in need of care. Expectantly, this area raises very sensitive issues such as privacy, access or dignity, also in connection to individual rights. A recent project on humanoid robots funded by the Ministry of Education and Research also focused on the area of health and care, mainly on the aspect whether robots were more accepted if they resembled humans or not[76]. If robots were described as a technical tool they were more likely to be accepted than if they were assigned more human attributes such as the ability to act independently. So, even in the area of care, where qualities such as warmth and helpfulness are important, robots shouldn't be humanized too much. This example uncovers how values of individual freedom or dignity, which are ascribed to humans, can also determine the design of technical systems such as robots. This in turn is highly relevant for S&T priorities and shows that values need to be balanced and weighed as well as uncovered and assessed, even regarding specific technological developments.

5.1.3 Roles of Technology Assessment, Ethics and Engagement

When looking for main advisory structures or bodies related to TA in Germany, several institutions can be named. Perhaps the most relevant one is the Institute for Technology Assessment and Systems Analysis (ITAS) in the Karlsruhe Institute of Technology (KIT) [77], which is one of the largest and longstanding institutions doing TA in Europe. ITAS is one of the largest research institutes for TA worldwide and as such, it focuses on the theory and practice of TA,

[76] Description of the project in German: https://www.bmbf.de/de/humanoide-roboter-sympathisch-oder-unheimlich-4918.html

[77] http://www.itas.kit.edu/english/index.php

producing knowledge for policy, decision makers and the public. The institute's wide field of activity ranges covers ethical, ecological, social, political or cultural topics and issues. Main funding comes through the Helmholtz Association, which in turn is funded via the BMBF (basic funding) as well as third-party funding (other ministries or European Commission). The German Parliament itself has a committee for Education, Research, and Technology Assessment and through this sets the agenda for the Office of Technology Assessment at the German Bundestag (TAB), a main advisory body for the parliament, which has been run by ITAS since 1990. The topics and issues TAB addresses have to be found in consensus with all parties in the Parliament, not only the leading majority. Using internal as well as external expertise, TAB writes reports which specifically address the parliament in order to support better informed decisions (Grunwald 2018b: 15ff.). Over the years, parliamentary TA has become an established practice in the German context, although institutionally still overall dependent on the will of the parliament and the parties in it. TA in Germany has developed in several institutional forms over the years. This ranges from organizations explicitly concerned with assessing the societal, environmental or economic implications of S&T to more 'conservative', technocratic ones which have changed from a previous skepticism of TA to its inclusion into their work (ibid.: 12).

In the following a list of main institutions concerned with TA is given, ranging from traditionally more technically oriented to focused on social implications and providing advice on S&T in the German context:

- acatech - the national academy of science and engineering represents the German scientific and technological communities, in Germany and abroad. As a working academy, acatech supports policy-makers and society by providing qualified technical evaluations and forward-looking recommendations. In 2008, acatech joined the national academy, which was jointly funded by the federal government and the federal states. The Convention for Technical Sciences of the Union of German Academies of Sciences (founded in 2002) became acatech[78].

- VDI/VDE Innovation + Technik GmbH was established from the Federal Ministry of Education and Research as a technology center (TZ). The task of the VDI-TZ, which was founded in 1987 as a department within VDI, was to promote technological developments in the microelectronics and physical technologies departments. Today VDI/VDE provides guidelines which specifically incorporate values such as safety, health, environment or social quality and aim to guide engineers for developing technologies accordingly[79].

- The EA European Academy of Technology and Innovation Assessment GmbH analyses the relation of knowledge and society given that science, technology and innovation change societies rapidly. The EA informs policymakers and business managers when facing the economic, social and political challenges presented by developments in science, technology and innovation. The Academy was established as a non-profit corporation in

[78] https://www.acatech.de/uk

[79] http://www.vdi.eu/

1996 by the Federal German state of Rhineland-Palatinate and the German Aerospace Center (DLR)[80].

- IZT The Institute for Futures Studies and Technology Assessment was founded in 1981 and examines in its future studies long-term futures, e.g. with assessing scientific-technologic developments, including the impact on society, economy and politics over different time horizons and pointing out new perspectives and options for action[81].

- The Fraunhofer Institute for Systems and Innovation Research ISI analyses the origins and impacts of innovations. They research the short- and long-term developments of innovation processes and the impacts of new technologies and services on society. Founded in 1972 ISI Fraunhofer provides recommendations for action and perspectives for key decisions[82].

- The Netzwerk TA was founded in 2004 and is a network of about 40 institutional and 250 individual members from Germany, Austria and Switzerland. It aims to support the cooperation among TA researchers as well as communicate TA to political, scientific, economic and public actors[83].

Next to these institutions, another key actor for TA activities in Germany is the Innovation and Technology Analysis (ITA)[84] area of the BMBF itself. Projects concerned with the multiple dimensions of future S&T developments especially regarding societal, ethical, legal or economic questions are funded through ITA and aim at providing assessments for the ministry but also citizens, researchers or representatives from other areas. From 2015 to 2017, 25 ITA research projects were funded and ranged from topics on digitalization, participation in innovation or consumer behavior. Currently, projects concerning artificial intelligence and virtual realities, digital platform systems or capacity building for engagement. In this way, ITA represents a further important part of the span of TA activities in Germany and their connection to decision making bodies such as the ministry.

This shows a unique position of TA in Germany: it is institutionalized, both on the level of advising politics and on the level of research. Also, it seems to be slowly but increasingly becoming more established among actors from the field of S&T itself, as the activities of VDI and acatech show. Of course, as past experiences of the U.S. Office of Technology Assessment (OTA) and its eventual closure (section 3.1) have shown, TA is always in a state of uncertainty, dependent on political will (especially for parliamentary TA). In Germany, as in several other European countries much experience in the practice of TA has been gained over the years and networks established (e.g. European Parliamentary Technology Assessment EPTA, or Netzwerk TA) providing a fairly stable ground for future work in TA. For Germany and its S&T developments it seems essential to have structures that can respond to growing demands for inclusion, anticipation or expert advice. The role of TA in Germany could ideally be seen as a 'balanced mediator' between S&T developments in the context of prosperity and

[80] https://www.ea-aw.org/
[81] https://www.izt.de/en/
[82] https://www.isi.fraunhofer.de/en.html
[83] https://www.openta.net/netzwerk-ta (in German)
[84] https://www.bmbf.de/de/innovations-und-technikanalysen-ita-937.html

competitiveness and issues of sustainability or engagement. Yet, increasing demands for engagement of citizens or stakeholders as part of the assessment, but also in the decision-making process itself raises issues especially in a representative democracy like Germany. Within the S&T structure in Germany, TA has a clear role as an advisor to policy and decision makers, especially in form of Parliamentary TA. Here the TAB, which has the explicit role to provide advice for the Parliament, but also other institutions doing TA have political 'legitimacy', which is also based on their autonomy regarding the assessment. This is an issue which also comes up in countries without explicitly termed 'TA', like we see in China and India (see sections 5.2 and 5.3), with questions arising such as who is politically legitimated to do TA or where should TA be located in the political system to ensure autonomy while still allowing for closeness for advice. Next to this, as TA is often changing as a response to new challenges or demands, the future of TA activities in Germany may also include different, more experimental forms, complementing classic parliamentary TA. This can already be seen in the context of "Real-Labore" (real-time laboratories), which aim to create spaces for transdisciplinary research for transition processes towards sustainability[85]. These kind of interventions are aimed at changing the way society and science interact (Grunwald 2018b: 38). This blurs the lines between advice, research, addressees and transformation processes and defines new roles for TA also in the context of a global level, as discussed below. Overall, we see again that TA is dependent on and unique to the political, but also socio-cultural context in which it takes place and has to evolve accordingly.

As we have seen, in Germany there is a tradition of TA as policy advice, which shows especially in form of Parliamentary TA. As described above, the TAB has the specific mandate (appointed every 5 years) by the German Parliament to conduct assessments on agreed topics. It conducts studies and writes reports by collecting expert assessments from different fields of relevance for the specific technology or issue. The clear addressee of these reports determines the 'kind of TA' that is done at TAB: it focuses on the requirements for the legislative and aims to "make a difference" in debates and decision making. Some examples can be named, where TAB reports created discussions beyond the Committee for Education, Research and Technology Assessment, for example an early study on Nanotechnology, which lead to a funding program on Nano-toxicology as well as a study on a nation-wide electric blackout, which sparked changes in ministries and municipalities (ibid.). In this form of TA, as parliamentary advice, the actors involved are mainly the TA experts or experts from other relevant areas such as law, ethics or science and the members of Parliament. Yet, as the blackout report showed other actors can also become important: such as ministries or local administration. Overall, as often, it is difficult to clearly trace the effects of TA studies in decision and policy-making, even with a specific addressee.

A further level of TA as policy advice in Germany can be seen in the projects done for German ministries, research organizations or the European Commission. These range from numerous S&T topics, with different foci: social implications, potential risks and benefits for stakeholders or environmental aspects, often addressing diverse target groups (e.g. public, policy makers, industry). Main actors involved are TA researchers, researchers from other relevant disciplines,

[85] One example for this is the "Urban Transition Lab 131", a project run at ITAS aiming to transition urban development in a specific quarter in Karlsruhe, Germany: https://www.itas.kit.edu/english/projects_paro15_qzrealab.php. Real-time laboratories are also referred to in the overall strategy of the BMBF (Bundesministerium für Bildung und Forschung 2014: 45).

policy makers, but can also include representatives of civil society or industry as a way to gain further insights on important aspects. An interesting example of a recently completed large-scale project in the area of TA as policy advice is the Helmholtz-Alliance "ENERGY-TRANS", which aimed to give an interdisciplinary perspective to predominantly technical oriented energy research in the German context[86]. This project, with work of around 100 researchers in 17 sub-projects, was initiated during a very specific political climate in Germany: After the nuclear power accident in Fukushima, Japan in 2011 the German government decided on the "energy transition", i.e. abandon nuclear energy and replace it with sustainable energy resources. From a TA perspective, such a rapid policy change means that not only the technical transitions are enormous, but also the social ones requiring knowledge on the affected systems as well as knowledge for orientation and action (Grunwald et al. 2016). This was the focus of the ENERGY-TRANS project dealing with consumer behavior, acceptance issues or participation in planning processes; so, in general, research on the transformation of socio-technical systems and establishment of new infrastructures to meet this challenge. Policy briefs published during the project showed possible areas for action for policy, but also for industry or research. ENERGY-TRANS was a project with the goal of providing knowledge in light of fairly fast and substantial changes of the energy system. The interdisciplinary approach, which became a collective orientation along a common framework in the course of the project (ibid.), shows additional elements of a TA as policy advice. So, besides the more 'clear-cut' form of policy advice, such as in TAB, we find TA research, which aims to provide policy advice in various areas also those of high political or societal interest. This advice can be about providing forms of knowledge to different target groups for decisions, but also for setting priorities. In these cases, the addressee may not be as distinct as in the case of Parliamentary TA and can entail industry (conditions for innovation), research (areas lacking) or civil society (social implications).

When looking at TA as public debate it is important to note that engagement is a key element of TA as described in detail in section 4.2.2. The inclusion of citizens or stakeholders in order to add to the assessment itself is key in order to better understand values and perceptions. Here two approaches can be identified, although they may overlap in practice. One is to engage citizens or stakeholders as an element of the assessment itself, to better understand the ethical, cultural or social issues and arguments. In this case, the goal is to improve the knowledge basis and in the longer run to come to more robust (policy) decisions. As such, this could be an element of a Parliamentary TA study. A second approach is to initiate engagement of these actors as part of the decision-making process itself, for example to help set S&T research agendas. In Germany, we find many examples of participatory elements as part of TA studies, ranging from topics like Nanotechnology, Big Data or in-vitro meat. In this second approach, different methods (e.g. focus groups, citizens' conferences) are used to increase the knowledge basis and to add to the assessment. Moreover, these activities can open debates and raise awareness, especially on new and emerging technologies (Grunwald 2018b). The participation of citizens as part of the decision-making process itself on the other hand is rare and difficult to realize in practice. This has to do with the political system in Germany as a representative democracy. From this perspective, the system has legitimate decision makers in place, elected or appointed, which therefore are able to make decisions. Therefore, often engagement aims to create suggestions for policy action, so for example citizens provide their priorities for future

[86] http://www.energy-trans.de/english/index.php

funding of research. One prominent example of this were the Citizens' Dialogues on Future Technologies initiated by the BMBF from 2011 to 2013. These were large-scale participation events across Germany on the topics Energy, High-tech Medicine and Demographic Change. The outcomes were citizens' reports with suggestions for priorities and action. Interestingly the Ministry engaged in a dialogue with the citizens and allowed for a re-framing of the topics during the process. Although the reports were given to the ministry and some effects in funding priorities can be traced, the large effect on policy decisions by the ministry is missing (Hahn et al. 2014). In practice, more often than not, unclear goals or target groups as well as the frame of the questions and issues are critical parts of participation efforts in the German context, as often in engagement in general (see section 4.2.1). Although the interest is high in Germany and approaches such as Citizen Science are gaining attention (and funding), it remains difficult to actually integrate engagement processes in decision-making, which will also be a continuous challenge for TA in Germany. Overall, it is important to note that TA as public debate in Germany has developed considerably over the last years. This has come from an increasing decentralized society as well as public demands towards more deliberation and inclusion. Further, this also implies that TA's role as merely providing scientific assessments and policy advice to political institutions isn't sufficient anymore and that societal advice is also needed (Grunwald 2010: 56ff.). In the past, intense and long-standing public and political conflicts and controversies such as those concerning nuclear waste disposal, which was mostly oriented top down until the 1990s (Grunwald 2018b: 65f.), or large scale infrastructure projects such as the Stuttgart train station[87] have led to an awakening of the political side towards the importance of communication and consultation. This, it can be argued, is not necessarily motivated by newly discovered ethical consciences of decision makers, but instead as a reaction to past battles and struggles. Next to this, another aspect of TA in public debate should be mentioned here. In the context of sustainability, engagement in transformation processes has gained attention in Germany. Here engagement is understood as co-design and co-creation of knowledge in transdisciplinary processes (Mauser et al. 2013). An example of this are real-time laboratories mentioned above, which offer spaces for transition processes to unfold. TA's role in this context changes from the more distant advisor in Parliamentary TA to one which accompanies processes of change. This of course needs to be reflected as it brings up issues of distance and embeddedness of TA practitioners. Still, this seems to be a useful way forward for a now overall well-developed TA as public debate in Germany (see section 7.1).

TA in engineering processes is perhaps the most challenging role as it requires an integrated approach of the assessment. Constructive TA, as we have seen in section 3.1, for example aims to accompany the development of technologies throughout the entire process. The idea behind this is that these processes become more reflexive and can integrate values, interests and possible outcomes of technologies better. This kind of TA is not as common in Germany as the previous ones, yet some examples show specific approaches of integrating TA in development. For instance, in the area of technologies for health and well-being bringing together TA researchers with engineers and developers is being used as a way to adapt the technologies to specific demands and requirements of the users. The TERRAIN project[88] for example is developing man-machine interfaces which produce acoustic and haptic signals to support daily mobility and overall more autonomy. The approach in this project shows that TA is done in close

[87] https://en.wikipedia.org/wiki/Stuttgart_21#References
[88] http://www.itas.kit.edu/english/projects_wein16_terrain.php

relation with the development during the entire process, focusing on technical, legal, economic and especially ethical and social aspects. By accompanying the user studies and participating citizens the TA approach evaluates findings and brings them back into the development process. In this sense, the TA researchers not only mediate between human and machine, but also between affected people, citizens, experts, and developers. A similar example of this is the project QuartrBack[89] which aims to enable people with dementia to safely and autonomously access their neighborhood spaces. The technology developed for this purpose should be demand-oriented by locating and monitoring patients as well as connecting to possible existing care systems. The aim is to combine an intelligent emergency chain with a network of relatives, care workers and volunteers, who can respond in emergencies. Here again, TA is integrated in the development process by investigating expectations and demands of different stakeholders as well as accompanying a wide field test which will apply the technologies and existing systems under real-life conditions. TA as part of the engineering and development process is an essential aspect of assessing technologies, especially if these are to be applied in sensitive areas, such as health. This approach means a specific role for TA, which is to mediate between potentially very different stakeholders and find inter- and even transdisciplinary ways to do this. It also means that TA needs to continuously reflect on its role, especially when this is close to the development process. In order for the assessments to be regarded as credible (also by the various stakeholders) TA researchers have to balance distance (important for the inclusion of different perspectives and awareness of the wider context) and closeness (needed for working with developers) in order to not be seen as merely promoting a certain innovation (Grunwald 2018b: 45). As both projects described above are funded by the Ministry of Education and Research this also shows a certain political will to enable this kind of research and advice in the German context. A further key area to be mentioned in the context of TA in engineering processes are activities in Life Cycle Assessments and sustainability assessments. One example of how this is integrated into research and engineering processes can be seen at the Helmholtz Institute Ulm (HIU)[90], which is focused on developing battery technologies for clean energy sources and renewables. Here TA has an essential part to play regarding questions on resources, recycling as well as environmental and sustainability issues. TA's role here is for instance to identify the availability of resources needed, toxicological factors or recycling of electrochemical batteries. This of course requires efforts from the technology developers as well as the TA-experts to bring together analysis of the technical aspects and systems with economic, social or ecological assessments. In a way, this also reflects similar efforts and more holistic approaches looking at social-technical systems as described above regarding the energy transition. With the integration of this work in more technically focused institutes such as the HIU we see that TA within engineering and research processes is present even if most TA activities in Germany remain in specifically designated TA institutions.

As the descriptions above show, TA is generally well-established on a research and institutional level in Germany. Main roles of TA as defined by the TAMI project in its Typology of Impacts (see section 3.1) can help us show the key activities as well as potentials for TA in Germany. Currently, the main roles of TA in Germany revolve in the area of raising knowledge through scientific assessments, social mapping and policy analysis. This covers the 'basic' spectrum of assessment as it includes the scientific, societal and policy aspects; all important for a comprehensive

[89] http://www.itas.kit.edu/english/projects_wein15_quartrback.php

[90] http://www.hiu-batteries.de/battery-research-center-in-germany/

understanding of S&T developments within a given societal context. Further, it can easily be included in a representative democratic system as in Germany, since it remains largely independent from the decision makers. In this sense, raising knowledge is part of the core business of TA in Germany, also because it is a way to map existing conflicts and debates next to technical options and policies. Likewise, the level of raising knowledge is grounded in a 'traditional', scientific oriented understanding of TA: to provide advice as an independent actor by assessing all relevant aspects. Also in the area of raising knowledge, TA can focus on its own assessments. Here other stakeholders or actors don't necessarily have to be involved, other than as a way to gain knowledge on a specific question or issue. This role of TA in the German system is especially prominent in the work of the TAB, which produces reports for the German Parliament. As we have seen, these are written by TA experts by including the input of various experts from diverse areas, depending on the specific S&T question. These general reports comprise scientific and social aspects and can include policy options. In this case, the frame and the goal of the report is clear: provide a comprehensive overview of the issues as well as potentials and risks of a specific technology as a basis for decision-making.

In the area forming attitudes and opinions, TA in Germany is mainly concerned with agenda setting, especially stimulating public debate and mediation, although this is more complex as it requires the inclusion of stakeholders or other actors in an active form. In the German context, there is also a strong and active civil society, meaning that interest groups, stakeholders, etc. are represented by various groups who can organize themselves effectively. Many issues can be and are addressed by different actors, who are all involved in discussion on S&T. If issues haven't already been addressed by civil society, TA can bring these on the policy agenda. Further, TA in its function of stimulating public debate can actually act as an impartial mediator for facilitating discussions, based on its finding from raising knowledge (technical options, social mapping and policies). This role of mediation is especially significant in the German debate on sites for nuclear waste, a long and controversial topic with many diverging expert opinions and political gridlocks. Here, projects such as ENTRIA[91] aim to conduct interdisciplinary research, which is independent e.g. from possible sites for the waste and addresses the public as well as research. TA's role here is to build bridges by conducting assessments and based on this coming to processes for eventual decision making that are agreed upon by a large number of the actors involved and therefore legitimate. This also reaches into the area of perceived democratic legitimization, in which at least different opinions are accordingly acknowledged leading the recognition of the process by all actors involved.

Regarding the area of initializing actions, it is difficult to find direct and causal connections between TA and specific policy initiatives in the German context. On some impact levels TA has a clear role (raising knowledge and forming attitudes), unlike in the area of initializing actions, which remains difficult. In Germany, TA often remains in the (legitimized) role of the advisor, independent from decision makers. Enabling actions on the level of policy is difficult for TA, also because certain decision-making processes are established. Therefore, an impact of TA towards initializing actions remains difficult to observe.

In the reframing of a debate, TA can offer clarity and possibly new orientation regarding potential benefits or risks concerning S&T developments, which can then be the basis for policy

[91] http://www.itas.kit.edu/english/projects_hock13_entria.php

decisions. However, introducing new ways of governance or even passing new legislation as actions initialized by TA remains highly difficult in the German context, assumingly also in other countries. One example of the introduction of a new process of governance can be seen in the commission for finding a long-term disposal site for nuclear waste. As mentioned above, this has been a highly debated issue in Germany for decades, involving many interest groups and positions. Unique about this commission, which was initiated by the German Parliament in 2014, was its structure: it was located at the Parliament, its members were appointed by the Parliament and the Federal Council. Yet it was not a committee or part of the party fractions. Instead it was made up of representatives of civil society, science and national and federal politics and as such prepared legislation, mobilized expert knowledge, engaged citizens and mediated between national and federal interests. Therefore, the commission itself wasn't tasked with finding a final disposal site, instead it developed criteria and recommendations for the search of a site, so for coming to a legitimate, transparent process. TA aspects were embedded in the commission's work, as it dealt with societal aspects, but also how to engage citizens or stakeholders as part of the search process. As a whole, the commission was able to introduce at least a first step towards a new process of governance in a highly disputed area.

From this brief characterization of TA's various roles in Germany, we can also identify certain challenges and future needs. As a fairly well-established and institutionalized undertaking, TA in Germany has specific set roles in decision making processes. As the TAB shows, there is political will and legitimization for TA processes as a basis for decision and policy-making. Yet, this established TA also remains tied to the political system and is dependent on its goodwill. As the more classic forms of TA show, this can 'limit' the assessment to expert reports and a single addressee (e.g. members of Parliament). Yet, in an increasingly globally connected and networked world with challenges such as climate change, the addressee of the national state can limit spaces of action. For TA, it is therefore also important, next to the national level, to address the global level. As an experienced TA country, Germany can offer a rich and knowledgeable basis for this, but needs to be open towards new ways of doing TA in diverse contexts. This also challenges notions predominant in Germany or Europe, that TA is directly tied to democratic and pluralistic regimes (Grunwald 2018a), which is discussed in detail in section 6.2.2 regarding normative foundations of TA. Of course, basic aspects of TA such as engagement and the inclusion of (lay) ethics are directly linked to a democratic understanding of how policies should be developed. Yet, moving towards a global level of TA also means reflecting and even including other value systems. This also means that certain roles of TA as described above may not be desirable in other contexts and that, for instance, different levels of engagement might be more appropriate in different value/political systems. These aspects are relevant for a global TA and examined further in chapter 7.

A future challenge for German TA can be providing insights and reflections to finding conceptual and practical ways to encounter TA in different settings and value systems. Building on its wide experiences, German TA can help set the scene for a global TA community as well as foster reflection on other settings and expectations and demands. In this sense, it could help create a (global) habitat for TA (Hennen and Nierling 2015: 54ff.). Mutual understanding is the prerequisite for learning from each other. The German context shows that TA, if it does not want to stagnate, has to react sensitively to changed social conditions and new socio-technical challenges. This shows in the increasing importance of engagement methods in TA processes to the implementation and research of trans-disciplinary projects. The processual nature of TA, a

constant questioning and reflection, is a basic requirement for establishing TA in other national contexts and then comparing them. Concrete recommendations for the future of TA in Germany in the context of global TA are provided in section 7.1 and ways towards a more general global level are examined in section 7.3.

Of course, the contexts in which TA can be institutionalized differ. The German case shows that impulses for the establishment of a TA vary, depending on whether they are scientifically motivated or in the form of consulting needs that are politically and socially desirable. For example, the curricula of some German universities e.g. have in recent years changed to include consequences and implications of S&T developments, mainly as an academic endeavor[92]. Further, politics (in the German case the Parliament) can be a strong driver for TA. Increasingly policy decisions have to be made in the face of unsure knowledge as well as diverse implications for society. Here, an institutionalized TA can offer legitimate and independent assessments as well as policy options. Further, these options can be elaborated and confirmed in processes of debate between advisors and advisees.

Ethics

Debates on S&T in general and in the German landscape, have increased and widened to include an array of different actors, as discussed in section 4.1 of this thesis. This "'ethicization' of the public discourse on science, technology and innovation" (Brom et al. 2015: 9) can be seen in many areas. In Europe, this has meant that ethical debates have developed in a way that includes expert as well as lay knowledge, through various forms such as surveys or engagement processes and through their resonance on a political level, even if this is not always causally determined. As we have seen above, Germany is embedded in the European context also regarding S&T, which shows why these wider developments also influence the German context. In Germany, institutionalized ethics are diverse and often address a specific thematic area. One of the most known official institutions is The German Ethics Council[93], which is an independent body made up of 26 representatives, who are proposed by the German Parliament and Federal Council. The Ethics Council has two main functions in providing a dialogue forum and acting as an advice committee. It therefore brings together specific scientific discourses and supports societal debates as well as provides statements and recommendations for political and legal action. Topics have a wide range, regarding research and technology foci include: big data, bio security, genome and stem cell research, cloning or synthetic biology. Different expert working groups provide statements or recommendations. Next to this, we can find a wide array of professional ethics represented in different commissions or councils across various areas. Especially in the area of health and clinical trials we can find this form of ethics at university hospitals or within medical associations as part of legal requirements for research. Next to this, many other research institutions have set up ethics committees as part of self-monitoring their actions. Next to formalized (even legally guaranteed) ethical activities, in Germany there is also a strong civil society often concerned with topic-specific issues (e.g. NGOs criticizing high emissions of cars in German cities or animal welfare, etc.) as well as active citizens who shape ethical debates. From this side, as well as the political arena, we find growing demands for

[92] One example is the Munich Center for Technology in Society, which offers study programs in S&T studies or Techno Science Studies (https://www.mcts.tum.de/en/startseite/)

[93] http://www.ethikrat.org/about-us

inclusion of ethical considerations from a wider public, also regarding S&T policies. The close ties to societal challenges in defining the strategic priorities also means that society has to be considered regarding ethical questions. For instance, the example of preimplantation genetic diagnosis (PGD) shows controversies in ethical debates in Germany. Strong debates resulted in a 2011 Act, which prohibited PGD, with only limited exceptions. In this sense, Germany is restrictive towards PGD compared to other European countries such as the U.K. or the Netherlands (Schroeder and Rerimassie 2015: 67). Further, as described above, the value of sustainability is especially prominent in Germany and as such important to ethical considerations, also lay ethics. Sustainability can be regarded as a reference point or normative frame for ethical debates on developments in S&T and their effects on German society. As the controversial issue of nuclear waste disposal shows, it is used to make ethical arguments for the protection of the environment, but also for taking responsibility for future generations. For TA, which in the German context has actively shaped the sustainability discourse[94], it remains an important aspect, also when taking up ethical debates in society as part of a TA study.

Engagement

Engagement and the inclusion of stakeholders and a wider public has gained political and societal relevance over the past years in Germany, also regarding S&T. This shows a change in the position of the political side towards engagement becoming a necessary element within decision-making processes. The importance of sustainability in the political culture of Germany as well as large scale infrastructure projects, which have resulted in large public controversy, have supported the rise in awareness of engagement. Coalition agreements from past as well as current governments show these demands for more engagement and a certain political commitment. Under the topic of research and innovation for the future, the coalition agreement of 2009 states that: “Research, innovations and new technologies are the bedrock of future prosperity. They are the source of economic success, growth and employment. At the same time, they will help us to tackle the challenges of our times, climate and environmental protection and fighting poverty and disease. This makes research and new technologies crucial for sustainable production and consumption, for resource efficiency and securing the world’s food supply. It is important in Germany, the land of ideas, for technologies not only to be developed, but also implemented. To this end we require a comprehensive dialogue about future technologies with and among our citizens. We advocate a future-oriented culture characterised by opportunities. We want to become once again an optimistic society, open to technology and innovation” (German Coalition Government 2009). This shows how a direct connection is made between S&T developments and their importance for Germany and engaging society to come to the actual acceptance and implementation of these developments. This shows the political expectations concerning engagement; it is regarded as a way to (again) gain approval as well as an openness of society towards S&T. The following coalition agreement of 2013 sees the potential of digitalization for engagement and communication. Also, there is the wish to come to better decisions as well as even including the public in research agenda setting. “Parliament, government and administration will make intensive use of the possibilities

[94] An example is the integrative sustainability concept of the Helmholtz Association, which was co-developed by ITAS and developed substantial rules for a more concrete application of the concept in practice. An example of its application is a project on sustainability aspects in tourism and leisure: https://www.itas.kit.edu/english/projects_klei03_ftd.php

for digitalisation and expand interactive communication with citizens […] We intend to use the potential for digitalisation in order to strengthen democracy. We intend to improve the quantity and quality of information on political decisions and to expand the possibilities for people to communicate in political decisionmaking. Open, comprehensive and comprehensible information must be provided at an early stage in advance of decisions. […] We will also seek out the expertise and opinion of the population by means of digital participation platforms, as a result of which citizens will be better able to exercise a constructive influence at an early stage. […] We intend to involve citizens and civil society stakeholders consistently in discussions on future projects and the design of research agendas. We intend to develop new forms of participation by citizens and scientific communication, and to bring these under the umbrella of an overall concept" (German Coalition Government 2013). This shows a certain commitment towards establishing engagement as a useful process within the German political system. The latest coalition of 2018 again takes up engagement stating that: "We want to intensify the dialogue between industry, politics, science and society and test new forms of engagement with the inclusion of civil society as well as strengthen science communication" (German Coalition Government 2018). Under the wider label of solidarity and renewal of democracy the agreement declares: "We will put into place an expert commission which will develop if and in which form our proven parliamentary and representative democracy can be complemented with elements of citizen engagement and direct democracy. Also suggestions for the strengthening of democratic processes should be developed"[95] (ibid.).

These statements from the different coalition agreements have had real-world effects. The BMBF has funded several (large-scale) engagement projects, ranging from Citizens Science to the Citizens' Dialogues on Future Technologies as described above. For TA, this means that methods as well as the conceptual reflection have become increasingly important for the German context. Yet, even though there is political commitment and several examples can be named of engagement initiated by the political arena, some aspects remain unclear. As the coalition agreement of 2018 states, the inclusion of engagement into the existing representative political structure of Germany remains a challenge. This is also important regarding the legitimacy of these engagement activities. On the one hand there is high demand (and correspondingly expectations) from the political side, on the other the actual inclusion of results is lacking. This gap doesn't necessarily come from methodological or procedural shortcomings of engagement processes, but from difficulties of political institutions to adapt to these new forms of inclusion. For German TA this is a challenge because essential parts of TA are to provide policy advice as well as the inclusion of various actors. In this sense, TA should find ways to build on experiences in engagement (also regarding controversial issues, e.g. nuclear waste) and integrate this into policy advice and political processes (e.g. output of engagement should be part of decision-making). This also means managing expectations towards engagement, which come from various sides (political, citizens, experts). The emerging and even institutionalization of engagement within the German context means that TA has to widen itself to include different forms beyond parliamentary advice. As the descriptions above show, TA in Germany does seem to be becoming more transdisciplinary and even initiating processes of transformation.

[95] Own translation.

Global TA

From a national perspective, the established form of TA in Germany is well-fit for the specific political system. It provides advice on numerous S&T developments with societal issues, often has a clear addressee (national parliament) and incorporates different kinds of knowledge (e.g. expert or lay perspectives). As a country with a representative democracy, Germany requires this form of TA, which may include insights or recommendations from citizens, but leaves the decision-making up to political representatives. As described above, this is partly shifting towards more co-creation forms with real-world laboratories and transformative research. This goes along with wider demands for more engagement in the policy setting, also in terms of S&T. In this way, the national characteristics of TA are changing and becoming, at least to a certain degree, more inclusive. A basic non-negotiable value of this is the right of the individual also in connection with democracy. Therefore, mediation such as bridge building or blockade running is a basic characteristic of TA in Germany. Activities surrounding building trust, creating platforms or providing neutral ground for dialogues are key to this role of TA, which is part of a democratic society accustomed to forms of public debate, with a lively civil society as well as citizens. In turn, this would probably be non-negotiable as it forms the value-basis of the political culture in Germany. Even if we can (currently) find movements questioning these standards and polices which are pushed through without public approval (or only by some groups), they remain the benchmark and provide orientation. This role of mediation may be more difficult in other countries with strong top-down structures or a marginal civil society.

As the description above shows, Germany has an established and experienced form of TA, which includes research, networking and advice and which can serve as orientation for a global TA approach. Raising knowledge for the importance of TA as a means to make more robust decisions in accordance with society's needs and responsive to specific stakeholders is a key role for German TA in the global arena. This of course does not come without difficulties, which may also result in disagreements on the appropriate methodology, e.g. forms of engagement. Therefore, when thinking about a global TA form, it is important to take into account the national specificities regarding certain technological developments as well as the more general framing of issues. As we have seen from the above, S&T priorities are based on certain values. This is also the case for TA, next to the framing of the political system surrounding it. Therefore, TA may vary not only due to different political, but according to value systems. In this way, a global approach would also include the consistent negotiation of specific TA approaches regarding a technology in each country and how this can be scaled up to a global level. Further, it would also mean a continuous self-reflection of TA and its methods, through the international level, the national must also adapt. This should include mutual learning, for example decentral or low-tech solutions or best practices as applied in some countries for specific needs may also be an option for the German context. A widening of options through the global context would enhance the self-reflection capabilities of a national TA; even a well-established one. This can form the basis of an evolving of German TA, which can take up methodological and reflexive adjustments to an ever-changing national and international context. These aspects are taken up in section 7.1 regarding recommendations for TA in Germany and include mutual learning, expanding transformation processes or finding ways of more meaningful engagement.

This section aimed to give an overview of TA activities in Germany. As an established process, German TA can provide insights into different methods (such as participatory or parliamentary

TA) and how overall it can be located within the political system. Key S&T documents show the need from the policy side for advice that incorporates various perspectives. Newer forms of TA as part of transformation processes are emerging and leading to a widening of the practices of TA. This creates a situation of TA in Germany which on the one hand has wide experiences, but on the other has to take up current challenges. Further, TA should reflect on its changing roles in the national context, which also becomes possible through the global level.

5.2 Technology Assessment in China[96]

This section aims to give insights into the socio-political landscape of China focusing on S&T developments and the main governmental structures and documents surrounding these. The largest population worldwide, rapid economic growth and advancements in education, food safety or science provide an interesting setting for how S&T are understood in China and what possible contributions of TA could be. A political top down structure, emphasis on progress and affluence, but at the same time harmony, peace and safety make up characteristics of China that can give insights into how TA can be adapted within this unique context, also regarding potentials of ethics and engagement. Certain tensions between rapid growth, a limited civil society and an emerging awareness of the importance of public opinion regarding S&T arise and provide a useful example for how TA could work in such a setting. The analysis of documents as well as fourteen interviews with key actors in S&T policy and TA in China give insights into the current status as well as the potentials of establishing TA further. This in turn can also provide input for a global TA, which should be able to take different socio-political settings into account.

5.2.1 Overall Chinese Setting

The People's Republic of China is the largest populated country in the world, with around 1.4 billion people[97] and is located in East Asia. The capital is Beijing; the largest city is Shanghai. It is a unitary republic and is governed by the Communist Party of China in 22 provinces, five autonomous regions, four municipalities and special administrative regions (Hong Kong and Macau). Economic reforms in the late 1970s resulted in rapid economic growth, China is the second largest economy by nominal GDP (an estimated $11.938 trillion in 2017) and the largest worldwide by purchasing power parity ($23.122 trillion).[98] This has led to the development of a middle-class of about 300 million and to China having the world's second highest number of billionaires[99]. Since 2010 94% of the Chinese population over 15 years is literate, as a comparison in 1949 only 20% of the population could read[100]. Connected to these economic strides is the development of science and technology. In recent years China has widely invested in S&T, in 2012 it spent $163 billion[101], in 2016 $233 billion, about 2.1% of the GDP[102]. The country is second in the number of scientific publications and first in PhD engineers. Overall, S&T is an

[96] Parts of this chapter have been published under the title "Technology Assessment in China" (Hahn et al. 2019).

[97] https://esa.un.org/unpd/wpp/DataQuery/

[98] http://www.imf.org/external/pubs/ft/weo/2017/02/weodata/weorept.aspx?pr.x=89&pr.y=14&sy=2016&ey=2018&scsm=1&ssd=1&sort=country&ds=.&br=1&c=924&s=NGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC&grp=0&a=

[99] https://en.wikipedia.org/wiki/China#cite_note-BBERG10012014-382

[100] https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=CN

[101] https://www.bloomberg.com/news/articles/2014-10-01/chinas-163-billion-r-and-d-budget

[102] http://english.cas.cn/newsroom/china_research/201710/t20171020_184378.shtml

important part of national identity and integral part of achieving economic and political goals. These vast developments, economically and socially, provide an interesting setting regarding how S&T policies are made. China has changed rapidly over the last decades and S&T have been an essential part of this. In the following the structures and values surrounding this will be described. This will lead the way to a description of current TA practices in China in the context of engagement and ethics, their location as well as what future needs could be.

When trying to understand the S&T policies of a certain country and the structures of assessment and advice surrounding them, it seems useful to start by looking at the most basic or general level of values and principles, as these provide the backbone of any governmental decision. A country's Constitution provides these general values and ethics that in turn shape decisions. These are common values that a specific society agrees upon and bases its decisions on: such as foreign or domestic policies, decisions on support of education or the arts, as well as S&T funding. We can state that as "the primary law of state, a constitution is the fundamental rule for reining in state behaviour and regulating regulations between the state and its people […] values reflected in the constitution are codified in the form of primary law and offer important guidance for making laws and policies" (Ma et al. 2015: 73). Therefore, if we want to understand the general policy setting of a country such as China this is a useful point of departure. Of course, constitutions are at the same time a product of past value systems and cultures and build on these historical influences. In this sense, looking at the Chinese context it seems important to take historical changes into consideration. Here, mainly three influences regarding current values can be identified: "traditional Chinese values, Western values imported since 1840, and new values grown in contemporary Chinese society" (ibid.: 75). The traditional Chinese values are influenced by the culture of Confucianism-Buddhism-Taoism, which focuses on the individual as the basis of judgements and extends this to a wider scope (e.g. to the family, to the state, even the entire world). This takes the value system from the individual and extends it to community. The effects of such a Confucian thinking on TA and are discussed in detail in section 6.2.2. Modernization on a global level made it steadily possible for Western values to come to China, including an affinity for Western S&T, ideas of freedom, equality, or prosperity as well as "concepts of rights and legal awareness has taken root in Chinese society and constitutes an important criterion for value judgements by the public" (ibid.: 75). In contemporary China, a socialist market economy has created new conditions which also bring about new values. These are somewhat conflicting between socialist ideals of common prosperity and harmony and market-oriented principals of individual success and competition, yet they also have a common denominator of economic development. Further, the values surrounding the concept of sustainable development have also had influence. This is described the context of the Chinese Constitution and the values conveyed in it. Beginning with the depiction in Article 1, the Constitution describes that "The People's Republic of China is a socialist state under the people's democratic dictatorship led by the working class and based on the alliance of workers and peasants". The socialist economic system is based on the idea that "socialist public ownership of the means of production, namely, ownership by the whole people and collective ownership by the working people" (Article 6). Article 7 describes that the "State-owned economy, that is, the socialist economy under ownership by the whole people, is the leading force in the national economy". This relates to the traditional values of collectivity described above, in the sense that this socialist approach puts the collective interests of society at its center moving past limits of individuals.

These main values showing in the Chinese Constitution can be described as: progress, affluence, peace and safety as well as harmony. Progress towards a higher stage (e.g. from capitalist to socialist to communist society) has a key position in the Constitution, finding its expression in Article 14: "The state continuously raises labor productivity, improves economic results and develops the productive forces by enhancing the enthusiasm of the working people, raising the level of their technical skill, disseminating advanced science and technology, improving the systems of economic administration and enterprise operation and management, instituting the socialist system of responsibility in various forms and improving organization of work". Here we see a close connection between economic and educational progress and the well-being of society as a whole. Further the importance of S&T in the context of progress is emphasized. In order "to improve productivity and the development of productive forces in society, it is necessary to popularize knowledge of and skills in advanced science and technology […] enthusiasm and support for scientific progress serve as manifestations of the importance of this concept of value" (Ma et al. 2015: 77). Affluence is a further important value represented in the Constitution, especially regarding modernization and advances in industry, agriculture, defense, education, S&T. Here the connection is made between development in these areas and overall improved living standards for citizens as well as Chinese independence and self-reliance. Article 20 states that: "The state promotes the development of the natural and social sciences, disseminates scientific and technical knowledge, and commends and rewards achievements in scientific research as well as technological discoveries and inventions". The connection between affluence, the well-being of society, S&T and innovation can be seen in the focus on strengthening indigenous capabilities. The values of peace and safety have a longstanding tradition in Chinese society, giving an importance to citizens' health in the constitution (e.g. Article 21). Harmony in the sense of a coexistence of humans and nature gives issues of sustainability an important role ("The state protects and improves the living environment and the ecological environment", Article 26). This is also extended to a harmonious society, as Ma et al. describe a speech given by then president of China Hu Jintao. The characteristic of a society in harmony include: "democracy and the rule of law, fairness and justice, integrity and friendliness, vigour and drive, peace and order, and harmony between man and nature" (2015: 79). With rapid economic development in China, this can be problematic especially regarding environmental issues, yet at the same time the values around harmony frame the reactions to these challenges. These values are the frame in which the Constitution can be understood and which form its basis. They also provide the foundation of policy decisions made by the government as well as how these decisions are regarded by society as a whole. In the context of S&T, "Progress, affluence, peace and safety, and harmony are the four values identified in the Chinese Constitutions that relate to people's ethical considerations of science and technology development" (Zhao and Liao 2016: 80) and therefore form important reference points.

As we see, the Constitution shows the main values and emphasizes what China as a country stands for, politically and culturally. Regarding the recent rise of China as a global actor, the economy, is also of main significance here. This again relates to S&T developments. China has emerged as a major player in the world economy expanding by an average of 10% a year over the last decades, rising as a major exporter and increasing its income per capita. "China's "open door" policy has been an integral part of economic reform. Adopted in 1978, it has resulted in a progressive opening to foreign trade and investment and culminated in China's accession to the World Trade Organization (WTO) in 2001. Through its acceptance of globalisation, China has

become the most open of the large developing economies. In some respects, China today is more open than a number of significantly more developed market-based economies" (OECD 2007: 11). Overall, the Chinese economy has gone from an agricultural to a service one, based largely on manufacturing. Regarding S&T, "China has relied heavily on technology imported from abroad, and the development of its scientific and technological capability has until recently lagged behind its economic growth. This trend was reversed towards the end of the last decade and since then significant progress has been made towards developing the country's innovative capabilities" (ibid.: 9). The close connection between the economic development and strives in S&T and innovation is not only limited to the Chinese context. Often S&T policies are closely connected to the aims of pushing S&T developments, coming to more innovations and eventually achieving more economic growth. Together with the decision to reform the economic system, "institutional reform of the S&T system was launched in 1985. The primary goal was to overcome the separation of R&D from industrial activity, the key shortcoming of the pre-reform S&T system [...] These reforms gradually enhanced the economic orientation of the S&T system by introducing elements of competition and market discipline. Major institutional innovations have included the establishment of a variety of government R&D programmes, the emergence of markets for technology and of non-governmental technology enterprises" (ibid.: 44). We see here the close ties between economic goals and corresponding S&T policies.

Regarding the economic development in China, a newer discussion has emerged taking into account the quality of growth, not only the quantity. This so-called "new normal" of development as coined by China's President Xi Jinping mainly regards economic changes. The basic idea is that economic development will enter a new phase of more sustainable growth moving towards a service industry with consumption becoming the main source of demand. Under this new normal the Chinese economy will be oriented towards an innovation-driven model, instead of a production-driven one. Further, the gap between urban and rural areas will decrease, raising people's income and its share of the national economy. In this setting, technological innovations play a vital role (邓京荆 2015). Reforms on a wide range towards the new normal are aimed at the challenges that have emerged through the old model of growth. This did help lift many Chinese out of poverty, but "has also produced various undesirable social impacts that are adding to pressures for reform. Most prominently, it led to growing inequalities of different kinds. Rapid urbanisation and urban economic growth, combined with China's restrictive residential registration (hukou) system, which inhibits internal labour flows, has led to rising urban-rural inequality and social divisions […]. There has also been growing inequality between regions, as the growth was disproportionately concentrated in the eastern coastal cities" (Green and Stern 2015: 8). In a speech given at the CPC Central Committee at its Third Plenum in November 2013, "[President] Xi was blunt about the challenges China faces: a mode of development that is "unbalanced, uncoordinated and unsustainable" […]; an increase in "social contradictions"; and a "severe" struggle to contain corruption. Public expectations of reform were "high", he said. "We absolutely must not waver". Mr Xi said it was impossible that all reforms proceed smoothly, without risk: "Things that we have to do, we have to do with courage." (Anonymous 16.11.13). This quote shows the high pressure for government to act and also to rethink how economic development and, with it S&T development is understood and enacted in China. It also shows the understanding that "[g]rowth in and of itself was no longer enough" (Zhang and Barr 2013: 135). The new normal attempts structural changes that attain strong, but lower economic growth, which is qualitatively better regarding social distributions

and environmental aspects. In this way, the new normal "places a strong emphasis on: shifting the balance of growth away from heavy-industrial investment and toward domestic consumption, particularly of *services; innovation*, as a means of raising productivity and climbing up the global value chain; reducing *inequalities*, especially urban–rural and regional inequalities; and environmental *sustainability*, emphasising reductions in air pollution and other forms of local environmental damage, as well as in GHG emissions" (Green and Stern 2015: 3).

Concerning S&T policy as well as TA-like activities, this new normal development is interesting as it shows a change towards an approach which is concerned with how growth takes place and what this could mean for society. Even though the arguments remain mostly economic (e.g. lowering economic growth to about 7% per year), stressing the quality of growth also means reflecting on what S&T developments or innovations mean for society. This adds a certain normative level to decisions and potentially how S&T policies are made. It also potentially increases the need for assessments that go further to include societal aspects, which in turn require the inclusion of a wider level of stakeholders.

5.2.2 Science and Technology Policy Setting

Policies regarding S&T can be understood as "the collective measures taken by a government in order to encourage the development of scientific and technical research and to exploit the results for general political objectives" (Zhu 2009: 66). This reflects in the way the Chinese government, as many others do, connects the development or well-being of society or principles found in the constitution to the advances made in S&T. Economic prosperity, ecological sustainability or well-being of citizens is tied to S&T or innovation capacities. Therefore, it is one of the main responsibilities of the state to develop policies to support this. Progress, affluence, peace and safety as well as harmony are goals for Chinese society and in turn shape the policies of the government and their legitimization. It is in this context that S&T policies and strives for becoming a more innovative society are formed and realized. As mentioned above, we find connections made between main societal goals, S&T and innovation as well as the connection to the overall aim of economic development. "China's re-emergence as a major power in the world economy is one of the most significant developments in modern history" (OECD 2007: 9). In China, there have been substantial developments regarding the economy as well as S&T; increasing the income per capita, reducing poverty, economic performances as well as investment of foreign capital. Yet many societal challenges remain: "China's GDP is unevenly distributed, particularly between the wealthier coastal provinces and the less developed western parts of the country; in fact, income disparities between urban and rural areas have increased. In a number of rural areas, poverty remains a serious challenge [...]. China is undergoing a fundamental demographic change, owing to a rapidly ageing population. It may be difficult to maintain its current high savings rate as the population ages, and indeed – in contrast to the developed world – China might be ageing before getting rich. [...] China's export growth has been largely based on the expansion of low-wage manufacturing utilising imported components, equipment and technology. [...] Large migration flows have contributed to rapid urbanisation and exert pressure on the social fabric and the environment. [...] China's economic growth has induced high demand for energy and raw materials" (ibid.: 15). We see a range of issues, such as wealth distribution, sustainability or demographic change, which also require (direct) developments and innovation in S&T. For the government, these societal challenges

make S&T policies necessary: “The Chinese authorities are well aware of these challenges and – through concepts such as the “harmonious society” – have taken steps to achieve a more balanced pattern of development. Science, technology and innovation can contribute significantly to this objective” (ibid.: 16). Overall, innovation policies include S&T policies as an essential part, also in China: “According to the current understanding of China’s innovation policy makers, S&T policy is the starting point of innovation policies, aiming at establishing and nurturing an institutional arrangement that facilitates S&T progress and innovation. It includes laws, regulations, guidelines, and codes of conduct for S&T activities as well as strategies, plans, and programs” (Liu et al. 2011: 918).

It also seems that the Chinese innovation and S&T system is now approached in a more nuanced way: “In contemporary economic thinking, an innovation system is defined as the purposeful combination of market and non-market mechanisms to optimise the production, deployment and use of new knowledge for sustainable growth, through institutionalised processes in the public and private sector. Not so long ago it would have been hard to talk about China’s innovation system from this narrower but more precise perspective” (OECD 2007: 21). This is also based on a change in China’s economic system, which comes from “having sustained a fairly long period of rapid economic growth, [which] has transformed [China] from a planning to market-oriented economy” (Liu et al. 2011: 918). This is based substantially on innovation and S&T developments and the corresponding policies. As is often the case, economic development or growth is tied to the developments in S&T and innovation. As the leader of People’s Republic of China from 1978 to 1989, “Deng [Xiaoping] developed guidelines, including ‘‘Science-technology is the first productive force, knowledge and talent shall be respected.’’ For the first time in China’s history, science and technology were viewed as driving force behind economic development” (Song 2008: 236). Historically, certain evolution points can be identified that have changed innovation and S&T policies. These can be pinpointed at national S&T conferences (Table 4), which show changes from the identification of the importance of S&T as a productive force to reform of the S&T system, to revitalization through S&T and to the aim of turning China into an “innovation-oriented country” stressing the role of indigenous innovation.

Table 4: China's National S&T Conferences (Liu et al. 2011: 920)

China's national science and technology conferences.

Time	Name	Significance
March 1978	National Science Conference	Deng Xiaoping brought forward the famous thesis that S&T is a productive force, intellectuals are part of the working class, and S&T is the key to China's "Four Modernizations" drive
March 1985	National Science and Technology Working Conference	Deng Xiaoping made an important speech "The Reform of the S&T System Is to Liberate the Productive Force." CCPCC issued the "Decision on the Reforms of the S&T System." Afterwards, China pulled off the reform prologue of the S&T system and set the main task to enhance the economic orientation of the S&T system
May 1995	National Science and Technology Conference	The strategy of "revitalizing the nation through the science, technology and education" (*kejiao xingguo*) was put forwarded and CCPCC issued the "Decision on Accelerating the Progress of Science and Technology," advocating that economic development should rely on the progress of S&T
August 1999	National Conference on Technological Innovation	CCPCC and the State Council issued the "Decision on Strengthening the Technological Innovation, Developing the High Technology and Realizing Industrialization," calling for the construction of a national innovation system and speeding-up of the industrialization of the S&T achievements
January 2006	National Science and Technology Conference	CCPCC and the State Council issued "Medium- and Long-Term Plan for the Development of Science and Technology (2006–2020)" (MLP) to turn China into an "innovation-oriented country" by 2020 through building an indigenous innovation capability

Currently the "Medium- and Long-Term Plan for the Development of Science and Technology (MLP) (2006-2020) is a main part of S&T policies in China. Within the various policies of the MLP, "37 can be placed in the S&T policy category, accounting for 46.8% of the total. This suggests that even within the high profile MLP, one of the key problems facing China's innovation programs – the centrality of S&T policy as the principal instrument for driving China's innovation agenda – has not been resolved" (Liu et al. 2011: 927). In detail, the MLP takes investments in S&T into account: "such as the 863 Program, the State Basic Research and Development Program, also known as the 973 Program, and the State Key Technologies R&D Program, all under MOST" (ibid.: 927). Further, talent and education are important parts of encouraging S&T advances and innovation. Main aims of the MLP are "developing capabilities for "indigenous

innovation" […] and to leapfrog into leading positions in new science-based industries by the end of the plan period. According to the MLP, China will invest 2.5% of its increasing gross domestic product in R&D by 2020, up from 1.34% in 2005; raise the contributions to economic growth from technological advance to more than 60%; and limit its dependence on imported technology to no more than 30%" (Cao et al. 2006: 38). The MLP is meant to reach several strategic objectives: "Building an innovation-based economy by fostering indigenous innovation capability […] Fostering an enterprise-centred technology innovation system and enhancing the innovation capabilities of Chinese firms […] Achieving major breakthroughs in targeted strategic areas of technological development and basic research" (OECD 2007: 48).

Overall, the MLP marked a change towards more integrated policies, so from individual and separate initiatives to the combination of S&T policies with financial, tax as well as fiscal ones. In this way, the MLP "was supposed to tackle the other biggest problem facing China's innovation policies – the lack of adequate coordination in the area of policy implementation" (Liu et al. 2011: 927). The MLP also marks an important point in changes within the bureaucratic system in China. It shows a "level of bureaucratic mobilization across multiple ministries that are not often easy to achieve even under the best of circumstances. Moreover, because the organizational culture and operating environment within each of the ministerial organizations is quite different in some key respects, any mobilization push has to take into the account the high degree of heterogeneity that exists across the Chinese bureaucratic structure" (ibid.: 928). Even the planning preparations showed a shift towards a more open approach at least in the beginning by "includ[ing] social scientists (mainly economists) and foreign scholars. Eventually, that openness gave way to a more secretive process in which the bureaucracy massaged the reports of the 20 working groups, attempted to reach compromises, and drafted the public version of the MLP" (Cao et al. 2006: 38). The focus on the importance of national innovation represents an awareness within the MLP which understands indigenous innovation "as having three components: genuinely original innovation; integrated innovation, the fusing together of existing technologies in new ways; and "reinnovation," which involves the assimilation and improvement of imported technologies" (ibid.: 40). This is based on the situation that China heavily relies on import of foreign technologies, which were meant to modernize the economy. Problematic is that important technologies remain in the hands of foreign partners and it seems that there is the "perception that technology transfer to China and related spillovers to the domestic economy have not met expectations" (OECD 2007: 12). The fast growth and progress in China has not yet transferred into innovation performance and capabilities and often these innovation advances remain limited to specific regions especially pushed for this. It seems that Chinese leaders have become more and more aware of this, "that those who own the intellectual property, and who control technical standards, enjoy privileged positions in, and profit most from, international production networks" (Cao et al. 2006: 39). In a situation of global competition and exchange this helps explain why the focus on indigenous or home-grown innovation to become an innovative society is so high in the MLP.

Overall, the Chinese Communist Party (CCP) has the final word in innovation and S&T polices as the overall authority in major political, economic and societal decisions. Even though the CCP's direct participation in S&T issues has gone down since the Cultural Revolution as well as after

the reforms of the 1980s[103] it still remains the main influence, "the reality [is] that China still remains largely a centrally controlled system with most policies formulated and executed from the top to down" (Liu et al. 2011: 918). We do find statements pointing to a certain degree of opening-up of the decision making processes, as Wang Yuan of The Chinese Academy of Science and Technology for Development mentions in an interview: "The participation of experts and think tanks in policy development and implementation is a symbol of the democratisation of governmental decision making in China" (International Innovation: 3). The Central Committee of the CCP creates innovation policies and through "leading groups" it can achieve impact as well. Such a group is "set up within the State Council to tackle issues involving more than one government agency; it usually is chaired by the premier or a vice premier who is likely to be a member of CCPCC [Chinese Communist Party Central Committee] Politburo or even its Standing Committee, China's de facto governing body. Its key function is to mobilize resources and coordinate efforts across the bureaucracy" (Liu et al. 2011: 920). This way, the CCP doesn't pass laws directly, but influences policy-making through indirect ways. Any major initiative is reviewed by a senior party official before given to the National People's Congress (NPC) for legislative deliberation or to the State Council and ministries for further specification and implementation. We find different "grades" of policies and as Liu et al. write: "According to our understanding of the workings of the Chinese policy-making apparatus, a CCPCC document is the most authoritative and supposedly most influential, impactful, and effective; it is followed by a law enacted by NPC, an administrative statute formulated by the State Council, and a regulation issued by the respective ministries under the State Council" (2011: 923).

This also shows why the effectiveness of policies depends highly on the political position of the organizations within the bureaucratic system, "the most strategically important initiatives related to S&T and innovation have all been launched by the CCP Central Committee" (ibid.: 929). Figure 5 shows the key actors in the R&D system and regarding S&T in China[104]. At the top we find the State Council as the main authority, followed by the State Science and Education Group which is an inter-ministry institution which serves as a coordinator, for example for the Premier of the State Council to coordinate S&T policies (Zhu 2009: 69).

[103] In 1985 a "Decision on the Reform of S&T System" was issued aimed at reforming the management system of S&T to align it better with the economy (Liu et al. 2011: 920).

[104] For a detailed account of the individual roles see Zhu (2009).

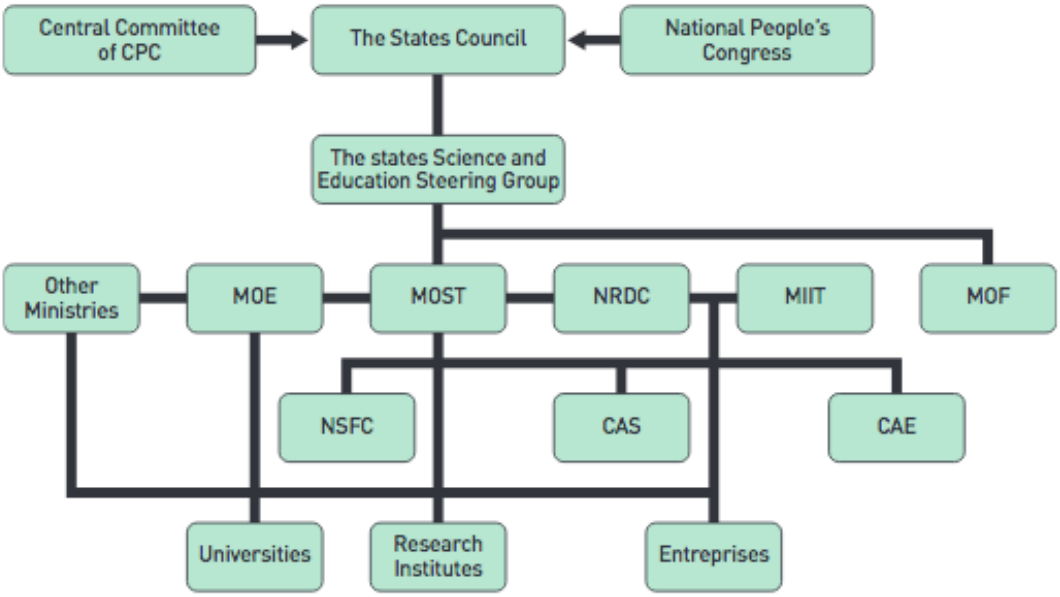

Figure 5: The Main Elements of China's Central Government's R&D System (Zhu 2009: 68)

S&T policy-making in China is part of the bureaucratic system, which formulates and implements policies in general. S&T policies, like others, take shape through the interactions between scientific and political institutions, in which actors from the legislative, the government, advisory bodies, conducting or funding organizations all play a role. The parliament and the highest level of state power, the National People's Congress (NPC) by use of the Standing Committee and the Committee on Science, Technology, Education and Health "has the authority to draft, enact, and amend S&T-related laws, which usually are drafted by a specific government ministry. Technically speaking, NPC also monitors the implementation of such laws and approves the state budget for science and technology affairs. Members of the Chinese People's Political Consultative Conference (CPPCC), an advisory body, many being non-Chinese Communist Party (CCP) member scientists and engineers, also voice their expert opinions and comments" (Liu et al. 2011: 919). In the center of the S&T government enterprise in China is the Ministry of Science and Technology (MOST), which conducts national S&T programs, including basic and applied research, commercialization of S&T, backing of innovation within companies as well as support of science parks and incubators (ibid.: 919). Correspondingly, the mission of the Ministry reads: "MOST takes the lead in drawing up S&T development plans and policies, drafting related laws, regulations and department rules, and guaranteeing the implementation […] MOST aims to serve socio-economic growth by coordinating basic research, frontier technology research, research on social service, key technology and common technology."[105] Here we again find close ties between S&T developments and economic growth.

A further important actor is the Chinese Academy of Sciences (CAS), which plays a large advisory role regarding S&T policy-making through academics providing services for decision making. CAS is active in "research, high-tech development, technology transfer, and training" (ibid.: 920). In its own mission CAS understands itself as "the linchpin of China's drive to explore and harness

[105] http://www.most.gov.cn/eng/organization/Mission/index.htm

high technology and the natural sciences for the benefit of China and the world […] Since its founding, CAS has fulfilled multiple roles — as a national team and a locomotive driving national technological innovation, a pioneer in supporting nationwide S&T development, a think tank delivering S&T advice and a community for training young S&T talent"[106]. CAS sees itself as driver for indigenous innovation and S&T developments in China as well as taking on an advisory role for policies in these areas.

A further central player is the National Natural Science Foundation of China (NSFC), which "mainly supports basic research and mission-oriented research projects through competitive and peer review processes" (ibid.: 920). The NSFC is the institution which administrates the National Natural Science Fund for the Central Government, "supporting basic research, fostering talented researchers, developing international cooperation and promoting socioeconomic development"[107] The administrative system in NSFC aims to improve decision-making in funding policy and implements as well as monitor and consult. Also here we find connections made between economic developments for society and the importance of S&T for this. Another important actors, the Chinese Association for Science and Technology (CAST) can be regarded as an umbrella organization made up of various academic and professional societies (Zhu 2009: 72). It understands itself as the "largest national non-governmental organization of scientific and technological workers in China, which also serves as the bridge that links the Communist Party of China and the Chinese government to the country's science and technology community"[108]. The societies of CAST (over 200) spread throughout China and allow for a wide network in the area of S&T. Overall, CAST is an important player in driving Chinese S&T development and has participated in shaping policies and regulations through its networks of scientists, engineers and other people working in S&T (ibid.: 72). Close ties to policy and decision making are provided by the constituent membership of CAST in the CPPCC. In its mission statement CAST describes itself as an organization aimed at developing S&T in China, opening S&T up to a wider public as well as providing advice for the overall S&T strategies: "CAST devotes itself to boosting the development of science and technology in China and enhancing science literacy of the whole nation, organizes and encourages scientists and engineers of the country […] to conduct academic exchange, science popularization and scientific and technological consulting and other activities according to the country's science and technology development strategy, accelerate the emergence of scientific and technological talents, voice the opinions of science and technology professionals and firmly safeguards their legitimate rights"[109]. Again we see here the alignment between strives in S&T and the development of China as well as communication and promotion of S&T in different areas. These organizations derive their legitimacy and standing from their activities for enhancing the development of S&T in China as a way to support the development of the country as a whole. In this way, we find close links between the self-understanding of these organizations and the well-being and development of China.

The Chinese Academy of Science and technology for Development (CASTED), which is part of MOST is a key actor in providing policy advice for S&T and also shows the growing importance

[106] http://english.cas.cn/about_us/introduction/201501/t20150114_135284.shtml
[107] http://www.nsfc.gov.cn/Portals/1/fj/pdf/01-01.pdf
[108] http://english.cast.org.cn/n1181872/n1257426/16297382.html
[109] http://english.cast.org.cn/n1181872/n1257426/16297382.html

of these activities in China. CASTED's "establishment was approved by the State Council and Mr Deng Xiaoping, the master architect of China's reforms, inscribed the name for the newly established research center [in 1982]. This should be seen as the beginning of government efforts to establish a systemic advice and consultation system" (Zuh 2009: 77). CASTED contributes to decision making by participating in the "formulation of all important national S&T strategies and plans, and has played crucial consultation and support roles for our S&T development" (International Innovation: 1). CASTED focuses on development of an innovative society, improvement of innovation capacities as well as providing advice for a macro decision making level regarding S&T development. This also includes the societal level of S&T developments, "taking into consideration social needs and realities" (ibid.). Key aims include providing studies and suggestions for the design of national S&T development strategies, conducting research for central and local government departments supporting national strategic decision making and policy, development of a core S&T strategy talent team as well as setting up an exchange platform to connect different research resources, networking international and national research[110]. As the then executive vice president Wang Yuan states: "CASTED actively carries out research to promote harmonious development between science, technology and society" (International Innovation: 2). Further, the academic set up of CASTED, ranging from natural sciences, engineering, economics or sociology reflects an interdisciplinary approach needed for assessing S&T and providing advice. CASTED is made up of various institutes with one explicitly focusing on the relationship of S&T and society. The Institute of Science, Technology and Society at CASTED "studies S & T-related social development issues, including social science studies on risk and disaster, social environment of innovation, studies on scientific community, education, employment, non-governmental organization, and frontier issues such as innovation culture, science ethics, and S & T and social inequality"[111]. Further, it assesses the social impact of S&T projects and gives policy advice also on sustainable development. These characteristics of CASTED show a close relation to TA or TA-like activities. Examples for TA-like activities include a national soft science program, which established an open exchange and stakeholder communication platform enabling debates on policy issues and expanding the consultation process. Also worth mentioning is the Wenchuan rapid assessment survey, which conducted a wide field survey on the people affected after an earthquake in the Wenchuan County in 2008. Needs assessments by direct participation of the local people were done and the findings were taken into account for the reconstruction plans. A foresight project on high-tech industries in China aimed at examining different fields of technology, which are of importance to social and economic development in China. Socioeconomic needs were analyzed, surveys on stakeholder opinions were undertaken and a comprehensive investigation on the benefits and problems was conducted. This wide consultation and the focus on societal needs were unique parts of the foresight project, which helped identify national priorities and crucial developments (Zhu 2009: 79ff.).

Overall, the S&T policy and decision structure in China is entangled in the bureaucratic system which in turn reflects the broader political foundation, as possibly in any given country. The way policy decisions are made reflects this, as "China's political system is not founded on the bases of separation of powers as it is the case with its western counterparts. S&T policies are mainly initiated and implemented by the executive branch (the State Council as well as its constituent

[110] http://2015.casted.org.cn/en/web.php?ChannelID=65

[111] http://2015.casted.org.cn/en/web.php?ChannelID=67

ministries and agencies)" (ibid.: 66–67). And even though we find, as described above, certain moves towards more comprehensive assessments and advice also regarding the societal impacts of S&T, it seems there are still underdeveloped aspects, such as public participation or wider ethical considerations[112]. Yet, it also seems that these issues, ethics and engagement, can be key parts for actually establishing TA-like structures in the Chinese context, which ultimately should help include the societal dimensions of S&T: "Societal perspectives are becoming more prominent in the construction of advice [in China], both indirectly, through the increasing involvement of social sciences in the decision-making process, and directly, through public surveys that are used as barometers of public perceptions in S&T issues" (Ladikas 2009: 129). Next to the broader demands for more ethics and engagement, concrete solutions are given by Zhu (2009) to establish policy-advisory structures in the Chinese context. For example, a State-level coordination mechanism such as a cabinet-level National Science and Technology Council made up of ministers, experts and industry representatives should be established. This would enable a steering of R&D strategies and coordination of all S&T policies (ibid.: 85). Also, the advertising of an institutionalized S&T policy advice system is important. This could be done by MOST coordinating the national R&D programs and providing S&T policy advice to other ministries on an executive level, which could prevent S&T policy advice succumbing to "the discretion of rigid, bureaucratic systems" (ibid.: 85). A further suggestion is the establishment of a high-level National Advisory Council for S&T with a chief science advisor appointed by the prime minister and located at MOST (ibid.: 85).

It seems there is a growing awareness from the political, but also from the side of researchers and experts providing advice, that some form of more established policy advice structure regarding the wider implications of S&T is needed in China. This goes further than assessing economic (indigenous) innovation potentials of companies or regulating how technologies are imported into China. It extends to the societal level of S&T developments and which effects (intended or unintended) these, often rapid, developments may have on Chinese society. The opening-up of China regarding economic development or the current new normal phase show a move towards an increased need for S&T policy advice, in correspondence with the societal challenges that continue to arise. Within any government attempting to develop and implement useful policies, which are geared towards wider society goals (e.g. economic well-being, sustainability) some forms of policy advice are needed. This is especially the case regarding S&T and innovation since within modern societies these have ever-growing effects on people's lives or the environment. And as described in other parts of this thesis, the global effects of S&T are a further aspect in need of some form of assessment. In China, the advisory structures for S&T are less well established than, for example, in Germany. There are institutions like MOST (including CASTED) or CAS which do function as policy advisors on different levels but their roles as advisors within the decision-making process remain unclear and debated. Yet, "there appears to be a clear political will to bring science and society closer together and avoid the pitfalls of diminishing public trust in science that are evident in Europe" (Ladikas 2009: 129), which would include a form of more systematic advice. As the descriptions above show, there is a certain tension between an inherited 'planning culture' verses the awareness that achievements in S&T developments or innovation need a certain degree of openness, decentralization and exchange

[112] Zhu (2009: 86) gives the example of misconduct of researchers, which isn't merely solved by regulations. Ideally, there needs to be an increased awareness and ethical sensibility of researchers as well as the institutionalization of values.

and further that the assessment of S&T requires a wider scope including stakeholders or the public. Overall, it seems that the relationship between S&T and society in China is largely influenced by discourses that stress "Innovation-driven development strategy; Mass entrepreneurship and innovation; Supply-side reform" (Zhao and Liao 2016: 1). In their account of Responsible Research and Innovation, which we have seen has similar aspects like TA (section 3.2) for the Chinese context, Zhao and Liao describe that in "China the [RRI] ideas of innovation *for* society has a long tradition in policy, whereas innovation *with* society has shown only in recent years and remains novel. This can be traced back to characteristics of S&T management in China that are shaped by developmentalism, scientism and top-down management" (ibid.: 2).

In the context of developmentalism the idea of S&T policy serving economic development is often stressed since economic growth is the prime goal as described above. A 2010 Chinese study on the public perception of Science shows that "89% of the Chinese agreed that Science and Technology will make our lives healthier and more comfortable"[113] (ibid.: 3). This strong belief in S&T or scientism can be found among the public as well as the government and coincides with the idea of S&T bringing economic and also social development. Also connected to this is the top-down management system of policy-making in China. Here, the government plays the main role in making decisions and policies, resulting in a comparatively weak public. Therefore, public engagement in S&T decisions is still rare. Yet, "the rapid social transition in China has led to a series of changes in the attitudes towards and behavior related to responsibility of innovation of various stakeholders, including public, scientific community, enterprises and government" (ibid.: 4). There are still strong 'traditional' discourses and structures that continue to shape S&T policy-making in China, yet it also appears there is an opening-up and an awareness that changes towards more institutionalized forms of advice (e.g. TA), quality of growth as well as wider inclusion are needed.

5.2.3 Values and Science and Technology

As discussed in chapter 4 of this thesis, ethics and engagement can be starting points for examining how S&T debates in society take place. They are also common denominators that form a basis for examination of these debates in different countries and both are central to TA. They connect the basic values of a society from which expectations and goals are formulated and then applied to S&T. Even though they may be more or less pronounced in different contexts, the assumption is that they can be found in all societies with S&T as well as on a global level. Therefore, it can be useful to look at which roles ethics and engagement concerning S&T developments and policies play in the Chinese context, also as a way of understanding better the setting for (potential) TA-like activities. This should have a wider level, not focused mainly on individual committees or offices, but a more general descriptions of how agendas were and are set and which contexts are important for this (Ladikas et al. 2015b: 23; Brom et al. 2015: 17).

Using the definition of ethics given in section 4.1 as a common platform for the deliberation and discussion of societal values which aims to inform policy-making, the tensions described above concerning the top-down, developmentalism and scientism debates and the growing awareness of wider inclusion in decision and policy-making become clearer. In China, it seems that ethical

[113] Compared to the European public in 2010, where only 66% agreed with this statement (European Commission 2010: 32).

considerations are mainly the concern of government or official advisory bodies and that characteristics such as top-down management or the strong belief in S&T tend to hinder public engagement in debates about ethical aspects of S&T developments. From an official side, there is an awareness of the importance of ethical reflection of science as Brom et al. (2015) point out by quoting then Chinese president Jiang Zemin in 2000: "The issue of scientific ethics is going to become more prominent in the 21st century. The bottom line is: advances in science and technology should serve the interests of the man-kind, serve the lofty cause of world peace, development and progress, rather than hurt the human race itself […] To build and improve scientific ethics, respect and protect intellectual property rights, and provide policy guidance for the research and use of science and technology in ways that meet the common interests of people around the world is a major issue to be resolved in the 21st century" (ibid.: 13f.). Here we see a connection made between the challenges of S&T today, the ethical and societal implications this has on science itself as well as society and the resulting need for some form of advice that can help navigate. Yet, it remains open who exactly should provide this advice and more importantly which actors should be or actually can be involved in ethical reflections.

Looking at a specific S&T development and growing challenge, the issue of new food technologies is one in which tensions between ethical aspects and technological progress become apparent. New food technologies are described by Coles et al. (2015: 118) as an area where China feels a need to catch up with developed countries and therefore also generate its own accomplishments (developmentalism), yet at the same time there is (public) concern of GMOs regarding harmfulness of health or the environment. Also the notion of scientism appears here in the sense that "GM foods naturally have political legitimacy and that the aura of science lends scientists and technologies an authority and reputation that tend to foreclose reflection on the legitimacy and social consequence of GM foods, thus endowing them with an automatic correctness" (ibid.: 121). Yet, it seems in China this area is also disputed: "Our society appears surprisingly polarized on genetically modified crops. At one extreme, hardcore proponents claim that GM crops are safe; public opposition is a result of ignorance; and foot-dragging on their commercialization compromises national food security. At the other extreme, die-hard opponents say GM crops are harmful; proponents have hidden agendas; and hurried commercialization threatens our national food chain" (范针 2013). Responding to this, suggestions of more information, in the sense of communicating to the public and raising awareness, informing labels or papers describing the state of research as well as policies seem to reach too short. This is because concerns about GMOs are about food safety or potentially harming nature, but also have a political level, such as the concern of China's independence from American companies regarding supply (Anonymous 2013). This shows the complexity of what at first seems to be merely a technological and supply issue, but then has wider societal implications also regarding country-specific values such as independence (China shouldn't be dependent on the USA), safety (GM foods should not harm people), harmony (food supply for a huge population needed) or affluence (China's wealth also depends on developments in GMOs). This also points to the situation of an increasingly globalized world, in which S&T developments have a wide reach and where GMO developments in one end of the world can have societal effects at the other end.

Regarding the relationship between globalization, S&T and ethical aspects, Zhang (2012) examines the development of stem cell research in China, which "exhibits neither linear

globalization as 'China becoming the West' nor simple glocalization as 'global research with Chinese characteristics'. Rather, it is a cross-border dialectic process in which existing Chinese characteristics are being reiterated and transformed" (2012: 3). This is an interesting case, as it is a much-debated research field with many ethical questions. And it is one in which discussions are often influenced largely by cultural or (as in many European countries) religious aspects. In the field of stem cell research, the scientific practices as well as the roles of researchers are shaped by national (Chinese) factors but at the same time also by discussions of the global scientific and bioethical communities, which forms a "cosmopolitanization of science" (Zhang 2012: 6). This is based on Beck's accounts of how globalization changes political and social contexts from within, a kind of internal globalization leading to non-linear arrangements shaped in dialectic processes (ibid.: 17). At the beginning, stem cell research didn't raise much concern in China, a country with no corresponding debates like the Christian ones in Western countries. Yet, the "publicity of Dolly [the first mammal *cloned]* in 1997 led scientists to call for the development of governmental regulations of biotechnology [...] The acknowledgement of these problems was not based on uneasiness from within Chinese culture but rather in response to ethical concerns first identified in foreign countries. In other words, when different nations import scientific technology, they also import many foreign concerns" (ibid.: 5). Looking at the overall development regarding its economic opening up, globalization and S&T developments in China the study of stem cell research shows the connection between growing international collaborations in science, the drive to become a leader in this area as well as the ethical aspects that are then encouraged. The promotion of scientific good practice and standards of ethical concerns (both internal and external ones) are a part of this cosmopolitanization. On a more general level, this shows that with an increasing global scope of S&T ethical considerations become part of the deal when new technologies emerge. In turn, this shows why assessments on these ethical aspects as well as wider societal effects is necessary and potentially will become more and more demanded from inside the Chinese government, researchers or the wider public.

Overlapping with ethics is the issue of engagement, which shows changes happening in Chinese society regarding the role of the public or civil society in decision making. It also shows the difficulties with conducting some form of exchange between the spheres of S&T and the public. As mentioned in section 4.2 of this thesis, engagement faces many problems, including how it fits into a specific political system. In Europe, there are many issues of engagement processes and their role within a representative democracy; in China, these inclusion problems are assumingly different, but not at all absent. Here the aim of this thesis is to provide more insights into how engagement is understood in the context of S&T policy advice and which activities are taking place as done with help of the interviews below. This is for instance relevant regarding newer ICT technologies and their widespread use that have to potential to enable new forms of engagement, e.g. online discussions on a specific technology.

As the descriptions above show, the top down structure in China gives certain bodies, and essentially the CP, the main role in decision-making. The government has significantly changed and also improved the lives of millions of people, mainly by lifting them out of poverty, yet it also seems to be increasingly faced with questions from the public as well conflicts regarding issues like well-being or air quality (Zhang and Barr 2013: 134). This also points to the growing importance of forms of engagement in China, also regarding S&T developments, either as a means of bringing society together in face of growing conflicts or as a way to show political opposition by citizens. Further, it shows that even in a structure which is very much dominated

by top down and developmentalism approaches, a certain degree of public inclusion is necessary and, as it seems, will also eventually be demanded. Given this unique setting, understanding engagement in China requires a wider or different look than only regarding distinct engagement activities or events. As described above, engagement is a wider term that includes public communication, consultation as well as participation. It can be assumed that in China very nuanced forms of engagement are taking place.

In their interesting study of Green Politics in China, Zhang and Barr (2013) examine the reality of civil non-governmental organizations (NGOs) and their activists dealing with environmental issues in the context of Chinese political structures. This is a useful account here as it gives insights into the setting between an emerging civil society and the state, making for unique forms of organizations and forms of engagement. Looking at the issues of environmental impacts and sustainability proves especially useful as these deal with many concerns and problems of a wider public (e.g. air pollution, food security and also GMOs). The aim of their study is to understand "how the struggle for environmental rights has entered the life of ordinary Chinese citizens [and how] green politics in China has led to a pluralization of political participation, and in some cases, has revolutionaised China's civil sphere" (ibid.: 2). For the authors, NGOs and their activities "could be regarded within China as the first large-scale public engagement with science promoted from the bottom up. [...] the trend towards public disclosure of environment information [in forms of handbooks, leaflets, online reports] and the general defence of the 'right to know', are both empowering and daring" (ibid.: 12). Overall, in China there is a general lack of awareness or a "mass unconsciousness" regarding (maybe not only) environmental issues based on a lack of knowledge of individual lifestyle choices and their environmental impacts as well as a lack of understanding regarding citizens' rights. This in turn reflects the strong government with its five-year plans and large policy initiatives. In this setting of top down structures and limited inclusion of the public, it is not surprising to find a lack of awareness of civil society. Therefore, the starting point of NGOs or "a main objective, and in some cases the major contribution, of China's grassroots activism is to turn the 'unconscious' mass into 'citizen stakeholders'" (ibid.: 131). The political importance of NGOs becomes clearer here as they are often the ones organizing and conducting public education and events (often in modest ways) on environmental issues in a setting with very limited forms of engagement[114]. Engagement requires a public that understands themselves as citizens with rights and which is a legitimate part of decision making. Therefore education and awareness-raising activities of NGOs present "an effective provocation of collective reflection, generating new possibilities for self-empowerment of the grassroots" (ibid.: 53). Zhang and Barr state that: "Such events [photographic lessons or bird-watching] help the public to recognise that they have a direct stake in the social and political decisions regarding China's path to modernization" (ibid.: 131). The events described have a fairly low threshold regarding engagement and by other countries' understandings wouldn't necessarily be regarded as participation. Yet, when "we consider the

[114] From the side of science there also seems to be little awareness or motivation to engage with the public due to the logics of the scientific system. Quoting a science editor, Zhang and Barr write: "There is little incentive for individual scientists to initiate public communicative efforts, since traditionally it is the opinion of the technocrats rather than the public that counts in funding and regulatory decisions. [...] They question why they should write for an 'unknown mass audience' outside their institutional box" (2013: 52). This tension is not unique to China in any way and can be found in many countries dealing with increasing engagement within the S&T systems. The funding or evaluation structures leave little room for the inclusion of engagement next to indicators such as top publications, efficiency or competitiveness (Felt et al. 2016: 753).

general level of public engagement in China, the routinised public education and events on environment-related issues organised by various E[nvironmental] NGOs should in themselves be considered as an achievement" (ibid.: 52). As we see, which forms of engagement take place and what is considered engagement in a certain country varies according to the political setting, the status and self-understanding of citizens or the topics.

Education or communication formats as the ones described, can help with awareness- and in a way capacity-building, as these events can empower citizens and in this way, encourage their self-understanding as actors within the political system and related to (S&T) decisions. They also raise awareness from the political side that claims from citizens are legitimate. In a sense, starting points for engagement. In the Chinese context, NGOs present actors that can disseminate ideas, provide empirical evidence as well as support the "creative search for alternative solutions. [They] have served to empower the general public and restrain government authority" (ibid.: 133). It seems that the Chinese government will have to adapt to a growing civil society and empowered citizens, with various actors stepping into decision making processes. Especially pressing environmental issues such as air pollution provide a ground on which a growing awareness of the public is especially apparent in China. Here the effects of demands for economic growth and S&T developments as well as their societal implications become obvious. A gradually pluralized political setting will continue to emerge, creating challenges for the government and its decision and policy-making structures. The idea of "authoritarian deliberation" as described by He and Warren (2011), focusing on China, brings together the apparent paradox of authoritarian rule and deliberation. They connect cultural specifics in China to the top down structures resulting in deliberation or engagement actually making authoritarian rule more resilient and adaptive. Engagement in the Chinese context can mainly be understood as communication (or science popularization), with some areas that are highly disputed and pressing (such as environmental aspects or GMOs). In this setting, it remains unclear whether engagement could actually challenge or alter (established) practices of S&T decision making or if it will be increasingly used to stabilize a top down structure. How to enable inclusion of a wider level of stakeholders within the policy setting is a key issue, not only in China. But especially in the Chinese context, we find tensions and pressures that can make for interesting spaces of engagement. Here, TA with its wide experiences in ethical reflections and how to include these in policy (via engagement) can offer useful ways forward.

These accounts of ethics and engagement issues in China are relevant for TA because they show the growing need for a more 'systematic' approach to providing S&T policy advice, which is sensitive towards the cultural and historical specifics of China, its current developments but also towards a seemingly emerging need to somehow incorporate wider societal aspects. In order to gain more detailed insights into S&T policy advice, the role of ethics and engagement and the political setting, in-depth interviews were conducted with key actors in the Chinese context. Since these interviewees mainly deal with interactions between S&T, society and policy, their statements can provide assessments as well as possible indicators of TA-like activities in China and what might be needed for further establishing TA. Also, they can help forms models of these interactions and help recognize which aspects play an important role. Based on this we can identify the importance of ethics and/or engagement in the Chinese context, gain a deeper understanding of the questions and processes of TA-like activities and therefore help uncover recurrent characteristics. The aim in the following is to focus on the identification of activities

that can be related to TA as well as in a broader sense, what the nature and extent of S&T debates is in the Chinese context.

5.2.4 Reflections from the Interviews

5.2.4.1 Questionnaire and Data Collection

What forms does Technology Assessment take on in China and how is it understood? Which role does it play in policy-making and on a global level? Who should be engaged in ethical considerations and how? These were the guiding questions for the interviews conducted in China. The main aim being to come to more in-depth insights regarding the development and current situation of TA in China, especially regarding engagement and ethics.

Early in the interview process it became clear that the questionnaire needed a high level of flexibility, due to language difficulties, but mostly because activities of the individuals and their definitions of TA or engagement and ethics varied considerably. The level of knowledge of TA(-like) activities ranged from understanding it as, for example, quantitative evaluation of future S&T developments to an in-depth understanding of methods of TA and their wider implications. Therefore, the focus was often very different depending on the interviewee. This seems to reflect the overall situation in China, where we find growing public and with it governmental awareness of consequences of S&T, but also a lack of ways to systematically take this up on a societal level. This showed to a certain degree in all interviews and was therefore one of the main themes of discussion.

The interviews took place in December 2016 in various institutions in Beijing, China. The interviews took place in English, with simultaneous translations when necessary. The interviewees were provided with a short input shortly before the actual interview regarding TA and how it is defined in the European context, including methods used and possible impacts. This was done in order to give a starting point for discussions, since it was anticipated that the understandings of TA would differ. In total 15 persons were interviewed in 11 interviews (see Table 5), some of them in group settings, which was due to organizational specifics and availability. The institutions represented were: CASTED, CAS, Beijing Institute of Technology (BIT), CAST and Chinese Academy of Medical Sciences, Peking Union Medical College.

Table 5: Overview of Interviews China

Institution	**Individual interviews**		
	High level (e.g. director)	Senior researcher	Junior researcher
CASTED	1	2	1
CAS		1	2
Chinese Academy of Medical Sciences		1	
BIT		2	
CAST		4	

An interview questionnaire was prepared in order to efficiently collect data during the interviews regarding the main research questions of this thesis. Yet, as mentioned this questionnaire had to be adapted depending on the interviewee and their understanding of TA. Therefore, the wording of the questions as well as their sequence varied. The aim was to keep

the questions fairly short and open in order to allow the interviewees to reflect and give their own understandings especially of TA.

The first questions were aimed at gaining a more general view of S&T in China and main societal aspects. Therefore, questions revolved around the main challenges, societal issues as well as the ways policy is connected to these aspects as shown in Table 6.

Table 6: First Round of Interview Questions China

Societal Aspects of Science and Technology:
What are the main grand challenges that Chinese S&T deals with?
What are the main societal issues influencing S&T in China? (prompt here if needed: access, inclusion)
How does policy connect these issues and the development of S&T in China?

A next round of questions was focused on the more general level of TA, how it is considered and where it is located (or should be) in the Chinese system (Table 7). These questions were developed in a fairly open way since it was anticipated that understandings of TA will vary. Also questions revolved around S&T policy-making and the structures surrounding them in order to uncover the specifics of the Chinese system and to allow the interviewees to give their reflections on this.

Table 7: Second Round of Interview Questions China

Definition:
What is TA for you? How would you define it? What do you think of the European definition?
What is the role of TA in your country's S&T policy structures? Is there a role in the S&T social debates?
How could TA improve science and technology policy-making in your opinion? What changes would be needed in order for this to happen?
Roles:
Where do you think TA has the most importance? And why?
What roles does TA plays in your country? Why?
Institutionalization:
What in your institution do you do that is TA?
In the Chinese context: Where does TA take place?
Where do you think TA should be located? Should it be institutionalized? How?
Should TA directly address the People's Congress? Who should be the main addressee of TA?
Who should be the experts doing TA activities? And why?

The third round of questions was concentrated on the areas of engagement and ethics (Table 8). This focus was chosen based on the theoretical insights gained beforehand (Chapter 3). The

assumption that ethics and engagement are common denominators in any S&T societal discussions or decisions as well as essential parts of TA formed the basis of these questions. Here the goal was to understand if, and if so, how engagement and ethics play a role in the Chinese S&T context. Also the questions aimed at finding out who is regarded as important for ethical considerations and therefore should be included in these discussions. The procedural level was addressed, although this proved to be challenging, as the analysis below shows.

Table 8: Third Round of Interview Questions China

Engagement:
How could engaging the public regarding questions of science and technology take place? Do you have experiences with this?
What can be benefits or risks when engaging the public?
In your opinion, is it better to engage the public or stakeholders early in the technology development? Or is it better when the technology is more developed?
Next to giving policy advice, TA can also actively shape technology. This means TA is embedded in the development of technology (TA-experts interact directly with developers and innovators). Do you think this a useful approach? Or should TA (policy) provide advice 'from a distance'?
Ethics:
Who should be involved in helping you identify and assess potential societal risks and ethical aspects of research? Why?
What role do ethical considerations play when you assess technologies? How do you apply these?
How do you think ethics assessment could be done ideally in your area? Who should be involved in this (public, experts?)

The final questions revolved around the global level of TA and what form this could take (Table 9). The aim here was to gain insights into this from the "Chinese" perspective: is it an important or necessary approach? What (cultural, political) specifics should be regarded for this? These questions only made up a smaller part of the questionnaire, since the assumption is that

Table 9: Fourth Round of Interview Questions China

Global level of TA:
Do you think TA-like activities are important on a global level?
How would you like to see global TA take place? What form, what institutional arrangement?

All interviewees were asked these questions, although sometimes the order varied. Also, as described, the diverse backgrounds of the individuals as well as the lack of a set definition of TA made it necessary to adjust and adapt some questions.

The data collection was done with audio recordings and semi-transcribed interviews. According to guiding questions the interviews were analyzed and partly transcribed. These were based on literature review of the S&T policy system in China as well as the experiences from the interviews and discussions in the field. The following questions functioned as an overall frame for this:

1. What are the main societal aspects of S&T in China?
2. What does TA in China mean regarding institutionalization and roles?
    a. Which methods of ethical consideration are used?
    b. Which methods of engagement are used?
3. What aspects are important for a global level of TA?

According to these questions, the interviews were analyzed and are interpreted in the following, including direct quotes from the different interviews which highlight important aspects and underline arguments.

5.2.4.2 Societal Aspects of Science and Technology in China

The specifics of the policy system, its societal, cultural, historical characteristics shape the way S&T are governed and embedded in China. As described along the literature above, the top down structure as well as close connections between S&T developments, economic prosperity and advancements in society are important to understand the different aspects of the S&T system. They show how and why certain policies developed and why there seems to be a lack of assessment, especially regarding societal and environmental issues. The ideal of economic development as a societal goal and the importance of S&T in this context remains a very common perspective in the Chinese context and the main effort from the government side.

> *"this is the discourse: we are at the lower level of development and some developed European countries are at this level so the most important thing is to get to this level and when at this level, people can think about more individual things and then chase the quality of life more than the amount" (Interview 6: 57:30).*

> *"personally, I think that the Chinese government does not really think that the other aspects is more important than the economic advances" (Interview 3: 5:00).*

This main aim coincides with the top down structure of the government and in the context of S&T policy-making. Research is driven by high level programs, which are often in the context of economic development or growth. Economic developmentalism as described above is the main narrative and results in a lack of critical views on the implications of S&T within society. The overall structure of top down and development often emphasizes the economic potential of S&T and the good this brings to society.

> *"this idea is related to the chase of the GDP, chase of development, developmentalism […] when we try to understand science we lack the rationality and cultural part in science […] development is a political question, always emphasis on development […] this discourse still has influence now, you will find in China when people talk about issues of science first we think about the use" (Interview 2: 9:31).*

> *"for Chinese government, I think that until now the economic development is still more important unless the pollution is so bad, then they start thinking about the steel factories surrounding Beijing, but money and fortune are more important than health and sustainable development" (Interview 3: 15:11).*

Important for the S&T setting in China is the absence of an explicit public sphere (e.g. independent organizations), which is able to provide critical input to the dominant discourses on the further development of S&T mainly under economic terms. This of course has implications for TA activities in China, as they remain limited in terms of reach and inclusion of a wider public. The ability of the public to reflect on S&T developments as well as the neglect or

absence of societal aspects of S&T corresponds with the top down structure, also reinforcing it. To understand the current situation and the way decisions are made and priorities are set in China, these factors are highly relevant. For TA, this is means it potentially would have to deal with and foster changes in thinking as well as the structure itself.

> *"in China, we lack the social organization to balance the powerful discourse of development so it seems that we are not so responsible […] the change process is complex, we lack the culture the historical background […] we need a change of ideas, concepts and a change of policy and the institutions of politics" (Interview 2: 14:00).*

> *"from the culture perspectives, the understanding level of Chinese people lacks behind Europe because technology forecasts or developing future ideas is task of the government" (Interview 1 (P2): 23:40).*

Even though there is a lack of (public) critical discussions, pressures regarding accountability and responsibility are rising and lead to an opening up towards possible issues regarding S&T developments such as GMOs or environmental problems. Raising awareness from the side of the government as well as the public can lead to an increased need for assessment of various factors. The notion that technology also can bring negative impacts and that a purely technocratic approach isn't sufficient seems to be gaining traction, which also implies that TA has a role to play in providing input for this growing awareness.

> *"I think for Chinese case, the government should take more responsibility, but you know Chinese government is very strong and powerful in society and decision makings […] the government is starting to get concerned with different voices from society not only from scientific society or industry but also communities: that's a good chance" (Interview 3: 10:38).*

> *"its changing, there are several incidents in the last few years: food things, environmental things, huge GMO controversies in China which was related with political things, so how we should see technology is changing, before we were quite technocratic" (Interview 4: 3:30).*

Even though this mainly comes from outside pressures, such as environmental problems or public resistance to certain technologies, there seems to be an emerging awareness that the societal aspects of S&T developments are important and that only orienting these along economic criteria isn't sufficient. Here, tensions arise between the predominant top down structure and a realization that some form of inclusion or deliberation is needed. Even though this isn't taking place in an institutionalized or broad way, there are changes happening and a certain attentiveness of the government side is emerging. This can take place in smaller windows of opportunity, such as surveys or online feedback on policy documents (e.g. MLP).

> *"A unique characteristic because China is such a top down country so for evaluation or TA we always miss a third party so the really independent evaluators are missing like consultancies, NGOs, they are quite weak, at this moment it's impossible for them to take big programs from ministries to assess technologies or do big evaluations, it's possible to engage them in part of this, like discussions, to do surveys interviews" (Interview 5: 51:05).*

> *"the MLP [medium-long term plan] when making this the government [MOST] actively set up a procedure of public engagement: they were collecting opinions and comments from the public […] also in recent years the Minister of MOST said in many occasions that in S&T development we must have more public engagement in order to ensure that S&T is in the correct way" (Interview 11: 20:55).*

Still, this is only at the beginning and therefore questions how it initiates changes towards wider considerations are relevant. In a setting in which a public sphere is still mostly missing as well as institutions to represent it, but where controversies do come up, there is potential to initiate changes in thinking and policy decisions. This has to begin with raising awareness also among the actors involved in S&T developments such as scientists. It seems that in the Chinese setting, there need to be 'lobbyists' for the societal implications of S&T as well as TA activities. Correspondingly to the top down structure, addressing top level scientists can be a way to bring these issues on the agenda. For TA, this would mean engaging with these actors, seeing them as change agents.

> *"the difference between Germany and China is that the decision-making and political systems in Germany already have some institutions of engaging the public and gathering the publics' attitudes and opinions, but in China we are trying to raise the awareness of scientists and then these elite scientists influence the policy-making to change the political institutions regarding S&T to try to make some policy recommendations and laws and then organize those activities" (Interview 2: 48:47).*

> *"for China it needs many, many more years to catch up such things from the top-level decision makers to the bottom level, scientists should at least be motivated to do so" (Interview 5: 55:27).*

This of course also reflects an expert approach to the societal aspects of S&T in China and the overall positive image of science. Scientists should be made aware of issues, then pass this on to the policy or public side. Again, the top down orientation and scientism show as main characteristics here and define which target points TA(-like) activities can have in this system. Yet, this can be regarded as a starting point for further ways of engagement.

> *"it's the acceptance: to what extent the government and the scientists can accept it? […] the first [step] is that the government and scientists need to be aware that this is something we have to do, given this we can then go to the next step of how to find the better or proper way to help the public participate" (Interview 11: 1:06:53).*

> *"if we only target policy makers the implementation of the policy will face many problems […] the decision-making system in the Chinese context is government officials plus scientists, so scientists can influence the decision making in a very strong way" (Interview 2: 34:80).*

As described above, this expert orientation is also a result of the missing public as a strong voice in the debates on S&T. This is in contrast to other societies (such as in Europe) where there are established, active and legitimized publics. In the Chinese system, this specific way forwards seems to be an appropriate and practical starting point to attempt to raise awareness and establish more holistic assessments of S&T.

> *"I know what you're talking about with TA, I think in the theoretical aspect its already very important in China, but if you're talking about the real influence in policy-making or public life we still have a very long way to go" (Interview 6: 26:50).*

> *"because of the scientism in China, the scientists have high confidence in technologies and that the public just doesn't understand, a kind of pride or even arrogance […] in the emerging technologies, the young scientists are more open and aware of the importance of communicating with the public. In fields like Biotech or Nano top, scientists were actively communicating with the pubic on WeChat like writing popularization articles to then discuss" (Interview 11: 32:50).*

We see that the Chinese context, with factors such as developmentalism, scientism and top down structures it remains challenging to include wider aspects in the assessments and decisions on S&T. China often understands itself as a developing country when it comes to S&T, in which issues of responsibility or accountability are seen as a barrier. Only after a certain level is reached are the societal or environmental implications relevant. Again, tensions show here, as a certain development stage has been reached, with many societal benefits and achievements, but now also with growing and more obvious consequences.

> *"I think a lot of problems depend on which stage we are at, China is now standing at the faster developing stage […] Some scientists will say: our country needs to develop as fast as possible, you should not put responsibility as a barrier in our way of development, we just want to promote the technology development as a great opportunity" (Interview 5: 16:45).*

Even within this overall notion of S&T development, growing public awareness and action is putting pressure on the government side. Resulting from changes to everyday life through S&T as well as specific controversies, such as GMOs described above, the public seems to be demanding wider considerations from the government side. For TA, this means that an essential part of its activities (including the public and their ethical considerations) is gaining importance in China. The government has to increasingly find ways to deal with these demands and expectations, within its top down structure.

> *"the public in China is becoming more and more aware of their rights and they have more reflection of S&T development especially the possible negative impact […] the public more and more frequently tries to make their own voice and they put pressure on the government […] calling for more concerns about the social impact of S&T" (Interview 11: 10:30).*

It seems that in China the relationships between society, the government and S&T are changing, which in turn provides opening for TA(-like) activities. If a growing public is becoming aware of consequences of technologies and that they can have a voice in the process of decision-making then processes to enable this should be established.

> *"there is an emerging demand of the pubic in China now, many people want to participate in research process, people want to see the labs, to know the process, they are not satisfied with only knowing the results and they start to question why this happened" (Interview 8 (P2): 1:01:55).*

> *"I feel like it's a good time to talk about these things now because we're kind of changing in these years and people are more and more aware of these risks, even my mom is talking about the GM things, they notice this kind of thing and want to involve and contribute their views" (Interview 4: 19:56).*

In the light of an emerging awareness from the government, the public as well as the scientific side, there seem to be open spaces to be filled by TA in China. As we see through the interviews, even with still dominant notions of developmentalism, scientism and top down structures as well as a lack of an established public sphere the potential of TA in China seems to be to connect to these emerging discussions. This will show in interesting ways as it also means dealing with tensions between established ways of doing things and new forms of coming to more robust decisions on the direction of S&T for Chinese society. Next to understanding the overall setting of S&T it is therefore also important to uncover how TA is currently understood in China and which forms are needed in the future.

5.2.4.3 Technology Assessment in China: Institutionalization and Roles

Developmentalism and the drive for economic growth influence the way TA is understood in China. Assessing a technology is often understood in terms of its economic or innovative potential. Thinking of the typology of different roles and impact of TA (section 3.1), this means scientific assessments on technical options are the main concern here. This corresponds with a system which is mainly concerned with using S&T to achieve substantial growth and prosperity. Yet, basic values such as peace and safety or harmony also influence the way decisions on S&T are made. As described above, the opening up of the economy, apparent effects of S&T and emerging awareness from the public create a setting in which the need for advice has grown. In order to maintain a harmonious society, there need to be ways to negotiate between these different factors.

For TA, this means an adaption to this specific Chinese context. Even the translation of technology assessment into Chinese isn't a simple endeavor since focus on the societal aspects isn't apparent in the literal translation, which would mainly be concerned with economic factors.

> *"when I listen to TA the first thing that comes to my mind is from the hard science side, what is the value to make profit for the company? It's much more on this level. But from the society perspective in China it's not such a popular term" (Interview 8 (P2): 1:18:40).*

> *"for Chinese, it will be clearer if we term it as the assessment of the social impacts of technology that would be much more clearer for leaders and the public" (Interview 8 (P5): 1:20:00).*

Due to the overall lack of public debates on S&T, TA in the Chinese context also implies science communication or science popularization, so providing information on the outcomes of S&T to a wider public. This is mainly a one-way activity in the sense of scientists presenting their research to an interested public. For TA, this has implications especially regarding the inclusion of the public, as the descriptions on engagement (in section 5.2.4.5) show.

> *"in China, we use the term science popularization, in Europe this is questioned because it is one way, experts give their knowledge to public, lay people" (Interview 7: 17:40).*

TA is not an established term or practice in China. Of course, TA is dependent on the specific socio-political context in which it is applied regarding its institutionalization, methods or addressee. In the Chinese context, it seems that as it is not as recognized, TA is often translated into the different areas of expertise, for example innovation evaluation of technologies. This creates a situation in which there is an increased need to come to standards regarding the methods used in order to have comprehensive results which are useful for policy makers.

> *"TA researchers should have consensus on common methods, standards, otherwise it becomes too multi-disciplinary, conclusions of the assessments should be similar otherwise the policy makers will get confused […] and it becomes a totally random process" (Interview 11: 42:56).*

This is also relevant regarding the actors involved in the TA process and where it should be located ideally. In an overall setting of scientism, the role of experts is especially important in this regard. They are seen as the ones who can provide input for TA and also as a way to ensure the quality of the assessment.

"often the top experts are consulted because its assumed they know the whole picture" (Interview 1 (P1): 9:41).

"we need some professional form of TA […] institutions and experts to do it in case it might be misled by lay people […] the question is important: how can we judge the quality of TA? We need standards and criteria that's why we need professional institutes" (Interview 11: 36:46).

"the physics society represent the scientific community and by doing this [TA] scientists could raise their reputation" (Interview 2: 46: 35).

Depending on the function of TA, for instance as a communicator or policy advisor, raising knowledge or forming attitudes, its ideal location in the Chinese system varies. One aspect regarding where to institutionalize TA is the closeness to the political decision makers. A certain distance is important in order to give independent options, yet this may limit the influence of TA activities. As a more indirect form of communication TA activities can be focused on educating the public and for example the media and through this gaining impact on the policy level. Existing institutions such as CAST or MOST can be possible spaces for TA, yet would require changes regarding their structure to become more inter-connected to other ministries or institutions. This makes an argument for TA activities to be conducted at several levels or to have it in a fairly high position in order to provide direct advice.

"TA should ideally be located in the government in several ministries, not just MOST, but also Ministry of Health, Ministry of Education […] they should all have TA activities in their ways […] a decentralized way of TA, in ministries, is better because China is such a big country" (Interview 7: 22:33).

"if we have a TA institute I hope it's at a national level, like at the president's office, who could directly advise the chairman or the president" (Interview 4: 14:09).

"CAST is a good place to do the assessment/evaluation because at CAST there are different societies, this is an advantage because it has a lot of experts in different scientific disciplines we can use this expert resource to do the evaluation" (Interview 8 (P2): 56:53).

As described above the societal setting of S&T is changing and with it the need for better embedding these developments in society. The necessity for TA also results from uncertainties regarding the implications of technologies for different stakeholders. For TA and its practitioners, the main role at the moment in China seems to be to find (qualitatively sound) methods to incorporate the various expectations and advise the policy side.

"I think it's a progress, the way we are assessing technology is changing because the way we are seeing the technology is changing so TA should be a way to help us to better understand technology in society […] I think especially with the emerging technologies the scientists and policy makers they have seen the uncertainties" (Interview 4: 2:34).

"S&T policy researchers like us that are trying to collect information from the public about their needs, comments, worries about technology and we try to transfer this information to the policy makers and make suggestions about what to do to have a better environment" (Interview 11: 30:15).

Next to this growing awareness, TA(-like) activities are taking place in China, for example in larger institutions such as MOST or CAS. Often these aren't termed technology assessment, yet can be regarded as such in the Chinese context. These can also be important actors to push forward the understanding of TA and its relevance for providing advice on the societal

implications of technologies. Yet, again their location within the overall system remains difficult in terms of independence and effectivity of their advice.

> *"we have similar institutes that support the decision-making, which might not be called TA, but forecasting or planning [which are] located in MOST or CAS" (Interview 1 (P1): 23:47).*

> *"in CASTED we were trying to push the leaders to be more aware of this TA or responsibility of science and technology and the relationship between S&T and society, but since we are too close to the government or the policy-making centers sometimes […] it could be more difficult" (Interview 8 (P5): 1:33:10).*

We see from the above that the overall context and broader changes shape the way TA is understood and practiced in China. Since it is not institutionalized there are various ways it takes place, also where in the system and what its roles are. This raises the question of which kind of TA is useful in the specific context, for example a more embedded form (e.g. close to decision maker) or as a more distant observer. If TA is close to the decision maker it can have more impact on decision-making, if it is further away it may be regarded as more credible and independent.

> *"embedded TA is better in Chinese context […] finally we should inform the decision-making" (Interview 7: 42:28).*

> *"I think that if you try to do it [Constructive TA] the TA or STS person will lose their expertise or better your legitimacy for the policy maker. I think in China the distance will work better […] in China we use a distant opinion which is more accessible" (Interview 4: 25:35).*

> *"I think in China its typical that assessment comes last [laughs]" (Interview 4: 39:00)*

Often TA is seen as the evaluation of a technology in terms of economic potential. This of course reflects the overall situation of the importance of S&T for economic growth as well as competition on an international level. As a result, TA is often regarded as the assessment of the advancement of a technology and its monetary benefits for China. Here TA should provide foresight on S&T in order to improve efficiency and as a basis to justify decisions on certain technologies.

> *"since early 1980s […] until recent years there were two issues for Chinese TA: one: Is this technology advanced? Two: Can this technology make money?" (Interview 3: 3:52).*

> *"The term used means more evaluation of the process of a S&T project its economic price […] the question of whether it works in the market or not" (Interview 7: 1:00).*

> *"TA is one of the many methods of R&D evaluation" (Interview 5: 31:34).*

> *"TA stands for neutral, not normative and a useful means for technology foresight: to map, position the future 20, 30, 40 years how the technology will develop" (Interview 5: 32:32).*

This view of TA is not surprising in the Chinese context, which only just now seems to be increasingly becoming aware of the far-reaching societal implications of its rapid development, also of S&T. TA as evaluation serves the current system of developmentalism and top down management with input that can be easily translated into its narrative of progress and affluence. Yet, as described above it isn't sufficient to cope with growing tensions between development and possible negative effects. TA in China should therefore provide input beyond the economic evaluation of a technology or innovation to include the wider societal repercussions.

"TA for me: how much will this technology cost to our life, to society? Regarding all aspects, not only technical ones" (Interview 1 (P1): 3:57).

This role of TA seems to be necessary in order to better develop S&T according to values such as peace and safety as well as towards the goal of a harmonious society. In China, the understanding of TA often remains vague since societal aspects, an essential part of TA, are not always accounted for when assessing technologies. Main activities in the realm of TA are focused on scientific assessments, lacking other forms of TA as forming opinions or initializing actions. Based on this, experts are seen as important actors to push forward the inclusion of societal aspects, e.g. high-level scientists, reflecting the top down structure of decisions. Communication or popularization is focused on one-way information flows: from the scientists to the public. Still, we can identify an emerging awareness of the importance of TA as a more holistic approach towards incorporating societal aspects into decision-making. The needs, fears, expectations and demands of the public are seen as becoming more important factors, which cannot be overlooked in the future. Correspondingly, this means that future TA in China will increasingly have to account for forming attitudes and opinions (e.g. by introducing visions or scenarios or re-structuring policy debates by evaluating policies). Whether future TA in China can actually initialize actions remains debatable since reframing of debates or new decision-making processes require strong TA actors. Further, the lack of public debates or civil society actors, as described above, can also hinder this. This then brings us to the essentials of TA, ethics and engagement and how they are actually understood and practiced in China, in turn showing ways forward in establishing TA more comprehensively.

5.2.4.4 Ethics and Technology Assessment

In questions on ethics, we find that again predominant ideas of growth, scientism and top down structures influence the reflection on S&T. In this system, it is the experts that are often seen as the main actors in ethics, also because the public isn't necessarily aware of issues surrounding S&T and isn't regarded as capable of ethical reflection. S&T are still regarded as important factors in the rapid growth of China and the public often seems to acknowledge that their further development is therefore justified. Therefore, in China ethics is still mainly seen as the realm of experts, such as top-level researchers or social scientists in high-level institutions such as CAS. In this position, these experts are seen as qualified to consider the responsibility of science and research.

"CAS researchers are top level so they consider more social responsibility […] it's a long way to go for the public to understand science, […] the members of CAS they understand more of the real role of science in society and that's why they have more social responsibility […] we have made big progress, you can see that the top scientists in China they more and more talk about ethics of S&T" (Interview 2: 20:58).

"of course, start from the researchers, the scientists to think about this, also engineering and of course also the policy makers should also include the public but I'm not sure if they would like to, whether they treasure their opportunity, right?" (Interview 6: 27:23).

"generally, when we ask such a big question to the public about ethical problems they have no idea. China is a developing country so S&T has a good name for everybody, if something is wrong then maybe someone did it wrong, it's not the technology itself, these are very strong ideas in many ordinary people" (Interview 10: 20:35).

A further aspect of experts in regard to ethics is that of research integrity. This is an issue in China and is seen as an aspect of ethics. Of course, this is mainly effects of the academic system and is connected to scientists and experts, even if some scientific misconduct may also lead to public responses.

> *"it's about integrity and beyond that: to think about the public's good" (Interview 7: 46:23).*

> *"in China, lots of scientists are having problems with their integrity" (Interview 4: 8.30).*

It seems that in China lay ethics doesn't really play a role in the reflection of S&T. As described above this is connected to a system, which is predominantly focused on science popularization. Therefore, considerations of possible ethical implications are done mainly in institutionalized ways and this is seen as the more important step at the moment. This connects to the top-level scientists as the main change agents for an establishment of TA described above. In the Chinese system, it seems key at the moment to encourage experts to consider ethical aspects and societal implications of S&T in order to raise awareness on the policy but also the public side.

> *"this year some scientists in CAS initiated a project to research the ethical problems of gene editing and this shows the change of CAS, a very famous scientist initiated this project and this shows the change of CAS from only being concerned with scientific problems to concerned more and more about social impact of science and influence of society to science […] at this moment, the social responsibility of top scientists is more important" (Interview 2: 44:06).*

In a system, which at the moment favors mainly scientism and top down approaches, involving top scientists in ethical reflections seems to be a useful way to bring possible issues forward and potentially on the agenda of policy makers. Even though there is a rising awareness that public opinion is important it seems that this isn't sufficient to enable more open ethical reflections including stakeholders or the wider public. This is also connected to the lack of experience of public engagement and its inclusion in decision making. Still, we do find an emerging awareness that engaging the public is somehow important in order to account for their concerns and wider societal issues as well as adding to the experts.

> *"the public is increasing their concerns about possible negative impacts of the technologies, not only for themselves but also for the environment and future generations […] lay ethics is more like the common sense, closer to the general public, professional ethics might have blind points […] the general public's opinion should also be included" (Interview 11: 12:55).*

> *"ideally every stakeholder should be involved, especially the weaker groups, patients […] the experts have their perceptions about risks but the patients or lay people have their own experience about risk, usually they are different […] the professionals and the subjects have different perceptions about risk" (Interview 10: 22:20).*

There is an understanding of how lay ethics can add to ethical reflections and that it can expand the kind of knowledge about potential effects of S&T. Due to tensions between rapid development, negative aspects of S&T and an overall still dominant technocratic approach, there is the perception that there should be wider ethical reflections, beyond those of experts or policy makers, also as a way to deal with these pressures. Yet, in China we mainly find experts' ethics at the moment, which is why for TA it can be useful to connect to this as a starting point. There is an awareness that wider ethical reflections are needed, yet the public is seen as mostly lacking the capabilities to actually be included. It remains open how this will develop in the future. Pressures, also from the public side will require some form of adaptation of the top down

expert structure, yet may result in very controlled forms of ethical reflections, perhaps more on the side of gaining acceptance for already decided policies. For TA in China this means that it should support this emerging potential but should also reflect on its own 'ethics', how it is used by whom to which end? This of course is also directly connected to engagement, another main characteristic of TA, and, to a certain degree, somewhat contradictory to a top down management with a strong belief in science development.

5.2.4.5 Engagement and Technology Assessment

The issue of engagement shows very well the tensions described above, the pressures arising and a growing awareness of the need to somehow include a wider public to come to more accepted decisions on S&T. Overall the view seems to be of still fairly separate spheres of science, policy and society. Engagement with society is regarded as difficult due to a lack of tradition and limited knowledge of the public about S&T. As described in part 5.2.3 above, debates on GMOs and activities of NGOs do show an emerging civil society, which can enable citizens to participate in forming an opinion on S&T. Yet this can be regionally very different, depending on how advanced S&T are and people's awareness on issues. Many activities can be considered as communication (popularization) and consultation, how to actually involve citizens further remains challenging. This reflects also in the top down structure, in which it is predominant and doesn't have official ways of initiating and incorporating engagement.

> *"always the government emphasized development, it's the same in China and Western countries, but the difference is that in Europe you have a citizens' society but in China the government is still more important, we miss the society or community […] we lack a counterpart of the powerful government, the society or community part, a balance" (Interview 2: 12:16).*

> *"public participation is not so common and we lack the channels and mechanisms to organize more engagement […] TA is extremely important and very necessary in China because we need, we don't have this tradition of public engagement and participation" (Interview 11: 9:20).*

> *"I think the citizens are not very strongly motivated to engage in it, there's no tradition or culture to do so […] it is taking place in niches, maybe only in Beijing or Shanghai, in areas where they have a stronger culture of science, of public engagement in science […] in other areas like my hometown people do not have any idea of engaging in science, it seems impossible" (Interview 5: 13:33).*

In China, a missing 'culture of engagement' is described, which shows in a general lack of awareness and demands from the public's to be included as well as on the scientific side to acknowledge inclusion of others. Yet, regarding the more controversial (GMOs) there seems to be a growing consciousness that there are potential risks to society that should be taken into account. Here again, we see an emerging awareness through a contested technology and the possible risks it brings to society.

> *"Engagement is the thing we are most missing, not just missing phenomenon but missing culture in people's minds, an awareness, they don't have motivation to engage they don't think they'll make any impact" (Interview 5: 46:55).*

> *"we found that the Chinese public has little knowledge on benefits of GMO crops so the scientists didn't make enough efforts in the past to tell the public […] the scientists think it's enough of a benefit to say it's a new technology […] we find that people are more aware of the risks that the benefits" (Interview 11: 34:25).*

Even though overall there is still a lack of public debate, it seems that especially regarding controversial topics with possible effects on the environment there is a growing need to catalyze this through some form of inclusion. This is also because there are more extreme protest movements coming up, especially if before worries or fears weren't considered.

> *"in the following years more and more Chinese citizens, they have awareness of civil society, more and more Chinese people especially the high educated people, will notice that the applications of the new technologies is a big issue for the country […] waking up, awareness of civil society" (Interview 3: 5:55).*

> *"people discovered there are risks, but they don't have a good channel or mechanism to express their worries and to participate in policy-making process. So, they either stay as the silent majority or they come up with very radical or extreme social movements" (Interview 11: 15:30).*

For the government side, this means that somehow these voices have to be considered, at the very least to avoid controversy and protest. TA can potentially function as a facilitator of these processes and through this enter the policy system in a more comprehensive way. As described above, the government side is also growing aware of TA, also in regard to the inclusion of the public.

> *"10 years ago, when we talked about TA in the government they said, oh it sounds interesting but that's all. But in recent years you can actually see that they are actively talking about public participation" (Interview 11: 19:23).*

Again, within the top down system, top scientists can function as 'brokers' of engagement and ultimately of TA. Therefore, they can be a target group for TA in order to foster reflection among different scientists and as a way to also bring this to policy makers. Encouraging interdisciplinary can benefit the way the academic sphere deals with questions, bringing exchange also on societal aspects of S&T. In the light of a still overall limited knowledge of S&T in the public this can be a realistic and practical step towards bringing different aspects into research and potentially balancing out the strong drive for S&T development.

> *"We think that the realization or awareness of scientists is more important […] we are building a platform for a dialogue between social and natural scientists in the decision-making system, both of them are changing their original ideas. The natural scientists realize more and more the social aspects of scientific work at the same time the social scientists change from very critical attitude to a more constructive attitude and we are going to more and more build a balance" (Interview 2: 33:10).*

Due to limited experience as well as restricted knowledge from various sides, engagement in China is still in early stages. If a culture of debate as well as general knowledge is lacking then it is important to ensure that involved people are well informed throughout the process. Here, TA can take on a role as an organizer of such engagement processes and to enable a sound basis for debate.

> *"we should organize engagement carefully and keep the people involved informed" (Interview 7: 41: 57).*

In general, in the Chinese context practical knowledge on how to do engagement, but also a consistent approach to these activities and their input into decision-making is still mostly missing. As with TA itself, standards are needed as well as exchange on experience and methods. For China, TA could provide knowledge on these processes, for example reaching consensus on controversial issues through an engagement exercise. A further aspect here is how these standardized processes are actually incorporated in the Chinese system. It seems that through an emerging awareness there is potential to include these into the decision making to a certain degree, yet for this they have to be regarded as legitimate and rational input.

> *"we should try to build up a more rational and standardized way of public engagement so that we can express and they can make their voice heard […| with this communication of knowledge and information so that the government and the scientific community […] and public, so that each side can express what they really want and what is their opinion [we should] try to achieve a kind of negotiation: negotiating their needs, their worries otherwise it comes to extremes. The problem is we don't have this kind of mechanism to get to a balanced negotiation so that's why I was thinking we could learn from the European TA practitioners to see how can be built up more rational and standardized processes to include all voices from different sides and to reach this so-called consensus" (Interview 11: 16:05).*

Since there isn't much experience with them, the location of engagement processes, e.g. which institutions initiate or how outcomes are used, remains unclear. Even though government concern with public opinion on S&T is growing, processes as well as actors for carrying this out are missing. As with TA, it is still a predominant distant position which seems most appropriate for the Chinese system.

> *"the government is starting to get concerned with different voices from society not only from scientific society or industry but also communities: that's a good chance […] but we do not have good institutions for this, like law, regulations or procedures and techniques so that's our challenge" (Interview 3: 12:34).*

> *"I still hope we can do the upstream engagement, […] in China, we use a distant opinion which is more accessible" (Interview 4: 27: 25).*

Against this background, the understanding of engagement in China is often as a communication activity, which can help support informing the public on S&T. This means that participants in engagement are seen as recipients of information, for example on the benefits of a certain technology for them or society. Feedback from the public back to science or decision makers isn't taken into account in this view.

> *"they enjoy the activity, for science there are no direct benefits, they have indirect benefits because they see that they benefits society, they have feeling about the social responsibility" (Interview 10: 7:19).*

Here we also see a tension in the present situation in China. Between an established understanding of the public (as recipients), which results in engagement as a popularization activity and between engagement as an inclusion of various views and perspectives as a way to solve societal problems with S&T that is adapted to needs and expectations. Of course, when the public is engaged in discussions there is the potential that questions regarding scientism or the top down decision making come up.

> *"it [engagement] can truly help us to understand the society [..] this is a benefit, if we engage the public more we can give them better answers, it can help the government to better solve problems" (Interview 4: 20:58).*

> *"after the inspirations the public had, their thinking became diverse, but this will be a challenge for the management of government […] the public starts to question the authority or expertise, its different from the mainstream understanding or attitude to science" (Interview 2: 25:47).*

This points to possible risks of engagement in China, where the overall goal is harmony and a general stability of the political system. Engagement as a process disturbs established ways of coming to decisions, in any system which is built on representation. Also, engagement could slow down rapid economic developments of the past as it may put certain priorities or decisions into question. A further risk is the size of a country like China, similar to India, it is diverse and varies substantially from region to region regarding culture, language or access to technology.

> *"it's like the advantages and disadvantages of democracy in a way, democracy is not the best institution for example for economic and social development, it sometimes has really low efficiency […] these things can slow down S&T development, but they're also a kind of security to make sure S&T is going the right way. […] And of course, there are other problems with the public […] China is so big with big variety and so public engagement itself is a huge problem" (Interview 11: 54:37).*

> *"the public raises their expectations, they believe, I've told you so much why is there no response? And one of China's important political goal is to be stable, society should be stable, this kind of engagement could raise controversies more, it won't easily get consensus, so we have to figure out if we don't have consensus then what can we contribute to the government and to the public?" (Interview 4: 22:20).*

As these questions on the effects of engagement and its incorporation into the system show, there seems to be a growing need to find ways forward regarding the inclusion of a wider set of actors, yet it is unclear how this can be done in the current system. Will engagement lead to gradually pluralized forms of civil society or will deliberation instead support the current top down system? Engagement as part of TA has to adapted to the political setting, yet take into account demands for more openness.

At the moment, what is understood as engagement is often done with online tools (such as surveys or online discussion platforms like WeChat[115]). Through these people's opinions can be collects, especially since smartphones and easy internet access (at least in some parts of China) has become a consistent part of everyday life.

> *"engaging public at the moment best done through gathering people's opinions online. Try to find remarks and comments on different events or articles for example on WeChat […] the online life becomes a bigger and bigger part of people's lives, the smart phones represent more and more people's lives and thoughts, if people comment on news during their daily life then this represents their thoughts or decisions" (Interview 7: 26:50).*

> *"the Chinese population is big. We can use ICT to create people network, this network changes and maybe there is new knowledge coming, also from common people, this can be used to enhance our assessment power" (Interview 8 (P3): 1:07:20).*

[115] WeChat is a popular Chinese social media application that includes instant messaging, payment services as well as posting and commenting functions.

> *"we mainly do surveys that are regarded as engagement. In the process of policy-making the survey plays important role: because it gets the public opinion in each step of the policy-making process" (Interview 11: 46: 52).*

Next to insights into the understanding of what it is, this points to the forms of engagement that are currently done in China and potentials in the near future. Small scale engagement can be a starting point to gather experiences and to try to bring outcomes to policy makers. Also, smaller engagement processes are easier to realize and more practical to experiment with. In an overall setting, where the inclusion of a wider realm of actors is still limited, these first steps are needed to encourage more activities.

> *"we have to do it in small scale first because we didn't really do it until now. Before the large-scale engagement the first thing we have to do is the small scale and experiment and make this kind of result noticed by the policy makers and try to convey them this is important" (Interview 4: 17:45).*

An example of a smaller engagement process, unique for China, is a consensus conference in Beijing on GM food conducted in 2008 by researchers from CAS. Interested citizens as well as scientists working in the field gathered for discussions on the technical aspects as well as the societal implications of this complex S&T issue. Important was that the CAS researchers were trusted by both sides and could therefore act as facilitators. As an experiment, this conference also showed that engagement remains difficult as many of the involved actors weren't familiar with the method of consensus conference.

> *"we think the Danish method might be good and then we tried to do an experiment in a Chinese community. There were many obstacles during the process and the local government helped do this because of the personal relationship with [NAME], they trusted him and helped with organizing this event, many volunteers said they do not understand the meaning of this consensus conference […] during the conference experts sitting at the backside, sitting far away and the volunteers sitting in the center, some people felt uncomfortable with this" (Interview 2: 21:57).*

Another, wider issue regarding this engagement experiment was that from the side of research or policy this wasn't seen as an important event. This of course again relates to the overall setting, in which such a process doesn't have an official place within the system. As an experiment, it gave insights for the CAS researchers conducting it regarding the methods and output, yet it remained, not surprisingly, limited to this single event.

> *"several officers from local government and from CAS, they maybe didn't realize that this may be a very important activity or event in 50 years this event may have significance in maybe 100 years" (Interview 2: 29:30).*

This shows the difficulties of engagement in China. The policy side as well as the citizens didn't (yet) seem to acknowledge it as a useful activity. Within the system of top down and developmentalism it seems that such an engagement process was seen as a disturbance with an unclear function. It remains to be seen whether other similar activities following this event, already ten years ago, will take place with more effects on the side of policy or public. In the emerging awareness, they may have more potential to actually be included at least to a degree.

> *"why did they not continue after this consensus conference? I asked and I feel like they had lots of pressure or concerns which prevented them from continuing it […] I think the pressure I'm talking about, my impression, they didn't want to really talk about it, maybe from the top*

> *level this kind of engagement does not make much sense, or much direct effect, towards the technology or the research they are doing, maybe they just consider it as an ad-hoc activity to have a look at it but it doesn't make much sense, that's my impression" (Interview 5: 12:45).*

Still often we find activities which are mainly understood as communication activities, also from the potential addressees of outcomes such as policy makers. Even if the researcher initiating the engagement may do it to actual participate with people, if the recipient (e.g. policy maker) doesn't regard it as a useful and legitimate activity, then its reach remains limited. In areas where established and regulated forms exist, such as stem cell research, there isn't much awareness that engagement could add to the decision-making process, as the legal requirements have been met.

> *several years ago [2013] I organized a public event we included patients and elderly people in community and I invited scientists, social scientists and policy makers to be joint together, the topic stem cell research […] but for policy makers they say, what you do is only for the public to know about the stem cell research, but my responsibility as policy maker is the clinical trial which is far away from the public, it only matters for scientific community, so it's of little use for their regulation" (Interview 10: 4:35).*

As we see here, engagement has a long way to go in China. The overall context, top down management and decision-making structures, developmentalism and scientism, influences the habitat for engagement processes. Yet, as mentioned, there does seem to be an opening up towards the importance of somehow including a wider public in future developments. Even the basic goal of a harmonious society requires the resolution of growing discussions on certain technologies such as GMOs. The range of understandings of engagement, from surveys to consensus conferences, reflects the diverse situation in China. A strong adherence of S&T development and economic growth tends to foster an understanding of engagement as science popularization, communication or education. Yet in the light of changing attitudes and growing awareness this seems to be shifting. In this situation, an understanding of engagement would include actual inclusion or exchange, also towards policy or decision-making. Yet this remains in contrast to a top down "authoritarian deliberation" in which engagement or deliberation is used as a way for the system to become more resilient and adapt instead of moving towards more deliberative structures (He and Warren 2011: 270).

It seems that here is a potential to expand TA activities as well as engagement processes. Overall, the inclusion of the public or stakeholders is regarded important to a certain degree, yet experiences with methods or processes are lacking. There is a growing awareness from several sides (policy, public and scientific), but often the public isn't regarded as capable of participating. Therefore, experts are still regarded as main actors in providing advice for policy. Communication or popularization of S&T is regarded as a first step for fostering more public understanding of S&T, possibly providing a better basis for engagement. TA's role in the context of engagement in China is very practical (e.g. providing experience in methods), yet also substantial in the sense of adapting to a system which could allow for engagement. The question here is whether potentially increasing engagement activities will result in a gradually pluralistic setting or in deliberation in support of the established system. This is also relevant in the context of the global level of TA. Engagement as an essential part of TA will have to play a role in various countries and political settings, bringing up the question how it will be adapted to the specific context.

5.2.4.6 Chinese Perspectives of a Global Technology Assessment

In China, as a global player, there is a general awareness of the global scope of S&T developments. The economic opening up and advancements in education or the rise in the GDP as well as spending on S&T, all take place in an international setting, with competition worldwide. Global challenges such as climate change are on the agenda in China. Therefore, there is an awareness that also TA should be global in its approach.

> *"technology's global influence makes global approach necessary" (Interview 7: 46:54).*

> *"with global issues like global warming: we need to address these with TA as well" (Interview 11: 1:03:10).*

A global level of TA could take place in form of summits or negotiations that bring together actors on an international platform, such as the climate change summits. This could build on common global ethics standards or values, which are more independent from national contexts. In the light of globalization and the economic opening up, China is more open towards the global developments as well as towards exchanges on TA. This is also connected to China's self-perceived role as a global leader.

> *"in very general way we have global standards for ethical considerations: e.g. basic ethical principles: no harm, benefit, justice, respect, peace; so, this is universal values for everyone" (Interview 10: 35:15).*

> *"global assessment is possible, because China is much more open and wants to be involved in global developments, before China learned from developed countries and now we want to work with other countries" (Interview 8 (P2): 1:04:10).*

> *"globalization is also a very important because Chinese science is getting globalized so when Chinese scientists communicate with those from other countries they learn and start to understand that the public is important" (Interview 11: 35:30).*

Next to this global level, the local and national cultural, socio-political specifics are important for a global approach. As described above, how engagement is conducted and how it can be incorporated depends on the specific setting. For China, a global TA is important, also as a possibility of mutual learning. This is especially relevant for a country in which expertise on TA is limited. Yet, at the same time the specifics of the Chinese system would require a national and local adaptation of TA also in order to function in its specific structure.

> *"one common thing is that we all believe that we should have TA, a better way, a better position of society in the institutions and then we could discuss more how it should be and we could learn from each other […] But on the other hand, we have to put it into the local context, the different national level in China, this is why I say the global vision is as important as the local" (Interview 4: 35:35).*

> *"the idea of different levels of TA is important because we need a more generalized idea of TA, but when implementing it in a specific country or culture then we have to take culture, political system etc. into consideration. It's similar to the global warming issue, its multi-level, we have a global concept of it and in each country, we have different ways of doing it" (Interview 11: 1:04:43).*

The question of a global level is of course a difficult one, especially since the situation in China is so diverse and TA is largely unestablished, as the statements above show. Global issues such

as climate change as well as the expansion of S&T on an international level make a global approach necessary. However, it seems difficult to come a more detailed global TA approach, possibility because TA is still understood very differently and not as established in China itself. Further, the issue of how to adapt TA to the specific national and local contexts remains important. As the accounts above show, China has a political setting which supports more top down approaches, a societal situation in which there is only an emerging civil awareness and an overall strong narrative of growth and progress. In this sense, TA in the Chinese setting may have to look very different than for example in India or Europe. A common ground (ethics and engagement) can be found, yet may also vary substantially. This leaves the question of what a global TA would have to take into account (and what not) and which different levels of TA there may be in different countries. This is explored further in chapter 7 regarding the implications of a global TA for specific countries, on a conceptual level as well as how such a global approach could be structured.

Overall, the descriptions above show a certain tension between a top down government that has centralized ways of decision-making and a growing awareness and demand for a degree of inclusion of, not only experts, but stakeholders and the public. It seems, that this gives some openness to introduce more systematic approaches to S&T policy advice, such as TA in general or specific methods for engagement. Since the economic opening up and strives in S&T advancement, there is an increased need for advice on how to govern this and especially how to connect these developments better with society. In the current situation where "China's science and technology policy has moved from purely economic-oriented to a more inclusive perspective that take into consideration public well-being, and [we see] efforts to introduce different forms of public participation from various official bodies" (Wong 2016: 160) it seems necessary to think further how TA can be established.

Of course, this has to be done in a way that is culturally and politically sensitive, meaning that TA and its methods have to be adapted to the specific setting. This is important regarding the global level of TA, emphasizing the importance of nationally or locally specific approaches. The relevance of cultural differences become especially clear when reflecting on engagement. In many countries engagement is associated with democracy, voting, and the voicing of opinions, meaning for example that including the public in questions of S&T is part of the normative framework. Yet it seems in China "the shift towards a more inclusive perspective is likely to be driven by pragmatic concerns over (material) well-being of the public, and is a response to destabilising problems caused by science and technology" (ibid.: 160). In this sense, the main motivation for engagement would be to collect the public's opinions on decisions that have already been made, as can also be found in engagement efforts in Western countries. Also, the statements above on ethical considerations and the importance of mainly experts involved in this, reflect this situation. There is awareness of the importance of actually engaging the public within a general lack of a culture of engagement and lay ethics in China. This again shows the tensions in a system, which is still overall top down but where more and more actors (e.g. experts in S&T policy advice, citizens, scientists as well as decision makers) are realizing the importance of finding ways to open up these decision processes as least to a certain degree. This of course presents a challenge for (global) TA, which is grounded on ideas of actual engagement and has historically emerged in Western democracies and debated further in section 6.2 of this thesis regarding what TA habitats can be shaped like in different national contexts.

He and Warren describe the situation in China as “governance-level participation is developing in the absence of regime-level democratization, combined with a high degree of experimentalism with consultation, deliberation, and limited forms of democracy” (2011: 271). In this understanding, deliberation or engagement is done for functional reasons as a way to respond to growing pressures due to complex situations with many actors and ambivalent outcomes. More and more "the government will need to adapt to an expanding civil society - one that plays a greater role in the bargaining processes so typical of Chinese policy making [...] the government is learning to stomach an increasingly pluralised political sphere" (Zhang and Barr 2013: 135–136). In the light of this, the government may rely on deliberation or engagement in anticipation of possible demands for empowerment and as such creates a connection between its authoritarian structure and deliberation. This also corresponds with statements given above in which show pressure for inclusion as well as the need to find useful approaches to enable this, yet while remaining within the overall top down system. He and Warren describe features of deliberation that are rooted in Chinese culture, such as responsiveness and attentiveness and give examples of deliberation activities such as public hearings or elections, yet conclude that the overall result is authoritarian deliberation as the outcomes remain within the context of government approved agendas and control (2011: 276). This then changes the assumption of engagement or deliberation being directly connected to democratic (Western) structures and only possible within these. This assumption could hinder global developments towards more responsible developments of S&T as it wouldn’t allow for an alternative normative basis (Wong 2016: 155). For a global TA it is therefore important to continuously reflect on different normative foundations (see section 6.2.2). The perceived tension between top down, even authoritarian structures and the growing demand for inclusion and engagement is actually somewhat ‘absorbed’ by deliberation as described above. Yet, it remains to be seen whether this will lead towards more democratic structures in the Chinese context[116].

This section was focused on the S&T policies in China and how they are understood in a societal context. Understanding further what potential TA has as well as its role in better aligning S&T developments with societal needs and expectation was a main aim. This is especially relevant in such as large country which is politically structured top down, but where a rising consciousness can be observed that a wider public should somehow be better included in decisions. We do find TA activities in China, yet often understood as evaluation or science popularization. Experts still make up most of the decision making as well as ethical reflection. This also requires a certain degree of learning in China regarding methods of engagement. Yet, it also shows that TA has to adapt to the specifics of the Chinese setting. The interviews and the documents provided a basis for a reflection on this especially in the light of tensions described above. These reflections provide the basis for more concrete recommendations for TA in the Chinese context described below in section 7.1.

[116] It seems that more and more Chinese academics see the increase in deliberation as a way towards democracy, also within a one-party system by changing the character towards functional effects of democracy. This would include a “layering new institutions over old ones for the purpose of enhancing their effectiveness, while also transforming their character in democratic directions”(He and Warren 2011: 283).

5.3 Technology Assessment in India

This section will describe the socio-political setting of S&T in India by looking at main documents, such as government S&T policy statements and white papers as well as relevant institutions and their main tasks. India, as the largest pluralist democracy world-wide and a post-colonial country provides an interesting case for how S&T policy is done and what main aspects play a role in its societal embedding. Rapid economic growth and a diversity of cultures, languages, but also large disparities in literacy or access to basic necessities create a unique setting for S&T developments and how TA can contribute to embedding these in Indian society. This shows the habitat in which (possible) forms of TA or TA-like activities are done or can be shaped. This setting also provides a background for the nine interviews conducted for the Indian case study with key actors. These provide insights into and perspectives on the current status of S&T policy in India, forms of ethics and engagement taking place and further shed a light on what main issues or problems are regarding TA in India.

5.3.1 Overall Indian Setting

The Republic of India is the second most populated country in the world, with over 1.2 billion people[117] and borders with Pakistan, China, Nepal, Bhutan, Myanmar and Bangladesh. The capital is New Delhi, the largest city is Mumbai. About 80% of Indian citizens are Hindus, followed by Muslims with about 14%[118]. The Indian economy has been one of the fastest growing ones in the world after market-oriented reforms in the 1990s. It is the world's sixth largest economy by nominal GDP with about $2.654 trillion and third by purchasing power.[119] India is a nuclear state and has the second largest army worldwide, yet also has to deal with immense issues such as poverty, healthcare or literacy. This creates a unique setting for a country which has experienced large economic growth, an advance of an urban middle class and a more important role geopolitically, yet remains challenged by providing basic needs for many of its people.

India gained its Independence from the United Kingdom in 1947. The creation of the Indian Constitution was an important step to regulate the sovereign state, with its democratic institutions as well as the rights of citizens. As a federal republic and representative democracy, India is made up of 29 states and 7 union territories. The head of state is the President of India and the Prime Minister is the head of the executive and runs the union government. The Parliament is the legislative body and is composed of President as well as two Houses: the Rajya Sabha (Council of States) and Lok Sabha (House of the People). After elections every five years, the Lok Sabha elects the Prime Minister. The Rajya Sabha as the upper house of the parliament is made up of members elected indirectly by the legislative assemblies of the states as well as the electoral college and union territories. 12 members are appointed by the President of India and are usually representatives from the arts, science, sports, business or media.[120] The central government has three main sections: executive (the President, Vice President and Ministers), the Legislative or Parliament (the two Houses and Prime Minister) and the Judiciary (the

[117] https://esa.un.org/unpd/wpp/DataQuery/

[118] www.censusindia.gov.in/2011census/C-01/DDW00C-01%20MDDS.XLS

[119] https://www.imf.org/external/pubs/ft/weo/2017/02/weodata/weorept.aspx?sy=2018&ey=2018&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=47&pr1.y=2&c=534&s=NGDPD%2CPPPGDP%2CNGDPDPC%2CPPPPC&grp=0&a

[120] https://en.wikipedia.org/wiki/Elections_in_India

Supreme Court of India)[121]. As a federal state, power is divided between the central government and the state governments, which for example take care of internal security. Each state has two houses: the Vidhan Sabha (lower house, corresponds with the Lok Sabha) and the Vidhan Parishad (upper house, corresponds with the Rajya Sabha).

On the local level, there is a unique structure, namely the village "Panchayats", which are described in the Constitution functioning as basic units of administration. Its members are elected by citizens in the territorial constituencies and the Constitution states clear guidelines, such as the number of women (at least one third) or the length of the elected time (5 years) (Government of India 2015: 130ff.). On the federal level, there is the Ministry of Panchayati Raj, which aims to empower and enable the Panchayats for inclusive development and social justice[122]. As such a large democracy, India is highly diverse and heterogeneous regarding its population, religion and even the environment, which is important regarding the political and cultural context of India. In this setting, elements such as the Panchayats, which allow for specific and local governance and their explicit tie to the overall structures through the Constitution or Ministry, are important. These localized forms were envisioned by Mahatma Gandhi as a decentralized foundation of India's political system as a way of self-governing and direct participation of villages and were given authority as institutions of self-governance and support of social justice (Amendment of Constitution in 1992). Yet, due to issues such as vote-trading the empowerment of the Panchayats remains limited and many responsibilities continue to be centrally governed[123].

The Indian setting, similarly to China, is deeply influenced by rapid economic growth. This has changed India substantially regarding various aspects. The Indian economy is continuously growing at a projected annual GDP growth rate of 7.5% in 2017-2018, which makes it the fastest growing G20 economy overall. Exports in services since the 1990s, inflow of foreign capital as well as gradual loosening of restrictions on these foreign investments have resulted in the GDP per capita more than doubling in the last ten years. This has had effects on the overall well-being of Indian people, declining extreme poverty (from around 50% in the 1990s to about 20% today) and access to education as well as life expectancy rising. Economic liberalization in India began in the early 1990s with the goal of making the economy more market and service oriented also towards foreign investments (OECD 2017). "[F]rom a broad development strategy perspective, India's growth experience can conveniently be broken down into two phases: the first phase running from 1950 to 1980 […] and the second phase from 1980 to 2004 and ongoing […] In phase I, the development strategy was inward looking and relied on a command-and-control type of environment. In phase II, the development strategy became outward oriented and relied on market incentives" (Ahmed 2007: 51). This correlates with globalization tendencies and with India becoming a global player regarding economic development. A key driver often mentioned in this context is the growing population in India, e.g. the growth of India's working age population, which is expected to peak at around 67% in the next few decades (Australian Government 2011). Yet, also important for the economic development in India is its diversity

[121] http://www.elections.in/government/

[122] http://www.panchayat.gov.in/about-mopr

[123] https://en.wikipedia.org/wiki/Panchayati_raj#Post-Independence_period

and the large differences between rural areas (where more than 70% of people rely on agriculture[124], and urban ones).

In an OECD Report on the promotion of strong and inclusive growth in India, policy recommendations address that the strong growth of the economy over the past decades results in the need to increasingly contribute to the well-being of people. Issues revolve around social protection for workers or labor market regulations, but also issues of sanitation or hygiene. Main recommendations are to support a more productive agricultural sector, introduce better school infrastructure, benchmarking of workforce skills to sustain global competitiveness, increase spending on health, further trade facilitation reforms, foster investments by promoting responsible business conduct as well as empowering of local governments for infrastructure projects (OECD 2017). Overall, there remain vast differences in the overall setting in India: a country where on the one hand the agricultural sector lags behind productivity compared to others like manufacturing or services, but made up half of total employment in 2013 (ibid.: 7). Or where child mortality is still twice as often as in other major emerging markets. On the other hand, India has a Space Research Organisation (ISRO), aimed at developing space technology and planetary exploration[125], which is makes up an important element of the country's self-understanding as an independent and sovereign nation. In this tension between basic needs and high aspirations regarding (scientific or economic) development the question arises which function S&T has, or should ideally have and which values shape this. Derived from fundamental needs such as clean water or food security, values revolve around accessibility and basic human dignity, which the state has to take care of. The priority of initiating and supporting high-tech developments is based on an understanding of India as a main player and that progress will in turn serve all people. Values of independence and autonomy of the country play a role here and determine priorities such as a space program. In a way, these different understandings are opposed and may lead to discrepancies and gaps in how S&T is framed, its role in Indian society and regarding future developments. This in turn also has implications for TA in India, as it has to take these very different 'streams' into account in an appropriate way.

5.3.2 Science and Technology Policy Setting

The planning and development of S&T policies has always been a central part of the democratic structure in India. Especially the identity of India as a post-colonial state has shaped S&T policies substantially and vice versa. Understood as a way to foster S&T development, then economic growth as well as societal wellbeing, S&T policies are used as a tool to foster S&T and direct it towards national interests[126]. Historically, the "responses to modern science within the national movement and Indian society were varied, and so was the understanding of science. Often science was equated with modernity" (Chaturvedi and Srinivas 2015: 84). In this way, science is deeply connected to the Independence of India; to its self-conception of a sovereign country. This especially shows in the writings of Jawaharlal Nehru, who was India's first Prime Minister after Independence and as such supported the establishment of several scientific institutions as well as fostering of science education and research. Science was seen as a way forward towards progress and modernization and a scientific temper was part of an ideal citizen. In a statement

[124] http://thecommonwealth.org/our-member-countries/india/economy

[125] https://www.isro.gov.in/

[126] For a brief overview of S&T policies in India see: Chaturvedi and Srinivas (2015).

from 1958 Nehru says: "The key to national prosperity, apart from the spirit of the people, lies in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important […] But technology can only grow out of the study of science and its applications" (Singh 1988: 157). The close connection between S&T and the aspired political development is also because "scientists and technocrats […] shared the visions of the politicians. This alliance led to a broad consensus on applying science and technology in India and to continued support […] from successive governments" (Chaturvedi and Srinivas 2015: 85). A "Nehruvian discourse", emphasizing the key role of the state in S&T for national development and modernization, is still dominant in S&T policy today (ibid.: 90f.). This has resulted in an overall big science model, structures as top down, expert-led with mainly centrally controlled institutions (Pandey et al. 2019: 152ff.). At the time, after Independence, political ideals of how modern S&T in India should relate to society varied (Zachariah 2001; Gandhi 1984; Kumar 2000; Jodhka 2002). Even though the Nehruvian approach was and still is the dominant one, other groups, based for instance on Gandhian ideals, pushed for decentralized and locally specific S&T models, which saw the public in the center (Gandhi 1984; Visvanathan 1997; Prasad 2001). Here S&T were considered to be tools for village revitalization or even social revolution. Modern science would have to be adapted and priorities set oriented along specific local needs in order to come to sustainable, self-reliant and inclusive forms of S&T. The laboratory or scientific discipline as orientation (as Nehru suggested) wouldn't be sufficient in order to understand the relationship between science and society. Instead, each local entity (e.g. village) should be a unit in itself. Overall, this Gandhian view of S&T in society has been mainly excluded in formal policy-making, yet it has been adapted by some actors, for example in the area of sustainable technologies (Pandey et al. 2019: 160f.). Controversies connected to the ideal of big science from the late 1980s on have led to disappointments and disconnects regarding the Nehruvian ideal of the relationship between S&T and society. Large dam projects and resulting local displacement, the Bhopal Gas disaster or risks from nuclear power plants were followed by the rise of civil society groups and NGOs in the 1990s. Mostly these groups favored a Gandhian approach also regarding advice on S&T policy and the inclusion of wider groups.

Overall S&T activities in India take place in various areas. These range from research and development in private industry, independent research institute to S&T in NGOs (especially on the regional development level). Looking closer at the main areas of governmental S&T, on the policy level there is the Ministry of Science and Technology with the Department of Science and Technology (DST), which publishes key S&T documents and are described further below. Other central institutions include: The Department of Space (DoS), Defense Research and Development Organisation, Department of Biotechnology (DBT), Department of Atomic-Energy (DAE) or the Department of Scientific and Industrial Research (DSIR)[127]. Three important actors in driving the S&T agendas of India are the DST, DBT and DSIR. The Department of S&T designs S&T policies as well as fosters R&D through Extra Mural Research Schemes. It also specifically supports S&T for equity, empowerment and sustainable livelihoods at grassroots levels. The Department of Biotechnology is focused on positioning India as a global and competitive player in this area, ensuring its growth but also as part of inclusive development. The Department of

[127] http://www.dst.gov.in/st-system-india

Scientific and Industrial Research promotes industrial research and innovation, aiming to position India globally and to create benefits for people.

Within the Indian government several advisory bodies have been set up aimed to inform S&T policy decisions and have been active under different names since 1995 (Sikka 1995). Advising committees for science on the national level are the Science Advisory Committee to the Cabinet (SAC-C)[128], the Science Advisory Committee to the Prime Ministry (SAC-PM) and the Office of Principle Scientific Advisory (PSA)[129], which is a secretariat for SAC-C and coordinated S&T decision-making. These three committees advise the government together regarding S&T policies, SAC-C being responsible for the implementation of policies, PSA and SAC-PM for formulating them. State-level S&T councils have routine meetings with SAC-PM regarding the implementation of S&T goals and priorities. Further, the Advisory Committee for Coordinating Scientific Research (ACCSR), the first such a committee in independent India was chaired by Nehru and focused on building coherent scientific institutions (Pandey et al. 2019: 155). Table 10 below lists the different national committees for S&T advice over time.

[128] http://psa.gov.in/sac-c-advice-to-goverment

[129] http://psa.gov.in/about-us-introduction

Table 10: National Committees for S&T Advice (Pandey et al. 2019: 155)

S.No.	Name of the National Level Science Advisory Committee	Years Active	Chairman	Goals and Major achievements
1.	Advisory Committee for Coordinating Scientific Research (ACCSR)	1948-55	Pandit Jawaharlal Nehru	Promote institutionalization and organization of science in India
2.	Scientific Advisory Committee to the Cabinet (SAC-C)	1956-68	Dr. Homi Bhabha	S&T cooperation with international organization, promote scientific and technical activities
3.	Committee on Science and Technology (COST) ,	1968-70	Dr. B.D. Nagchaudhri	Recommendation for national science and technology council
4.	National Committee on Science and Technology (NCST)	1971-74	C. Subramanian, T.A. Pai, P.N. Haksar	Science and Technology Plan, State Science Councils, Science and Engineering Research Councils
5.	National Committee on Science and Technology (NCST)	1975- 79	P.N. Haksar, V.G.Rajyadhyakasha,	Panel report on futurology for- education, transportation, communication, housing, rural and urban development, food and energy
7.	National Committee on Science and Technology (NCST)	1977-80	Dr. Atma Ram	Sectoral reports on health and family welfare, mining, transport, special materials, waste management
6.	Science Advisory Committee to the Cabinet (SAC-C)	1981-83	Dr.M.S. Swaminathan	Establishment of national council for S&T, National Biotechnology Board, Technology policy statement (drafting)
7.	Science Advisory Committee to the Cabinet (SAC-C)	1983-85	Dr. M.G.K. Menon	Technology policy, entrepreneurship, science communication
8.	Science Advisory Council to the Prime Minister (SAC-PM)	1986-90	Professor C.N.R. Rao	Setting up of TIFAC, recommendation for the technology policy implementation, technology missions, robotics
9.	SAC-PM Office of Principal Scientific Advisor (PSA) and SAC-C	1991- 1999-2001	A.P.J Kalam Professor R. Chidambaram	Management of land and water resources, Successful nuclear weapon test, technology development fund
10.	Office of Principal Scientific Advisor (PSA) and SAC-C	2000-2018 2005-2014	Professor R. Chidambaram Prof. CNR Rao	National Science and Technology Innovation Foundation (NSTIF), Formation of 5 Centre for Policy Research, STI policy 3013, National Nanotechnology Mission, society for Electronic Transaction and Security, Rural Technology Action Group
11.	Office of Principal Scientific Advisor (PSA)	2018-2021	Professor Vijayraghavan	Yet to begin

Think tanks associated with ministries play a role in shaping policies as well as decisions in the S&T area. The National Institution for Transforming India (NITI Aayog)[130], created in 2015, can be seen as a main policy think tank for the government. It provides advice for the national level but also for the States and as such functions as a platform for the Government of India and the States to act together on national interests, fostering Cooperative Federalism. Another important actor in this area is The Technology Information, Forecasting and Assessment Council (TIFAC), which is a think tank under DST focusing on analyzing future technology domains, assessing possible S&T routes and support of innovation especially between industry and academia. TIFAC has published technology vision documents as well as roadmaps for thematic areas such as health care, water, energy, transport, infrastructure, manufacturing, materials or ICT. Research and Information System for Developing Countries (RIS) under the Ministry of External Affairs focuses on policy research regarding international economic issues and

[130] http://niti.gov.in/

development. One area of RIS is analyzing new technologies and development issues, also regarding capacity building on various technologies (e.g. biotechnology). Another actor in the area of S&T policy is the Energy and Resources Institute (TERI), which is an independent think tank concerned with sustainable development, especially regarding clean energy, water, pollution management, sustainable agriculture and climate resilience. They focus on rural areas and stakeholders such as students and works together with scientists, economists, sociologists and engineers. On the university level, the Jawaharlal Nehru University has a Centre for Studies in Science Policy (CSSP), which researches connections between S&T and society and explicitly aims to engage with policy challenges. Topics include: S&T and innovation policies, gender in S&T, globalization of innovation or technology future studies. Overall, advice on S&T in the Indian policy context takes place in high-level bodies, often by head of large scientific organizations. As Table 10 shows, over time these bodies have been reconstructed to better incorporate the aim of socio-economic development and S&T programs. Including members of the Planning Commission (now done by NITI Aayog) or from other ministries has led to the alignment of the goals of advice on S&T and issues and questions regarding national needs (ibid.). Figure 6 shows the overall structure of S&T policy advice in India.

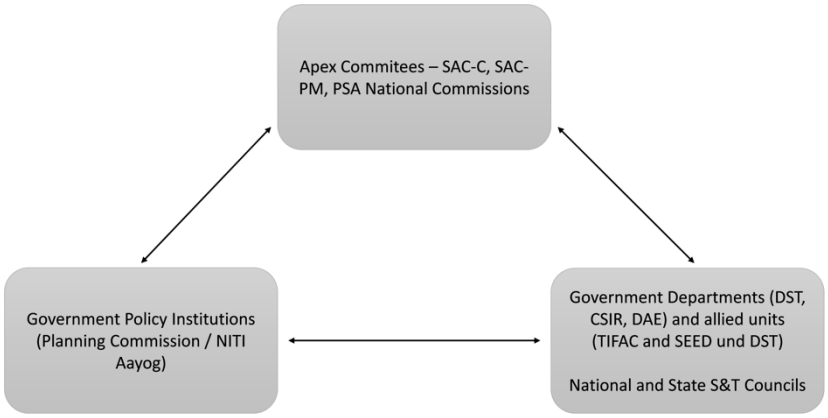

Figure 6: Science and Technology Policy Advice in India (Pandey et al. 2019: 153)

Overall, S&T in India can be characterized in four broad pillars: techno-nationalism (development of own technologies e.g. space, defense, nuclear energy, supercomputers), inclusive growth (focus on S&T working for poor people by combining equity and excellence), techno-globalisation (interactions between internationalization of technology and globalization of the economy, e.g. outside use of Indian low-cost scientific manpower), global leadership (creation of systems that allow for innovation and reversing the "brain drain" out of India). India represents a country with low economic strength but high indigenous S&T capacities (Mashelkar 2008: 299ff.). This shows in the S&T policies over the past decades, which highlight the importance of national S&T to the emergence of a global player.

These documents on S&T policies show the main foci of the Indian government. Since Independence, four S&T policy statements have been released (in 1958, 1983, 2003, 2013), which have set the general frameworks in connection to society[131]. The Scientific Policy

[131] Since 1952 there have been 12 five-year plans overall, up to 2017. For an overview see: Chaturvedi and Srinivas (2015: 85)

Resolution of 1958[132] recognizes the importance of science for the development of India and the need to apply it to the country's needs. Here the focus is on S&T and its industrial potential as well as an ideal promotion of a 'scientific temper'. With this strong emphasis on industrialization, S&T is seen as the way forward for India's large resources of man-power. This should help India move past pre-Independence colonialism, which saw scientific institutions as a way to expand the British Empire's rule. As an independent country, India would now have to build institutions and capacities in basic sciences that would benefit the country itself. The 1958 resolution stresses the importance of developing S&T at an early age in order to reduce drain of capital especially at an early age of industrialization as in India at the time. Therefore, as the resolution states, the cultivation of national S&T is of great importance of the Indian government and their S&T policies. The resolution shows a certain urgency to initiate programs for the development of a newly independent country and to foster the S&T capacities that are directly tied to the needs of the country for example in education, industry, agriculture or defense.

In the Technology Policy Statement from 1983 the strong agricultural and industrial basis resulting from the 1958 resolution is described. Building on this, a next step is seen in the continuous fostering of S&T as the very basis of economic progresses, which in turn will lead to alleviation of poverty. Also, here we find the importance of political freedom, which in turn is tied to economic independence. Developing S&T in India is seen as an important next step, beyond expanding scientific knowledge. Further, there is a strong connection to the local in the statement: S&T need to fit to the specifics of local communities. The financial opening up of India also reflects here as the approach is that of a mixed economy with private, public and joint sectors and including those with foreign equity participation. Since Independence, the development of indigenous and the adaptation of imported technologies is stressed as a way to gain further self-reliance, also in terms of national security. Indigenous technology development within the country by strengthening and diversifying shows the priority of reducing dependence, while still mixing with imported technologies. A certain distance of Indian scientists regarding local realities and issues resulted from the strong focus on building state-supported world-class scientific capacities, therefore the shift towards indigenous resources (Pandey et al. 2019: 162ff.). The document also refers to technology assessment for acquiring technologies. The evaluation of potential imported technologies requiring large investments or regarding national security should also be assessed according to aspects of employment, efficiency and environment. Overall, priorities in the statement include employment (ranging from use scientific talent to diffusion of technologies to reduce regional inequalities), energy, productivity or the environment (Government of India 1983). Regarding institutional changes, through efforts from the National Committee of Science and Technology (NCST) itself set up in 1971, the SAC-PM and resulting from this 1983 policy itself, TIFAC was created in 1988.

The Science and Technology Policy of 2003 was developed by involving (social) scientists, activists and citizens, which also was done via a draft online version open for discussion. A main objective in the document is to integrate S&T into all areas of national activity while taking sustainability into account, overall a more holistic approach. Referring to the past documents, the commitment of India to promote the spread of science is highlighted as well as the advances regarding food production, eradication or control of diseases and increasing of life expectancy. This document shows a more comprehensive view towards the effects of S&T on society and

[132] http://www.nrdms.gov.in/sci_policy.asp

goes beyond a 'scientific temper' focus to include S&T developments for every day. The benefits of S&T are mentioned, yet also dramatic changes in S&T and the relationship with society. This in turn requires a multi-institutional and international approach as well as a policy view that sees science and technology as closely connected. In this setting, policies should enable S&T to raise the quality of life, especially in disadvantaged parts of society but also ensure that India remains competitive in the new era of globalization. For this a main objective is to ensure that all citizens are able to participate in S&T development and application. This shows the aim of fully integrating S&T activities on a national scale. Challenges are mentioned in the document and include: food security, agriculture, water or energy but also the alleviation of poverty. For this, appropriate technologies should be widely distributed through networks. Regarding the academic field, the goal is to create and maintain centers of excellence and through these rise to the highest international standards. In this context, the importance of social responsibilities and commitments of these institutions is stressed. Cooperation between the private and public sectors are seen as a way to encourage research and innovation in key areas (e.g. agriculture, water, health, biotechnology or information technologies). For reaching these goals a dynamic and flexible S&T policy is needed. Further, this is seen as a way to ensure India's role as an important "global player in generating and harnessing advances in science and technology for the benefits of all humankind" (Government of India 2003). The implementation of this is described in several points, such as investments in S&T, new funding for basic research or human resource development. But also issues of governance are addressed. In order to gain continuous input for policies, scientists as well as professional bodies will be utilized in order to inform government decision making. A further aspect is the use of indigenous resources and traditional knowledge, which should be integrated with the development of technologies (e.g. research on traditional systems of medicine and its commercialization). The public awareness of S&T is described in the overall policy strategy and revolves around science communication activities. Public interest should be increased and scientific knowledge be disseminated in order to popularize and promote S&T. The ethical, moral, legal, social and economic aspects are mentioned and the importance of the public's capacities to consider these. Yet, creating awareness and promoting S&T is seen mainly in providing information to the public (mainly one-way communication) (ibid.). This policy is focused on developing more robust innovation systems in India in order to enhance exchanges between the government, industry as well as the scientific side. In this approach, the management of this remains in the area of scientists and engineers in a top down way. These are also the actors who then mainly decide what the relationship between S&T and society should look like and what socio-economic impacts could be (Pandey et al. 2019: 164f.).

The latest general S&T policy document is "Science, Technology and Innovation Policy 2013", which focuses on faster, sustainable and inclusive growth of the Indian STI system. In preparation for the document, an approach paper was initiated by the Planning Commission of the government to set the main targets and define key challenges. It was developed using a web based consultative process open to all interested persons[133]. The policy document itself refers to the previous ones from 1958, 1983 and 2003 and now regards the importance of innovation as an instrument of policy, in which "S&T led innovation [is] a driver for development" (Government of India Planning Commission 2013). The integration of S&T and innovation is tied

[133] http://planningcommission.gov.in/plans/comments/inter.htm

directly to the global competitiveness of India (the country should be among the top five scientific powers by 2020) as well as contributions to the social good and economic wealth. The approach of science diplomacy is mentioned as a way to establish strategic partnerships with other countries. Next to this, endogenous resources are needed to realize "***Science technology and innovation for the people*** [as] the new paradigm of the Indian STI enterprise" (Government of India Planning Commission 2013). The document shows a strong emphasis on making India a top contender in the global science community, for example the impact of Indian publications should improve and at least match a world standard. A further goal is to increase spending and activities already at school levels in order to develop young leaders in S&T. Gender aspects, inter-university centers, participation in global R&D infrastructure and big science projects, performance-linked rewards and investments are policy objectives described in the document. A further aspect is the development of national indicators for the innovation which take into account measures of excellence as well as relevance and affordable innovation, which in turn can direct evidence based policies. Also, global challenges such as climate change are mentioned, in which STI play a role in finding solutions on a national as well as contributing on an international level. New policy initiatives towards the establishment of partnerships with the private sector are described and include establishing large R&D facilities for public-private-partnerships, nurturing business incubators or allowing for multi-stakeholder participation on the R&D system. This also concerns the inclusion of NGOs, which is specifically mentioned in the context of their role in the delivery of STI outputs, especially rural technologies to the grassroots level. The document also described the importance of public awareness and public accountability, again focusing on science communication as a way to promote the "civilizational aspect of science, or scientific temper" (ibid.). The main goal hereby is to raise the knowledge of people and decision makers of implications of technologies (ethical, social, economic aspects) and also to assess the performance of the national STI system by means of an "autonomous and robust evaluation system, which includes social scientists" (ibid.). Overall, this document "comes with an active recognition that despite 50 years of state-funded support to the enterprises of S&T in India, economic reforms in the form of liberalisation, a majority of the population is still excluded from the developmental agenda" (Pandey et al. 2019: 164). Yet, it seems it still has a mainly technocratic and expert-oriented approach, focused on inclusive growth and trickle-down effects if economic growth. The informal sector in India makes up a majority of the livelihood in India (Gadgil 2014), which isn't accounted for in the policy document, focused mainly on S&T development programs. This would then include focusing government attention and funding on changing institutions or ways of governing towards actual inclusion of the public. Low-cost S&T solutions that have been developed also need to be made available for, for instance, rural population with the help of improvements in investments and governance or institutional mechanisms (Pandey et al. 2019).

It is clear from the descriptions above that the government sees India as becoming a global leader in science while at the same time supporting indigenous innovation with a close tie to the concrete challenges facing India. The Science Advisory Council to the Prime Minister provided a report in 2010, in which the vision of a global leader is clearly stated. This connects the well-being of a large part of the population (including access to education, health care and living in security) to the strategic fostering of science and at the same time the emergence of India as a global leader in the two next decades (Science Advisory Council to the Prime Minister 2010). The report references studies from the United States and describes that India is not comparable to

the world peaks at the moment but aims to change this by tapping into the vast potential of the country, e.g. large population. It also addresses fairly critically that India is still behind other countries and needs to invest more in S&T resulting from the large economic growth of the past years. Again here, main challenges facing India are identified, such as equity and social justice, health care for all, food security, skill development or stronger innovation systems, and the connection to the appropriate use of science. Also mentioned in the report is that during the past planning periods S&T Advisory Committees (25 in total) were called for but only partly implemented. Many of them weren't able to actually create impact, namely programs or projects. In order to raise the investments and the impact of S&T the Council calls for the restructuring of the scientific advisory system, which for example exploit the strengths in national laboratories. For this a new mechanism must be implemented by the Prime Minister and the Cabinet in order to better the functioning of the Advisory Committees it ensure that science plays its role in national development across different sectors (Government of India Planning Commission 2013). In the report, a part is dedicated to the question of how to get good advice regarding pressing issues and S&T developments. The economic or social impact but also the potential political debates of these initiatives require advice. Here again, mainly science communication is called for in addition to efforts by the Government "to get the most unbiased and accurate advice possible by calling on the academies of science to present accurate accounts of the state of the art" (ibid.: 31). It is further suggested to use the Science Advisory Council itself or a National S&T Council, which could be assigned major scientific assessments "by commissioning reports through well-defined contracts and for advising the government on relative priorities in S&T and associated investments" (ibid.).

A key document regarding the future of S&T in India and its integration into society on all levels is the report "Technology Vision 2035"[134], which was written by the Technology Information, Forecasting and Assessment Council (TIFAC). TIFAC has conducted a previous vision study for 2020 (in 1996) with the aim of providing direction in S&T to make India a developed country. This was done in the light of India's growth and new expectations resulting from this. The Technology Vision 2035 is written from the perspective of India as a developed country in 2035 and is centered around identifying the different needs of Indians and how S&T can meet these. For example, the document acknowledges that "in the past few years, environmental and public concerns have become central to any development-related policy planning and impose additional constraints. They have to be wedded into any policy planning exercise rather than added on later. [The report] considers the technological 'peoplescape' of India to be as important as its technological landscape" (TIFAC 2015: 28). The people-centric approach of the Vision is based on characteristics such as the large size of India as well as its diversity. This shows in the 'categories' of Indians in 2035 that the report departs from: rooted and remote (20%), left out or left behind (30%), creative and innovative (15%), globalized and diaspora (30%), alternative lifestyles (15%) and beehives and production lines (55%). Basic needs such as identity, prosperity and security vary in importance among these groups, for example the beehives regard security as important whereas the globalized see identity as an essential need. The Vision takes the relationship of technology and wider society into consideration, describing that boundaries between the two cannot be drawn clearly, resulting in the perspective of "social constructivist […] in which society and technology are mutually impacting" (ibid.: 46). Based on

[134] The full report can be downloaded here: http://www.tifac.org.in/images/pdf/tv2035/TV%202035%20Doc-Last%20final-release.compressed.pdf

this, 12 prerogatives, which should be available to each Indian by 2035, form the core of the Vision and form the policies needed to reach this. These address individual needs (e.g. food security, healthcare, energy, water, education, housing) as well as collective ones (e.g. mobility, public safety, diversity, transparent and effective governance, climate resilience, conservation of natural resources). Each prerogative is described in detail with technology concepts and approaches, which relate to each including an assessment ranging between readily deployable and still envisioned. On a more general level, the document also reflects the increasing global competition and the pressures that result from this. Further, it makes the direct link between S&T development and independence: "As the colonial period reminds us, the consequence of technological underdevelopment can be the loss of our freedom and autonomy. Since Independence, India has sought to maintain its strategic autonomy at all costs" (TIFAC 2015: 107). Part of the vision is therefore to ensure India is a major player in order to use its market attractiveness in a worldwide positioning. This shows a more towards a further opening up towards a global level of S&T: "Since technology is a fundamental element in comprehensive national power, accessing, producing and leveraging technology will remain a core national interest with strong external linkages" (ibid.: 108). In the beginning of 2018, the Office of the Prime Minister stated that the Technology Vision 2035 should be taken forward by all connected departments under the lead of NITI Aayog. This can be regarded as an encouragement for the work program of TIFAC and shows an interest of the government for this type for assessment and foresight.

A further vision document is the "Science & Technology Vision 2032" in which the think tank NITI Aayog aims to create a common vision for the next years, including a strategy for the next 7- and a 3-year action plan. The overall vision is to transform "S&T, education and innovation eco-system to achieve improved quality of life and strategic advantage in India, through sustainable development and cutting edge technologies to place India among the top science faring nations" (The National Institution for Transforming India 2017). As such the Vision aims to go beyond specific targets to transform the way S&T is managed and to address issues of quality of life especially in the poor and rural sectors. For the 7-year implementation strategy, the document proposes the establishment of a new body: The National Science, Technology & Innovation Foundation (NSTIF), which in sub-committees should identify and coordinate with different stakeholders for implementing S&T in areas such as sustainable development, resilience to disasters, technologies for national security, basic and mega sciences and grand challenges and cutting-edge technologies. For these areas, specific goals are defined (e.g. doubling agriculture production by 2032, reducing import of defense equipment by 20% by 2032 or a manned mission to space by 2032). The NITI Aayog vision document refers to the TIFAC one, stating that the technologies described in the TIFAC vision should be examined and appropriately followed for addressing national needs.

Overall, the documents and institutions described above show a certain line of development: from a newly independent country focused on gaining sovereignty also through S&T developments (1958), to an economic opening up and fostering of industrial growth (1983), to a focus on sustainability which includes societal aspects to a certain degree as well as India becoming a global player (2003), to an emphasis on inclusive growth, global competitiveness as well as increased private investments (2013). It becomes clear that in "India, as in many post-colonial countries, the state has played a major role in using science and technology for national development besides giving it a special thrust. While India succeeded in creating a sizable

science and technology infrastructure within five decades of independence, the globalization of science and technology and changes in the external economic environment necessitated a change in the orientation of policymakers" (Chaturvedi and Srinivas 2015: 83). This shows in the Technology Vision 2035 report, which is based on an understanding of India as a developed country, that must take the diverse needs of its people into account, also in regard to S&T policy-making. This document shows the quite rapid developments over the past decades as well as the discrepancies between many areas and groups in Indian society. S&T is seen as the way forward, there is a strong belief in its continuous growth and the need to widely expand and foster it (e.g. a space program). Similar to China, we can see the strong emphasis of development and further economic opening up. Yet, in India the pluralistic democratic structures as well as the strong consciousness and explicit awareness of diversity and heterogeneity (as an asset) shine through S&T policies as well as very basic needs of people. This commitment to diversity and the needs for strong and world-leading S&T development also has the potential to create certain tensions between the various needs. On the one hand, policies and S&T are concerned with providing clean water to all, on the other India is aiming to be a top player in the global scientific community. For S&T policies this means dealing with very diverse needs on the national, but also on the global level as well as different arguments for legitimization. Overall, the institutions described above seem to lack capacities to include the diverse input from Indian society. The mainly technocratic and expert-led, Nehruvian S&T understanding also means that the awareness of interdisciplinary approaches is lacking (Pandey et al. 2019: 169ff.). This shows in organizations that are either good in looking at the scientific aspects (e.g. TIFAC) or in the societal implications (e.g. TERRI). Yet the connectedness of these aspects is still underrepresented in S&T advice. In this sense, a challenge is that S&T policies in India have "to balance between competitiveness and inclusiveness" (Chaturvedi and Srinivas 2015: 87). These tensions and their attempted resolution also reflect in the specific values, which are part of S&T policies. Even though these aren't explicitly named in the policy documents, they do show in objectives and main aims to foster economic and social development as well as bringing the benefits of S&T to everyone. These values can be useful to understand policies in their wider societal context. Further, they also offer starting points for understanding under which criteria S&T are or can be assessed or even debated in the Indian context. This shows the specific characteristics, the cultural, ethical background which shapes any decision making on S&T.

5.3.3 Values and Science and Technology

Looking at the documents described above, the question arises, which values or ethical considerations are mainly relevant in the Indian context. The argument can be made that universal or commonly used values such as autonomy, dignity or justice often remain too abstract regarding S&T policies as well as the distribution of S&T. Especially in the Indian setting, with high diversity and substantial differences throughout the country, values like access, inclusion and equity can be more useful and relevant to understand S&T policies and their effects. When looking at the Constitution one can identify basic values and characteristics that in turn shape societal discussions on S&T, art, education or developments in society. It states main values such as justice, liberty, equality and fraternity at the very beginning, stressing the importance of freedom or dignity of individuals as well as the Indian Nation (Government of India 2015). Further, underlying beliefs such as self-reliance, strong trust in (economic) development, social progress and coherence shape the system as well as debates (also in S&T

contexts) in India (Chaturvedi et al. 2015b: 166). Access, inclusion and equity "can be considered ethical values and can be used to assess policy outcomes. This makes better sense in the Indian context, as it links societal development with science and technology policy. It also reflects the current thinking on sustainable and inclusive growth" (Chaturvedi and Srinivas 2015: 95). Access refers to the actual access of S&T as well as to information and the possible benefits of S&T. Inclusion means that all sections of society should be part of S&T developments, especially as beneficiaries. Their needs should be addressed in the development of S&T, as citizens and consumers. Equity is about the fair distribution of sharing of the benefits of S&T as well as directing S&T to facilitate this. Of course, the three are interlinked: access and equity can only be achieved with some form of inclusion. Using these as guiding principles to assess impacts of S&T policies, which "means S&T policies should ensure that policy design or institutional frameworks do not reduce access, result in more exclusion and more iniquitous distribution of benefits" (Chaturvedi et al. 2015a: 3). As mentioned above, a predominant discourse was and still is the Nehruvian one, which presumes that big science and S&T development can result in societal transformation, also regarding access, equity and inclusion. Yet, as neutrality of S&T was often assumed, attention was mainly paid to the application of S&T rather than to assessing it under aspects of access or inclusion (ibid.: 16). Policies have emphasized capacity-building and infrastructure development in single scientific disciplines, resulting in a lack of awareness or capacities of scientists and engineers to actually address social, ethical or cultural aspects Major scientific institutions mainly focused on disciplinary curricula and a hierarchical understanding of knowledge became predominant, following the logic "the more a discipline is limited to mind, coded knowledge and laboratory space, the more valuable it is. While if knowledge is developed in relation to practice in the outside world […] it is looked down on as inferior within the science hierarchy" (Pandey et al. 2019: 170). This has changed to a certain degree, for instance in Indian Institutes of Technologies (IITs) humanities and social science departments have become part of the institutions.

This shows why the strong emphasis on scientific development, big science and expert-led focus has led to a lack of indicators for access, inclusion and equity within the S&T policy system. Specific programs for these values are needed, as economic growth alone doesn't ensure their compliance. In this context, the authors call for a wider debate on socio-economic assessments of policies or programs. An example, which reflects these values is the Science for Equity Empowerment and Development (SEED) Program[135], which is located at the Department of S&T, as seen in Figure 6 above. This program specifically supports projects, which use S&T to improve poor and disadvantaged areas of society, especially focused on rural areas. The program links national S& institutions with grassroots S&T initiatives. The approach is based on need assessment and identifying technology gaps, technology appropriation, capacity-building and technological empowerment and overall sustainable growth. This example shows that using access, equity and inclusion as values to understand and assess such a program is more useful in the Indian context. It allows the outcomes of such a program to be regarded according to whether a specific group was able to actually make use of technologies, whether they were part

[135] The SEED program was established in 2011 and includes projects such as S&T for women, assistive devices for public bus access or solar food processing technology for making fruit bars from Himalayan fruits. All projects and programs are described here: http://dst.gov.in/scientific-programmes/st-and-socio-economic-development/science-equity-empowerment-and-development-seed

of the development process and whether the technology improved fairness. In this sense, a normative level of assessment is possible, e.g. was the program able to adequately address specific needs in a qualitative way?

Next to using these values as a way to understand policies, they also provide a way to shape S&T and its application towards becoming better suited to the needs of a diverse country. Access, equity and inclusion aspects should become part of the policy-making process itself. Further, "India should propose a network of institutions in developing nations working on AIE [access, inclusion, equity] issues and S&T policy issues and this can be integrated with multilateral S&T collaboration framework. This will enable developing a 'Southern' approach in AIE issues and will strengthen the capacity in S&T policy making in developing nations" (Chaturvedi et al. 2015a: 26). The S&T policy documents described above also raise questions or even certain tensions regarding the values of access, equity and inclusion. As stated, these seem especially useful for the Indian context, as they enable a fitting way of assessing developments and outcomes. Yet, the opening up and active move towards India becoming a global leader in S&T may also result in tensions with these values (as in many other countries of course). At the very least it means that these values need to be continuously reflected within the country itself (high diversity among people and regions) as well as in the context of India as an (aspiring) player on the global S&T stage. This is also where ethics and engagement (as described in chapter 4) play a role. If values such as access, equity and inclusion are defining ones for S&T policies, then the question arises how this can be accounted for. Ethical considerations by citizens as well as their engagement are needed in order to enable access and equity in such as heterogeneous setting.

As Brom et al. (2015: 17ff.) describe, the institutionalization of ethical debates in India (and China) does not necessarily follow the form of advisory committees as a way to protect citizens fundamental rights against S&T developments. Instead, looking at the policy developments also evident in the documents described above, ethics in S&T aim to shape S&T developments to resolving societal issues, especially by taking social justice agendas into consideration for those in need. From the beginning of Independence, the fostering of S&T has been seen as a way to empower India as a nation as well as address huge challenges such as water, health or energy. As seen in the S&T policies the agenda of sustainable and inclusive growth is one that has become prominent. In this sense, assuring the most benefits to as many people as possible is part of the 'ethical' considerations within policy-making for S&T. In India "the orientation of science and technology programmes has been to use science and technology for development purposes, and to catch up with advanced countries" (ibid.: 19). Seeing S&T development as a way to achieve more social justice, oriented along the values access, inclusion and equity, shows that in the Indian context, ethical debates often take place in a wider context than focusing on effects of S&T and possible risks for the individual.

For example, new food technologies[136] show a connection between the strive for development and issues of social justice. After Independence, a main goal for India was to increase food production substantially. The Green Revolution transformed agriculture in India by implementing modern technologies, focused for example on grain production. Yet, this

[136] Other technologies that stress the importance of innovation and development for solving societal challenges are nanotechnology (Fautz et al. 2015) or synthetic biology (Rerimassie et al. 2015). Discourses on these technologies show a stronger emphasis on innovation or potentials than risk tied to the goal of achieving accessibility, equity and inclusion.

revolution also produced negative outcomes for small farmers (tying them to seeds, fertilizers, etc.), regional inequalities regarding access to technologies as well as on the environment (Coles et al. 2015). In India, there has been a strong debate on GM foods, resulting in a moratorium on field trials of genetically modified crops. In this context, the question of how to deal with these debates comes up. Public and political debates, which are intensifying, for example on issues such as GM foods, require different approaches to policy and decision-making; there is a need to engage different actors. In India, S&T policies "which grew under Nehru's idea of "scientific temper" very conveniently left all decisions to scientists [now] there is a need to make the policymaking process more inclusive" (Chaturvedi and Srinivas 2013: 20). Reference to this scientific temper and needed advancement can be found in policy documents, where it is connected to the emergence of a progressive and enlightened society. For this, raising awareness is required in order for citizens to better understand the various implications S&T developments can have on their daily lives (including ethical, moral, legal or economic aspects). Under point 12 of the 2003 S&T policy this is addressed by calling for the support for the wide dissemination of knowledge on S&T, popularizing and promoting it (Government of India 2003). Overall, these activities can be understood as science communication (similar to the Chinese context), through which citizens should be empowered (by experts) to then ensure S&T benefits for all. More interaction is called for between natural and social sciences in order to add value and impact. In the 2013 policy document we find references to the role of NGOs in the delivery of S&T outputs on the rural and grassroots level as well as to the importance of public awareness. Again this is focused on the promotion of S&T across all sections of society highlighting the civilizational aspect of S&T. Debates should be based on evidence and the use of evaluation systems should ensure public accountability (Government of India Planning Commission 2013). This document stresses the importance of communicating and educating the public as a way to make them aware of ethical, social or economic implications. These documents show that while access and inclusion are key values within S&T policies and are referred to, the actual inclusion of lay ethics or implementation of engagement remains fairly limited. A truly inclusive form of policy development and application of S&T strategies for social justice would need to go beyond science communication. Instead it would mean finding ways of connecting the aims of accessible, egalitarian and inclusive S&T with engagement processes that can actually help identify needs. In India, the demand to achieve social justice through S&T needs forms of engagement that are not only about informing the public about S&T, but also show ways in which (ethical) considerations can be taken up onto the policy and development level. This of course, is not an easy endeavor since various stakeholders, interest groups and a diverse population need to somehow be heard. In this current setting TA can provide ways forward regarding the inclusion of societal needs and questions of social justice in S&T policy-making. Assessing technologies, but also coming to forms of including lay ethics through engagement exercises can be a contribution of TA in India.

5.3.4 Reflections from the Interviews

5.3.4.1 Questionnaire and Data Collection

How do pressing societal issues find their way into S&T policy-making? How are tensions between high-tech S&T developments and very basic needs of people dealt with? What forms does Technology Assessment take on in the Indian context? In a diverse country like India, how

can engagement and ethical reflection take place? What are specifics of the Indian context also regarding global approaches? These were the guiding questions for the interviews in India in order to uncover activities in the area of TA and to contextualize these.

As in the Chinese interviews, it became clear the questions in India also needed to be adapted to the various actors and settings. Since the awareness of TA as a concept, but also of ethical considerations as well as engagement methods varied, the interviews were very different in terms of the main topics of discussion. This provided diverse foci depending on the person interviewed, their background as well as position. Some interviewees had a background in TA (or TA-like activities) and for example knew the European or German discussions very well. They could therefore reflect on TA activities in India against the background of other contexts in which it is more established. Others, gave very specific insights into the characteristics of the Indian landscape; its diversity and main issues that it faced (e.g. access to technologies). As in China, awareness regarding societal aspects of S&T seems present, yet it isn't taken up systematically. Different than in China, there is an active civil society, which can shape debates and get involved in decision making. Yet, this is very specific to different areas or topics (e.g. GMOs).

The India interviews took place in May 2017 in Delhi in English. One interview took place in January 2018 in Berlin. The interviewees were provided with a short input on TA and the global context. In total 9 persons were interviews in key positions which can be related directly to questions of TA (Table 11). These were: *The Technology Information, Forecasting and Assessment Council (TIFAC), The Centre for Studies in Science Policy (CSSP) at Jawaharlal Nehru University (JNU)* as well as *The Ministry of Science and Technology.* Two think tanks were also included *Research and Information System for Developing Countries (RIS), The Energy and Resources Institute (TERI), Embassy of India as well as an independent researcher.* A local contact person with knowledge on TA and the Indian S&T policy setting identified and contacted these interviewees as they represented relevant institutions and personal positions. As in the Chinese case, the access gained through the contact persons proved to be highly important in order to even be able to interview these key individuals.

Table 11: Overview of Interviews India

Institution	**Individual interviews**		
	High level (e.g. director)	Senior researcher	Junior researcher
TIFAC	1		
Ministry S&T	1		
Embassy India	1		
RIS		1	1
JNU		1	1
TERI		1	
Independent		1	

The questionnaire was structured according to different aspects, which started with a more general level regarding societal issues in S&T, TA in India (roles, main addressees, etc.), understanding of engagement and ethics as well as the issue of global TA from an Indian perspective. The first round of questions aimed to address the relevant societal issues in India and how these connect to S&T (Table 12). This proved a useful way to begin discussions on how S&T policy is done in India and how it is framed.

Table 12: First Round of Interview Questions India

Societal Aspects of Science and Technology:
What are the main grand challenges that Indian S&T deals with?
What are the main societal issues influencing S&T in India? (prompt here if needed: access, inclusion)
How does policy connect these issues and the development of S&T in India?

The second round was focused on understanding how TA is understood and what TA-like activities the interviewees find relevant (Table 13). Further questions were concerned with the role of TA in S&T policy and what its potentials and institutional forms may be.

Table 13: Second Round of Interview Questions India

Definition:
What is TA for you? How would you define it?
What is the role of TA in India's S&T policy structures? What role does TA play in S&T debates in India? (prompt in terms of: stakeholder inclusion, policy relevance)
How could TA improve science and technology policy-making in your opinion? What changes would be needed in order for this to happen?
Roles:
Where do you think TA has the most importance? And why?
Where can TA have the most impact?
Institutionalization:
In the Indian context: Where does TA (in terms of societal assessment of technologies) take place?
Who should be the main addressee of TA? (prompt: government, parliament, public)
What expertise is needed in Indian TA activities? What is missing?
Where do you think TA should be located? Should it be institutionalized? How?

The next round of questions dealt with the idea of engagement and ethics based on the conceptualizations of TA in chapter 3 and 4 of this thesis (Table 14). Main aim here was to understand how TA can take place through engagement and ethics, how this is understood and what shape it take on in the Indian context. Building on the questions on the societal issues of S&T and the challenges facing India, this round of questions wanted to gain further insights into how engagement is perceived and conducted as well as who should be involved in ethical considerations of S&T developments. This is especially interesting in democratic India since there is a basic understanding that each citizen has the right to be heard, yet for example discrepancies in literacy can make this difficult.

Table 14: Third Round of Interview Questions India

Engagement:
How could engaging the public regarding questions of science and technology take place? What is your experience in this?
What are the benefits or risks when engaging with the public?
In your opinion, how should the public be engaged in S&T debates and at what stage of the technological development?
Ethics:
Who should be involved in helping to identify and assess potential societal risks and ethical aspects of research? Why?
What role do ethical considerations play when assessing technological developments?
How do you think ethics assessment could be done ideally and who should be involved in this process? (public, experts?)

Questions on global TA were aimed at uncovering how this is seen from an Indian perspective and where there are areas of communalities as well as non-communalities could be (Table 15). This also was aimed to understand what Indian expectations towards a global level of TA could be.

Table 15: Fourth Round of Interview Questions India

Global level of TA:
Do you think TA-like activities are important on a global level? How would you like to see global TA take place? In what form and what institutional arrangement?
What are the main Indian specificities that need to be included in a global TA undertaking?

As mentioned the questions were rarely asked in the strict order presented above. This was due to the very different backgrounds and preconditions of the interviewees. Because the interviews usually focused on very different aspects of the questions, in total they provide a useful basis to understand the various aspects of the S&T system as well as what components a TA in India should have and how it might be realized, also regarding engagement and ethics.

The data collection was done with audio recordings and transcribed interviews. According to guiding questions the interviews were analyzed and partly transcribed. The literature review of the Indian S&T policy system as well as experiences in interviews and discussions in the field helped form an overall framework of questions:

1. What are the main societal aspects of S&T in India?
2. What does TA in India mean regarding institutionalization and roles?
    a. Which methods of ethical consideration are used?
    b. Which methods of engagement are used?
3. What aspects are important for a global level of TA?

According to these questions, the interviews were analyzed and are interpreted in the following parts, again by including direct quotes from the interviews which highlight important aspects and underline arguments.

5.3.4.2 Societal Aspects of Science and Technology in India

The specific societal and political setting of India is the frame in which S&T take place. Competitiveness as well as inclusiveness shape S&T decisions and policies and are also the habitat in which TA(-like) activities in India take place and which define the needs described towards different forms of TA. As explained above, S&T take on a key role in the understanding of India as an independent country, which on the one hand has many basic needs fulfill and on the other strives to be a global player. Yet, the interviews showed a certain skepticism towards India being a global leader in S&T since the country was described in a passive role regarding developments in other countries, not able to set trends or lead in any specific discipline:

> *"Indian S&T follows a global trend in the sense that we are more like followers" (Interview 3: 0:50).*

Additionally, the diversity of India, ranging from cultures, languages to geography corresponds with the democratic political system, which has to take all these aspects into account to some degree. This results in a heterogeneous setting in which issues of access, or inclusion are important, as mentioned above. S&T solutions need to account for the range of people and their means, which in turn also frames and effects policy-making. Interviewees described the cultural, geographical and monetary divides across India, which result in the need for *"different formulas for different adaptations"* (Interview 6: 0:50). These societal aspects and their diversity need to be accounted for in S&T

> *"as it's very important to actually look at the technology from an Indian perspective because it's not one India. Its hundreds of India within India" (Interview 4: 1:08:50).*

This shows the complexity and diversity regarding the societal aspects of S&T, which need to be taken into account in order to understand the Indian context. Overall, as described above, S&T shape the self-understanding of India as a sovereign country and big-scale technologies with national interests have been the focus. Strives in sectors such as space, atomic energy or missiles are also key due to their strategic importance. This is an example, which came up again and again (in some form) during the interviews and which corresponds with the descriptions of the S&T documents above. For independent India, S&T has played a key role historically and continues to shape the way S&T are understood and what role they play for the country. The main notion seems to be science for development, in the sense of large-scale S&T activities are important to bring science as such forward, not necessarily tied to specific needs or necessities. This also shows in the lack of awareness of people's ability to make decisions regarding this and to be part of the discussions on how S&T should be shaped. Science is part of the civilization project of India and therefore the inability to reject certain S&T developments or discussing alternative options.

> *"I think the option of saying no to science is really difficult for some people to take" (Interview 8: 2:56).*

This can be connected to the Nehruvian ideal of science, as described above, which took on a central role during Independence and fostered *"big science" (Interview 8: 4:35)*. Included in this view was the idea that the public doesn't know enough about science and shouldn't have to. A certain contradiction shows here. On the one hand, S&T was seen as a main element of and

independent India. On the other, ideas of colonialism still remained in the sense that people weren't seen as capable of being knowledgeable about S&T developments.

> *"because I think that Indians also have a lot of colonial hangover, but, yes I think that this idea of this idea of 'people don't know anything' comes from very colonial imagination of a country that somebody from the West goes and looks at the people and their way of life and sees oh they don't know anything and their way of living life is not right" (Interview 8: 5:11).*

This seems to result in a lack of awareness or willingness for the government side to include different actors in decision-making, which in turn shapes the understanding of engagement and ethics as described below. Since S&T are part of large scale developments important on a national level, they aren't necessarily connected to everyday needs of people. Therefore, there isn't a perceived need to engage with other actors. A lack of readiness to encourage S&T developments to take various needs and aspects of accessibility into account was described in several interviews. This was related to a normative understanding of the importance of empowering people through S&T. It seems to be necessary that the government see S&T as a way to solve actual societal problems in appropriate ways.

> *"government […], please use S&T to seek innovative solutions, which are affordable also and which are accessible also to, to help people address these solutions" (Interview 1: 1:55).*

India as a developing country should see S&T developments as a way to empower its citizens. In the interviews, the underlying values of access and inclusions showed in the sense of providing a comparison to how S&T should be conducted and what it's role in society should be, also since

> *"in a developing country like India, S&T has a larger role to play in terms of empowering the people who are at the bottom of the parameter. So, S&T have to be seen as a tool of empowerment. And for that S&T have to be […] accessible, affordable, inclusive" (Interview 7: 1:00).*

Even though solutions for basic needs are necessary, there seem to be difficulties to find S&T developments that take this into account. This has to do with problems of scaling up, and the question of *"a prototype, but who will make it mass production?"* (Interview 1: 3:10). Further, the issue of affordability is a key point when developing technologies suited for users' needs. This also results in limited capacities and activities in important areas.

> *"the number of people who are working in these areas [e.g. Nanotechnology related water issues or health applications] and the number of projects also not big enough […] it's a very closed community with very little interaction with actors of civil society or within that community so there's not much […] debate" (Interview 3: 7:05).*

This in turn leads to a discrepancy in what kinds of research are funded, which was criticized in an interview, since only small amount goes to funding research on specific needs such as nanotechnology in the area of water or health. Decisions seem often to be made according to larger missions,

> *"funding is not decided by policy access, equity, inclusion or anything, funding is decided more by the way the whole Nanotechnology mission tries to work with" (Interview 3: 4:09).*

A main aspect of the overall societal setting of S&T in India was seen in the context of the country's diversity. This is a value or asset in itself, as it can help shape technology in more diversified ways. Again, this fits to the differences in the necessity to adapt S&T to actual needs

and many of the current S&T priorities. Based on diversity, also regarding different types of knowledge (e.g. traditional, grassroots) a more holistic approach would be possible.

> *"India has a more diversified knowledge system […] It's [diversity] is an asset, I don't think it's a challenge […] on the level of grassroots innovations […] in traditional system it was not compartmentalized, the need for technology [assessment] arose because the nature of modern science […] which branched out and the scientists moved away from the social implications" (Interview 5: 30:15).*

When compared to the S&T documents and priorities described above, it becomes clear that diversity isn't adequately addressed on this level. The societal setting of S&T is defined by diversity and the basic needs of people, which have to be addressed. If we compare this to what is described for example in the latest policy document of 2013 it becomes clear that even though it described inclusive and sustainable growth for people, the focus on the 'official' side is more on fostering India's role in the global competition in S&T by developing top S&T and raising public awareness via science communication. In this sense, in the overall system a holistic view, including societal aspects, is still lacking to a certain degree and S&T should be better connected to societal issues. Here building capacities regarding the links to society as well as taking into account things that are already happening on the local level can be a way forward. This means:

> *"changing the mindset of scientific community […] it's also the way science is practiced in India the way you have been taught, educated […] so, you start practicing in that way […] it was not that much linked to the society, it was more in the lab and all this" (Interview 9: 38:10).*

A key actor for this are the scientists themselves, who need to be better embedded in society and the specific contexts, which can lead to the development of better technologies.

> *"at the core you should be dynamic, you should understand what next, how to make it much more effective, how to make it much more better, how to leapfrog. So those things have to be embedded in the processes" (Interview 2: 13:23).*

There are changes, that give space to more holistic approaches. Here grassroots and frugal innovations enable developments that seem closer to the actual needs of people and it seems that this is gaining more attention in India:

> *"So, it's not only blockbuster technologies, but that kind of technologies also which comes from traditional knowledge systems. So that was something which was a bit lagging in the Indian sense, more focusing on big technologies and big science projects. Now it is also more from traditional knowledge systems […] it was there, but now it has got an institutional framing" (Interview 9: 36:50).*

This gives insights into the tensions within the S&T setting in India. The S&T documents described above, show priorities on a broad scale: global competitiveness, advancements of S&T on a high level, economic (sustainable) growth or raising of public awareness as a means to gain accountability. Yet, the relevance of values like access, inclusion and equity and correspondingly shortcomings in these areas are important to take into account. For India, science for science sake is a crucial element of a sovereign country and has been a key part since Independence. This is in contrast to a country in which basic needs such as water or health are still unfulfilled as well as large discrepancies between regions and people continuously exist.

> *"So, it's like they say, India is a mix of sub-Saharan Africa and Californian. We have, we are going to Mars and the Moon and also at the same time we have drinking water problems" (Interview 9: 35:35).*

This provides us with a useful basis for tracing TA activities and especially identifying potential challenges and issues to be addressed by it. Based on many of the interviews and the S&T documents, it seems that here lie the main challenges for S&T development in India. To account for (basic) needs, and through this taking access, inclusion and equity arguments seriously, while trying to achieve a role as a global player. The high level of diversity in many aspects of India's reality as well as a certain opening up towards other forms of knowledge regarding the societal aspects of S&T show the specific need for TA to help align these different aspects.

5.3.4.3 Technology Assessment in India: Institutionalization and Roles

Diversity and the societal challenges described above also reflect in the need for TA and what it should consider in the Indian context. Connecting S&T developments to the needs of society, according to values such as access and inclusion remains key. This can enable embedding S&T within the diverse Indian society and finding ways of empowering people and democratizing S&T. For this assessment needs to be, as one interviewee put it: *"region-wise or socio-economic status-wise, because then you'll only know what technology exactly you need*" (Interview 1: 7:10). Here TA's role is seen as a way to address issues at any level, from drinking water problems to space programs. Based on the typology of roles and impact of TA (section 3.1) this encompasses not only raising knowledge on technical options, but mapping possible social conflicts or exploring policy objectives. Further, TA in India should form attitudes and even initialize debates in order to fully address the diverse needs of the country. As another interview said: *"TA cannot be devoid of society and yes, countries like India might strongly pose these things about society and how TA can empower society at large"* (Interview 7: 46:20). In India it seems, that TA has a large role to play in the democratization of S&T and opening it up to all parts of society, not just experts. This coincides with the issues mentioned above, such as literacy. In a heterogeneous setting such as India, where many people are lacking capacities to understand, use or even access technologies it seems important that TA raises awareness and functions as a tool to enable dialogue and exchange, in the sense of also reframing debates. Also for the expert side TA can function as a platform.

> *"People have certain fears, maybe [of] certain technologies. And experts have fears that science could be not supported. […] And I think both these fears could be tackled with a common platform if there is a possibility of building on TA exercises" (Interview 8: 10:53).*

Yet, though TA has a key role to play, in the current situation there seem to only be limited possibilities regarding people working on it (e.g. universities, institutes such as TIFAC) and the overall recognition from the policy side. TA is mainly conducted in the scientific assessment and technical options. Therefore, a main challenge is capacity building and creation of professionals that can actually do assessments. A key factor here is the awareness of TA and the understanding of what TA is, which is still limited due to techno-centric views of S&T in India. This often remains detached from the actual implications of technologies or innovation. As described above, questioning S&T developments is seen as difficult in the Indian context, which in turn effects which recognition TA receives.

Based on these limitations, the ideal location of TA can be debated. TA within government agencies or as a specific council can provide a good setting to better inform policy decisions, yet this may also effect the autonomy of its assessments or policy recommendations through control by, for example, a ministry.

> *"Technology Assessment as such ideally speaking should not be attached to any department per se. But it should be more like a council funded by the government or being an autonomous body like a council or technology assessment [body], which would work within the government system but not attached to, not under the control of any specific ministry" (Interview 3: 11:30).*

TA's connection to the government could be on a high level (e.g. under the Prime Minister) in order for it to be done long-term and not be too influenced by political changes. This reflects the general difficulties of TA within the political system, in which it is dependent on continuous structures in order to conduct assessments but also has to be close to decision makers. For a sustainable form of TA, it therefore has to be engrained within the government's thinking and decision-making.

> *"I think the thing is that, a large country like India Technology Assessment should be part of the government thinking, should be a part of the government's policy structure and all" (Interview 3: 11:12).*

Locating TA close to policy is important for it to effectively inform policy and decision making. This entails it becomes part of the government structure, which in turn brings challenges regarding the openness of TA to address social justice issues. This also relates to the issue of autonomy. In the Indian context there still remains a very strong belief in S&T development, which creates a certain tension to a necessary Indian TA, which would adequately bring up the actual diverse problems facing the country.

> *"The moment you have TA under a governmental premises TA, it would be seen more as something that legitimizes the current technology planning or the current S&T framework" (Interview 3: 13:50).*

> *"I don't think in India it [TA] is devoid of the politics it is very much there and fuels the purpose of politics, wherein ideally it should be independent because if it is not independent it will never look into the idea of social relevance […] or inclusion, access or equity" (Interview 7: 18:50).*

A further possible location for TA in the Indian system is within think tanks, where it could have more independence but still be close to decision makers. This would entail institutions that have a level of autonomy regarding topics or methods because they have a certain distance from the government or Parliament. In the Indian context, it seems clear that due to the vastness and diversity as well as the many very localized issues around S&T, civil society organizations also have a role to play in TA. They can offer other views on S&T, that possibly aren't overlapping with current government priorities and therefore provide alternative views.

> *"Better to have an agency with can be a dissent, which really can provide some independent advice to the government or to the people or at least say this is what it is" (Interview 3: 13:10).*

In the present situation in India, TA is mainly situated at TIFAC, so ministry level (Department of Science and Technology), even though limited at the moment. This results in fairly weak ties to other departments or government institutions, which don't seem to see the need to incorporate TIFAC's work into their own. TIFAC often works on possible futures of S&T in India, as described

above in the Technology Vision 2035 document. This does include socio-economic issues and goes beyond mere forecasting activities, even though TIFAC is missing for example social scientists. This shows a certain development within an organization such as TIFAC towards including various aspects in their assessment, even if this is a process only just beginning and awareness still isn't ideal.

> *"We're not a passive thing, that no I'm sitting beside […] but we're part of the process itself. And, but most of the people don't understand this, they see the term forecasting and ok they're going to forecast. But we said no, no, that's not really our task. Somehow if we could change the name it would be nice [laughs]" (Interview 4: 1:13:45).*

Regarding the location of TA in India, TIFAC is an example of how such an institution can also be rearranged in the system. This reflects a general problematic issue of TA in India (and beyond), which, as described above, is between having appropriate access to the political side and independence. This influences the effectiveness of such an institution in that it determines the links to others and the connections it can make.

> *"It was very well planned out, implementation was not done properly. So, our effectiveness reduced […] But then we are a small organization. You can't change a country of 1.25 Billion" (Interview 4: 13:45).*

TIFAC shows that how such an institution is set up and where is relevant for TA, especially regarding more interdisciplinary approaches. There seems to be a newer awareness within TIFAC that TA (or TA-like) activities require a certain level of this, since S&T cannot be seen in isolation from society or the government and also has to internally implement interdisciplinary approaches.

> *"Then I had to actually develop in-house expertise to share what kind of things are likely to happen […] we had these groups [patent scanning, horizon scanning] within my organization but they were not talking to each other" (Interview 4: 56:30).*

For this development towards more awareness of comprehensive TA approach the development of the Technology Vision 2035 document is important. It takes into account (future) needs of various groups in India and aims to develop S&T vision accordingly. This document takes the perspective of India as a whole and its citizens, which can be understood as a swift away from a techno-centric view to include more societal aspects as a basis.

> *"You talk about quality of life of citizens and then how technology can fulfill that role. So, we don't start by talking about this technology but we talk about people […] As we went along we found that, we felt that we should not let technology drive our life. It should be our life driving what technology should be doing. So that became important" (Interview 4: 2:04).*

It seems the TV 2035 document as well as the internal process of its development is an important step in the context of TA. It departs to a certain degree from the view of technology as worthy of development in itself and as a tool for advancing India. It still takes on the perspective of citizens, their quality of life, even if only in theory (as there were no actual engagement elements in its creation). This may also be a reason why it has led to more interest from the government side.

> *"Fortunately, we have seen very good response. Partly because this [TV 2035] is not a boring document. It's important [laughs] you make sure that you don't talk about technology, you*

talk about people. You talk about quality of life of citizens and then how technology can fulfill that role" (Interview 4: 20:50).

In this context, the role of TIFAC as providing this kind of advice is becoming more significant and accepted, which can also be understood as TA-like activities gaining importance. TIFAC is more active in the everyday work of the policy side, they are becoming more relevant for the government. In this context, they go beyond responding to the specific demands from the government side, but moreover pro-actively provide ideas for issues such as access to public transport and travel time, also based on the TV 2035 work.

Next to this growing awareness for TIFAC's activities, even though knowledge of TA is still limited, capacity-building through universities, for example in S&T policy, has created a certain emerging group of TA experts. Next to institutions such as TIFAC or think tanks, universities can also be a possible place for TA activities, also because of their independence from the government.

"we have trained now more than 100 students, so that community was not there 15 years back you didn't have a larger community, but people also […] writing their PhD on TA […] social aspects, cultural aspects, economic, so more comprehensive view" (Interview 5: 14:20).

Overall, TA in India is (still) very dispersed. There are limited forms of institutionalized TA, such as TIFAC, which has the official mandate to assess technologies and to advise the policy side remaining mainly in the area of scientific assessment, policy analysis and social mapping. Yet, we also see that TA's function is unclear and changing and that how it was set up isn't ideal. In this setting, different forms of ideal TA and locations can be weighed: from closely linked to the government side, to independent think tanks to academic university activities. There seem to be smaller steps towards awareness from the political side regarding TA and societal issues of S&T developments, yet capacity-building is still an issue. This is important in order to create a TA community on different levels (e.g. government, universities, think tanks), which can shape how TA is done (including for instance forming attitudes and initializing actions) and which role it plays in Indian S&T policy-making. Also, it is important to have practitioners with capacities to deal with emerging TA activities, their location and possible political influence.

5.3.4.4 Ethics and Technology Assessment

TA in India is still fairly isolated from the political system and takes place in smaller niches within institutions such as TIFAC or university programs. This has to do with several factors as described above. In this situation, it can be helpful to look closer at the basic aspects of TA, ethics and engagement. In a socially, economically and culturally diverse country, with an overall strong belief in the development of S&T the issue of who is part of ethical considerations is an important aspect to TA and where shortcomings may be.

In India, regarding ethics in S&T, we find a fairly narrow understanding in the sense that it remains in the realm of experts. This reflects the general view of the need for S&T for development and the advancement of India (Nehruian view). In this vision, decisions on S&T policies or priorities are mainly left to experts. As the example of the Green Revolution described above shows, this was fostered as a way to develop the food and agricultural sector in India, yet led to several negative outcomes regarding inequalities or limited access of certain groups (e.g. small farmers). This shows a certain disconnect: the aim of ensuring social benefits and social

justice is there, yet when left to experts, decisions and actions may not be able to accomplish this. Here we see that ethics in a wider sense often isn't connected to policy-making in India. Ethical considerations are often also left to experts, for example in committees. Research ethics plays a role, for example in clinical trials, which are relevant in the Indian context. Yet, wider understanding of ethics in the sense of lay ethics doesn't seem to play a large role.

> *"Fundamentally, if we talk broadly in terms of ethical considerations, you have science ethics, you have research ethics" (Interview 3: 25:30).*

> *"Ethics committees [for clinical trials] have people who have scientific expertise, who have understanding about the society […] predominantly scientists" (Interview 7: 31:08).*

In this setting, experts are the main actors when it comes to weighing ethical issues, also those of various stakeholders. In the Indian context, it seems that the job of the expert is mainly seen as the one who conducts an ethical assessment, possibly by integrating other views of stakeholders in the process. For TA, this would mean that lay persons are included, but via an expert who ensures a process of weighing these different perspectives.

> *"There are always winners and losers and it's the job of the ethicist or the expert who is designing the study to clearly […] mark what happened in this process, who won and who lost and why" (Interview 8: 25:50).*

This in turn has implications for engagement (e.g. who should be engaged?), which are described further below. For ethics, this means that the form of committees or councils are regarded as a useful model, which can also be expanded for various specific technologies. These could also act as a bridge for linking the government, scientists, bureaucrats as well as the larger public. In this way, these committees could help bring together the many ethical arguments that may come up in a diverse country like India. They would function as a mediator, collecting different ethical considerations but also moderating them.

> *"Because the idea of ethics, the usage, the issues are not uniform across the country. They vary. And then in certain things people may even say: is there any ethical issue in that? We do not see any ethical issue in that. So, are there going to be any ethical issues? Let us try to solve it with our existing paradigm what we have, then trying to you know open up a Pandora's box by that way we'll start discussing ethics. And then some unresolvable issues may come up […] so let us not unsettle the current framework" (Interview 3: 27:10).*

In this understanding, committees would also ensure that established procedures aren't too disturbed by varying ethical perspectives and arguments, even possible conflicts. Next to this, using the values of access, inclusion and equity, which again, are a useful way to assess policies and S&T developments within Indian society, is also an important part of ethical considerations. Here we find the basic values of human dignity and social justice reflected within the need for ethical debates and as a way to reconsider S&T developments and policy decisions towards more embedded forms. This shows, as mentioned above a certain opening up towards the perspective of technology for people, and of course TA has a main role to play for this.

> *"It's all about justice, it's all about you [the government] giving them [citizens] the rights. It's about the right to decide. Right to choose. All ethical components. Don't drop them of these rights […] This equal justice. As a free human, they have all the right […] There are many areas where S&T can be made more accessible to people, more, ethically justified" (Interview 1: 1:00:05).*

In this sense, lay ethics is a key aspect for shaping S&T according to people's needs and ensuring access, inclusion and equity, overall social justice. Yet it seems there isn't a clear picture of how this can be achieved, also regarding some forms of institutionalized processes. Again, this relates to engagement, which is also fairly limited as much of it is understood as communication and information activities (described further below). It does remain open how in the specific Indian context, ethical considerations can be conducted as a way to put S&T developments in line with societal needs or wishes and empowerment.

One term that is relevant in the context of ethics is scientific social responsibility, which has recently been brought up by the Indian Prime Minister Modi. This is concerned with encouraging scientific organizations, that receive public funding, to develop S&T which is more adapted to the needs, especially poor parts of the population. Similar to the SEED program of the Department of S&T described above, which aims to foster S&T especially for rural parts of India, this idea of social responsibility from the scientific side aligns S&T with actual needs. For this to be successful it would also have to include ethical considerations of stakeholders in the development of new technologies. Also, it adds the idea of responsibility, so an ethical obligation to scientific work as well as the way advancements are assessed from the political side.

> *"Scientific social responsibility [SSR]. It's not only about space, not only about nuclear, there are many issues where science can play many roles, the grand challenges […] they will definitely have this whole mechanism [evaluation of science according to SSR], but this concept is very new. So, it will take some time to sink in […] But the PM has said this, then you can be sure that this currency is there. There is a little more concern of using science for basic needs" (Interview 1: 1:07:38).*

Ethics seems to be fairly limited to the expert side in India. Even though there are openings regarding the closer connection of S&T research and development to the needs of different societal actors, it remains unclear how this will be ensured in practice. Again, the tensions between high-level S&T advancements and basic needs show here. In order to approach this, it would be necessary to not only include ethical considerations on the level of science or the government, but also on the local, grassroots level, in order to also ensure the adaption of S&T to a diverse set of needs and expectations.

> *"it should be at the different levels, at various levels you have to consider how […] at the scientific level also you have issues of ethics, at the governance level also you have issues of ethics […] and at the same time at the grassroots level you have also" (Interview 9: 18:55).*

For TA activities, this situation of ethics means that they can be part of more formal arrangements such as ethics committees. This could be a way to introduce TA(-like) activities into existing and accepted structures. Yet, TA should also push forward a wider understanding of ethics, also as a way to actually take access, inclusion and equity into consideration and to help shape policies as well as S&T itself towards the needs of a diverse set of non-professional stakeholders. Leaving ethics to experts would limit the ability of TA to account for key issues in the Indian context. For this engagement is a key aspect as a way to include these ethical considerations in assessments and ultimately in policy decision-making.

5.3.4.5 Engagement and Technology Assessment

The access to information on technologies, all actors of society as part of the development processes of S&T and the fair distribution of benefits should be key aspects for S&T policy-

making and development. As described above, access, inclusion and equity should be applied to the assessment of S&T policies in the Indian context. These of course require some form of engagement in order to incorporate needs, expectations, but also fears into the way S&T are developed and governed. In India, where the Nehruvian view of science for social transformation is still predominant, the focus is often on the application side. Even though this also looks at how technologies are possibility used, it remains narrow and presumes that technologies are neutral. In a country where literacy is an issue, the question is how to appropriately include people in assessments of S&T. Therefore, engagement is mainly understood as communication or information activities, similarly to China. Awareness of possible effects of technology are often limited to people with education, which may also vary across the country.

> *"There is one thing which is very common here, science communication. So, making people aware. So, this is actually the major challenge, given the literacy rate here. Forget about scientific literacy rate, basic literacy which is a big challenge […] there are huge numbers who don't have access to any basic education. These are the people, citizens who are the majority of society. And when you're talking about any S&T solution you are targeting these people." (Interview 1: 39:35).*

This seems to be a key aspect when talking about the potential of engagement in India. Problems of awareness go together with limited education and create a situation in which many people do not necessarily regard themselves as agents in the decision-making on S&T. As we have seen in section 4.2, demands for engagement (especially in Western contexts) are often closely linked to an understanding of citizens as independent free agents, who have the capacity and even responsibility to be included. In India on the other hand, issues of how citizens see themselves corresponds with how the government side see its citizens and their capabilities.

> *"The problem with public engagement in India is that fundamentally […] there is some minimal understanding of certain things among the public on some complex matters […] to develop a good public engagement, but that is not happening because the public by enlarge is not very, what I would say, aware of science and technology. They are more like users. They do not have the better understanding of what exactly science and technology entails or why [it] can really make a difference" (Interview 3: 22:43).*

The issue of diversity, in terms of literacy, also plays a role in other areas in the context of engagement. Cultural or language diversity isn't necessarily a barrier regarding engagement, it requires appropriate methods that can address different groups or individuals and account for an array of perspectives. India as a whole has to deal with diversity in many aspects, for example politically. Also in how S&T is developed, implemented or used is diverse and can be very different in regions.

> *"Public engagement is the way you want to talk with public, establish two-way communication, establish various ways of you know assessing public opinion or taking their views into account. That you could do in many ways, diversity per se cannot be a barrier, cannot be a constraint" (Interview 3: 16:45).*

> *"there has to be a diversity, diversity in terms of geography, diversity in terms of cast, class, everything because sometimes a technology might be creating more of social inequalities […] in India social inequalities could be through gender, through culture, through language, so you make something in English and the illiteracy […] so you're actually letting, let's say the Southern India, […] assess that technology" (Interview 7: 35:35).*

Diversity, as described above, actually makes a strong argument for engagement since developments, decisions and policies should ideally be adapted to the specific contexts (e.g. concrete needs). Engagement is difficult in this setting, perhaps more so than in other countries, which are overall more homogenous in terms of education, income, language, etc. (e.g. Germany). For TA, this means that engagement of the different stakeholders is a challenge, yet one that is important to tackle.

> *"For me engagement is definitely a difficult exercise. Yes, it is very, very difficult when there are diversity of stakeholders. I mean it's difficult to have an agreement between two people talking so if there are multiple stakeholders. But that's the challenge everywhere […] so, it's not a challenge that's typical for India" (Interview 8: 20:17).*

Important for a realization of engagement processes is also the government side. As mentioned above, the overall understanding of S&T development is one that doesn't necessarily take citizens' views into account. The further advancement of technology is seen as an overall development of society, yet the discrepancies in various aspects and issues of access or equity aren't always considered. The relationship between policy makers and the public is mainly a one-way communication. Institutional unwillingness to actually engage with the public in a more comprehensive way enhances this situation. Citizens aren't regarded as a legitimate or credible actor, who should get a say in decisions and engagement is often perceived as causing potential problems by raising issues.

> *"whatever the government tries to do is more like one-way communication. So, they have some preconceived notions […] yes, it is good, people should be educated, should be told […] they don't seem to understand that what ultimately, we're trying to do is good for them. So, it is not much concern with what exactly are the fears […] Had it been the case, then there would be public engagement" (Interview 3: 20:20).*

> *"because they [government] are still saying that people are ignorant, they're still saying that the public needs to be educated rather than there has to be a dialogue between them. And they are still finding ways to say: oh, it's not possible to have a dialogue with the public. Because in order to do that there has to be efforts" (Interview 8: 1:50).*

> *"If we know that situation is messy we need not […] because its already trouble. Or if we try to do something it will backfire. So that sort of understanding of public engagement is the real issue" (Interview 3: 24:25).*

> *"so, the attitude, the techno-bureaucratic culture is challenge, that also should change" (Interview 5: 43:10).*

Next to political will and openness, scientists, but also experts for engagement are important in order to establish processes. Scientists often remain within their own field; wider societal implication don't play a role for their research. This of course corresponds with the overall view of science even if there is a perceived need to include the public in some way.

> *"we talked to senior scientists, technologists, it was not a good experience […] They couldn't see a broader aspect of life and then they were very limited" (Interview 4: 22:50).*

> *"most of the times I found scientists supporting the view that public needs to be engaged" (Interview 8: 7:55).*

As we see, how engagement can work remains vague. Even though there is the acknowledgement that inclusion is important, at least from the scientific side, it remains unclear

how this can be put into practice. This is also effected by a lack of expertise on how to conduct useful engagement.

> *"I think there is a lack of […] experts who are capable of engaging with the public […] these interdisciplinary experts who could be in both these worlds […]. It's not the public that is incapable it's the experts that are incapable of engaging the public" (Interview 8: 8:55).*

It necessitates these (TA) experts in order to develop and organize engagement, especially regarding more debated technologies such as GM foods. Face-to-face interactions can help come to better, more robust decisions since they build on the exchange of different views, also critical ones. This could initiate processes which can in turn raise the credibility and acceptability of decisions. Here lies a main challenge regarding TA and engagement in India. To develop actual debates on S&T by including various diverse stakeholders and connecting this to the policy makers.

> *"When you're talking in consultation, real consultation there you have to take stand and you have to justify. If you're wrong you have to admit that you're wrong" (Interview 1: 44:10).*

This opening up of decisions on S&T is a key aspect of coming to more democratic processes, that aren't limited to scientific experts or bureaucrats. This includes different forms of knowledge, which in a diverse country like India, are evident. Engagement should take place on different levels, also very local ones, in order to include views of technology users and their practices (e.g. farmers). Through engagement there would be the possibility to include their expertise on everyday aspects into technology development.

> ***"****There are different kinds of expertise that are required to engage in a political issue of your concern […] you can have the inter-rational expertise that the issue that concerns you, you are an expert in that and you can ask questions to the experts" (Interview 8: 7:10).*

The local is the level where people are often directly affected by technologies and where these developments can take on very different forms throughout India. Here lies a further challenge of TA in terms of engagement. To develop appropriate engagement forms for very local issues, but then also scaling these up to a certain degree, to a national level.

> *"So, I think you really need to fine-tune that to make it adaptive to different sets of society. Illiterate, partially literate, rural, urban and that can be done in India" (Interview 6: 28:30)*

> *"compared to the government we are a small sized [NGO] organization, so up scaling is a big challenge, we've had successful models here and there but how do you upscale it to make it like a national […] program? You cannot take it to that level" (Interview 9: 14:40).*

Here we find a possibility in the political structure of Panchayats, which are described above. As a very local form of governance they can offer platforms for engagement as they include people who are trusted in the community and could moderate such discussions. Yet, also here the issue of awareness and capability to even engage comes up. Therefore, this could possibility be more a very local form of communication and information, which could in turn result in empowerment to a certain degree, for example by people then asking questions that concern them.

> *"It's [Panchayats] one of the lowest level governing bodies […] so you actually go to small villages and the Panchayats […] It should not be feedback, it should I think be awareness program. And if the awareness program is good you get you get good questions from them" (Interview 6: 28:50).*

"questions will come, that will actually drive yourself to be more innovative and get things down to them. Make them ask questions" (Interview 1: 30:05).

For TA, the understanding of engagement in the Indian context leaves certain challenges. This coincides with the issues regarding ethics and is mainly due to the diversity especially in literacy and awareness. Overall, the tension between high-tech and basic needs shows here as well. TA in India will have to find ways to assess artificial intelligence or synthetic biology technologies according to societal aspects, while at the same time taking into account that this society has to deal with basic needs such as clean water or secure food. Communication and information, so the basic awareness building of S&T and possible societal implications, remains a basic challenge. In light of the political (un)willingness and openness towards actual engagement, this will not be an easy task. Perhaps here lies a further challenge of TA in India: to communicate to the political side that people' voices should be heard. As described above a lack of expertise regarding engagement makes this a difficult undertaking. Another challenge would then be how to implement these engagement processes in diverse India, ranging from the local Panchayat to the national level.

5.3.4.6 Indian Perspectives of a Global Technology Assessment

In India with a fairly limited understanding and dispersed use of TA, also regarding ethics and engagement, a global perspective remains difficult. This also comes from the overall setting of India in the international landscape. As described above, India often follows in S&T developments and is not necessarily at the forefront. Taking a leading role for global TA activities will therefore be difficult for India, but at the same time it could benefit from a global exchange of experiences in TA.

"India as such, a country will not be in a position to take lead in these things [global TA activities] because in synthetic biology or genome editing or any technology India is not setting the pace […] I don't think India is going to play a major part in a global TA" (Interview 3: 41:10).

"A global platform of TA […] you will learn from each other and it will be cooperative, very synergized kind of effort" (Interview 1: 1:16:40).

An important aspect of a global TA from an Indian perspective is mutual learning. This of course is not surprising in a country in which TA is done in limited forms and as part of very particular institutes such as TIFAC. As the descriptions above show, there is a lack of expertise but also governmental willingness to do TA. Therefore, learning from other countries regarding their experiences with new technologies and policies can be a useful way to foster TA further in India. This seems to be a role for India within a global TA network, not necessarily as an actor giving the tone, but one that can benefit from others and apply this to its own specific context regarding issues, socio-political setting or cultural aspects.

"we can also draw from a bottom up process, TA done in UK, TA done in India, TA done in Germany, TA done in China for stem cell, these things could be linked up and then you could analyze ok where are the issues, real issues? […] So, in that global TA, in these cases, can emerge different TAs from different countries and then different studies […] Global TA [should] really be sensitive to all the concerns, all the needs of different groups, different stakeholders or different countries […] Surely it could be attempted that there is some broad consensus on some issues" (Interview 3: 32:45).

Such a form of global TA, as a network of exchange and learning would have to be applied to Indian reality. Especially in such a diverse country there can't be a one-size-fits-all approach. The local and national dimension of global S&T developments is relevant here. This results in situations in which one country or society may accept a technology as worth fostering and applying while another may condemn it (e.g. nuclear power). The local and national level is therefore important regarding *"identifying indicators, developing trademarks […] that's where the challenge lies: how you have these global policies translating at the local level?" (Interview 9: 32:10)* and can vary accordingly. In this perspective, the form of a global TA would be as a network or platform which enables exchange but is also local and national in its application and scope.

> *"technology is global, but its impact is local […] But rather than each country doing its own task, but somehow, we have not been able to get together" (Interview 4: 1:06:32).*

> *"there are global concerns for example the climate […] But then there is this local context and technology and its impacts are not universal in some ways in the sense. […] All concerns cannot be global; some concerns can be very local […] there are context specific technology developments" (Interview 8: 30:30).*

When looking at a truly global scope and perspective of TA, beyond the national, the question arises where such an activity could be located. On the national Indian level, we find TA as part of TIFAC's work and therefore with a fairly clear addressee: the ministry. It seems, from an Indian perspective, there are institutions such as the UN, UNESCO or WHO which could be places for a global TA, depending on the specific technology or issue. Yet, this seems to also be a crux, since these addressee of or locations for TA should ideally be able to tackle the assessment of technologies that bring up crosscutting issues in very diverse national or even local contexts.

> *"Who would do it at the global level is another issue […] that's the big issue. It could be an organization like UNESCO, maybe to do it for certain things. WHO maybe will do it for certain things […] there is not many corresponding international organizations that can do these things […] The problem is if it's going to be something crosscutting like synthetic biology" (Interview 3: 36:00).*

Overall, concerns for TA in India are mainly on a national and local level. How to establish TA activities, especially the incorporation of lay ethics and processes of engagement, remains the main challenge. Diversity, access and equity, the inclusion of various actors as well as a general context with many tensions are the main issues facing a wider implementation of TA. The global level of TA remains vague and could mainly functions as a way to learn from other countries. Important here is the translation or application into the local. TA should find approaches and methods that allow for the specific context, also regarding culture, language, literacy level, etc. Here possibilities lie in the potential for a global TA to learn from activities in India, as here a 'diversity-sensitive' approach is key. A certain awareness, even if possibly not ideal yet, of diversity is there in India and can be a helpful input for a global TA. The implications of this for a global TA are explored in more detail in chapter 7.

India is characterized by its size and scope, regarding population, economic growth, but also diversity. As a newly independent country, it focused many efforts on developing S&T as a way to foster development and become a global player, also in terms of competitiveness. This understanding of S&T continues to shape the national identity of India as a sovereign and influential country and results, for example, in space programs. Yet, vast differences and

inequalities are also part of its reality. Basic needs such as water or food remain challenges, also for S&T developments. India lies between competitiveness and inclusiveness, which brings challenges regarding aspects such as access, inclusion and equity.

This is the overall setting in which TA activities in India find themselves: A political ideal of 'big science' and a lack of awareness from the wider public regarding possible effects of S&T. We do find the demand that S&T should help empower people and function as a tool for social justice. Yet, it seems that there is limited willingness or ability from the government side to actually incorporate diverse views and expectations in S&T decisions and priorities. This results in the understanding of ethics as mainly a job for experts and engagement as a communication and information activity. However, especially in such a diverse and tense setting, the argument can be made that more inclusive forms of ethics and engagement are required. TA in India could help align these differences better and support decision-making that is able to include an array of societal needs and expectations. This presents a mixed picture: on the one hand, the importance of TA as a way to include different forms of knowledge in decision making, on the other, the location of TA remains unclear in the Indian system. Close to the government in order to have access to decision makers, yet not too close in order to remain independent. This also reflects in the role of India in global TA efforts. As a way for mutual learning a global network can be helpful for India to gain insights into experiences from other countries, especially ones where TA is more institutionalized.

This section focused on S&T policies in India and their socio-political relevance and use in order to better understand the circumstances under which TA could possibility be done. Main documents and underlying values, such as assess and inclusion, were described providing the basis for analyzing the interviews done with Indian actors regarding their perspectives on TA, engagement, ethics as well as possibilities of a global level of TA. These showed tensions in a country between needs of basics like health or food and developments in new technologies as well as global developments. TA activities in India are limited at the moment, TIFAC as an institution does TA, yet focused mainly on providing documents for decision makers regarding desired futures. As the descriptions of ethics and engagement show, most is communication and expert advice. Further, the importance of a global TA is acknowledged, yet, as we can conclude from the interviews, India wasn't seen as a leader in this. The section gave a reflection of the insights from the documents and the interviews, discussing issues such as diversity, a strive for S&T as well as the need for the fulfillment of basic needs and what this means for TA in India.

Overall, chapter 5 provided an analysis of the empirical findings in the context of this thesis. It examined the countries Germany, China and India, with the aim of understanding how TA(-like) activities take place in very different socio-political settings, from established forms to emerging ones. Ethics and engagement, as essential parts of TA, were also looked at in detail to uncover how these are understood and practiced as well as how ideal forms are described. The overall socio-political settings were also described in order to provide background regarding the framing of S&T in the countries. The interviews with key actors in China and India were used to contextualize TA(-like) activities and the role of ethics and engagement in this. From these empirical insights we can see that S&T developments are framed according to societal needs and expectations, even if how these are assed varies. We see that even if TA is established in some contexts like Germany, new challenges regarding for instance transformation processes arise. In China we find issues of how to incorporate a wider public in a top down and one party

system. India points us to issues of diversity, inclusion and access. For TA the challenges in the specific countries are therefore unique as well as its (potential) location and role in the overall structure. The cases therefore show us that TA has to adapt to local or national specifics in order to be useful in this context. Yet, we also see that there seem to be communalities regarding the need for TA in order to align society and S&T better. These cases therefore provide the basis to further reflect on a global TA – what its implications are and what next steps could be. This is taken up in the next two chapters which attempt to compare or relate the cases to one another and derive recommendations for the countries as well as steps forward for a global TA.

6 Moving Towards a Global Technology Assessment

This chapter aims to bring together the findings from the case studies and discuss them along the key notions of engagement, ethics in order to also uncover how TA takes place across the countries. The specific situations in Germany, China and India are described, reflected and compared along key aspects important for ethics and engagement. This forms the basis for the different TA environments in the countries and ultimately possible parameters towards a global TA. Further, the normative foundations for TA are discussed as a way to address the possible implications a TA outside of a Western context may have. We see from the cases in China and India that moving TA outside of the context it originally developed in, also implies reflecting on the normative basis on which it can be grounded. Merely importing it into such diverse settings cannot be the aim of a global TA approach. Instead more integrative and culturally-fitting approaches of TA should be explored, hence different "TA habitats" (Hennen and Nierling 2015) (as already touched on in section 3.2 regarding international TA projects). This socio-political environment in which TA can or cannot take place depends on the structures, institutions and processes it is surrounded by and integrated in. TA has to be responsive to this habitat including policy contexts and decision-making processes, S&T priorities as well as political and cultural structures. Depending on these aspects, TA may differ in its positioning, approaches or addressees, which is explored in this chapter. Still, TA should also keep a certain normative core, which shows why a discussion of this, as presented in this chapter, is important in the context of a global TA. Based on the case study findings and the reflections across the countries discussed here, this chapter also develops first possible parameters towards a global TA.

6.1 Across the Cases

When reflecting on the cases, it becomes evident that we have very different, unique countries with their own specific history, culture and practices, which all influence the roles of S&T and the relationship to society. This in turn needs to be taken into consideration by TA in each setting. Germany, with established and parliamentary forms of TA, has explicit ways of ensuring TA is part of decision-making. Ethical considerations of the public or stakeholders via various engagement forms have become a common part of S&T policy-making, even if questions of actual inclusion of its outcomes remain difficult. The overall top down system in China and its strong focus on economic growth determines many policies of S&T, even if a "new normal" is redefining what level of (S&T) development is actually desirable in society, which in turn requires the inclusion of the public in some form. Access, equity and inclusion should frame S&T policies in diverse India as a way to meet basic needs of the general public. Yet, at the same time we find strong emphasis on big science also as part of an independent national identity.

As we see when tracing TA and its essential aspects (ethics and engagement) in the countries, several differences in the understanding and framing of TA as well as ethics and engagement can be found. During the interviews for instance, as described in sections 5.2.4.1 and 5.3.4.1, questions had to be adapted to the interviewees and flexible enough to incorporate differences in translation or activities that weren't explicitly termed TA, but could be seen as such. These ranged from the evaluation of innovation and S&T developments like in China to foresight activities in framing future S&T needs of a diverse public such as in India. Also, since forms of engagement and the inclusion of lay ethics are arguably still emerging in China and India there was often a need for further explanation during the interviews. This in turn can offer the starting

point for the comparison of these very different country cases: Which were the terms or ideas that needed the most explanation or a 'careful approach' in the interviews? Incidentally, these were the main aspects discussed in this thesis: ethics and engagement as well as TA itself. In a way this isn't surprising, since, as discussed in chapter 4 and section 6.2.2, these are mainly Western framed terms and ideas, which may have very different connotations in other parts of the world.

With a main aim in this thesis being to initially trace and begin uncovering different understandings and TA(-like) activities in key countries as a first step towards a global level, looking at the terms that needed closer explanation in the field can offer insights into the importance of the underlying political, cultural or historical settings, essential values as well as how they relate to one another across the countries, i.e. TA habitats. Therefore, in the following a somewhat explorative approach to the comparison of the cases is chosen. As the cases are unique and the empirical data in China and India very specific, a quantifiable comparison doesn't seem useful. Since the way ethics and engagement is incorporated into the countries context is very contextual, a quantitative comparison of the number of engagement activities or funds allocated for this cannot actually tell us anything about the reasoning behind this. Instead, the comparison should uncover why these activities take place or don't, along key aspects. Insights into these habitats can then help prepare specific country recommendations as well as implications for a global TA (as discussed in detail in chapter 7). Exploring similarities and differences along the broader terms ethics and engagement across the countries can offer insights into whether common ground can be found, also regarding TA. It can also uncover which issues need to be resolved or at least addressed when moving beyond the cases towards a global level. This can serve as a first basis for further reflections towards a global TA (chapter 7). For this, the main criteria or lines of comparison are rather broad: understandings of engagement and ethics along specific aspects.

The following reflections of engagement and ethics along these key aspects in the different countries attempt to describe why or why not inclusion and ethical reflection take place in different settings. In this way the key aspects such as S&T priorities and societal challenges, political system and cultural aspects or decision-making processes frame the habitat which enables or hinders such activities. Of course these are not clear cut and singly responsible for engagement or ethics. Yet, this can still be a next step in better understanding the TA habitat of the different countries (as done in section 6.2) as a way to prepare recommendations for Germany, China and India regarding TA in their context as well as on a global level (chapter 7).

6.1.1 Engagement

Engagement, the inclusion of the public or stakeholders in agenda setting or decision-making processes, is and has been an essential element of TA from its very beginning (Hennen 2012). Different forms, e.g. public communication, public consultation or public participation describe how information flows between the public and (political) initiators (Rowe and Frewer 2005). Levels of engagement can be identified ranging between mere non-participation to citizens' power, from manipulation to actual citizen control (Arnstein 1969). Thus, engagement can vary greatly between informing, consulting, involving, collaborating to empowering. As discussed in section 4.2, issues of motivation for and effectiveness of engagement are criticized and remain highly debated also regarding appropriate methods, e.g. focus on consensus (Felt and Wynne

2007) or forms, e.g. 'artificial' decontextualized engagement (Bogner 2012). Further, the inclusion of outcomes of engagement exercises, for instance within representative democratic systems remains a challenge. Current policy developments such as Responsible Research and Innovation or Responsible Innovation stress the importance of including stakeholders throughout the S&T development processes (Schomberg 2012), yet often remain unclear how to do this in practice. For TA, also in light of current approaches like RRI, it remains a continuous issue how to include engagement as part of the assessment as well as how to integrate its outcome into decision and policy-making.

Remembering the discussion in the beginning chapters 2, 3 and 4 of this thesis, wider forms of knowledge, beyond expert-based, are needed in order to govern and better align S&T and society (Jasanoff 2003). Because many S&T developments have wide-spread implications, including social benefits or risks, it becomes necessary to incorporate ethical and normative reflections, also as a way to legitimize decisions and encounter distrust or confrontation. In this way, lay people's views expressed within engagement processes, become equally valid to those of experts. Overall, this forms the basis of most discussions on engagement in S&T, at least in Western countries. Over the past years, we see a trend towards increased arguments for engagement as well as processes to complement this, especially in Europe or the USA (ibid.: 235ff.). Next to changes in modes of research this can also be related to understandings of liberal democratic foundations and socio-political structures, which give strong arguments for the inclusion of ideally all citizens within decision-making processes. Because individual freedom, self-determination and rationality are main features of liberal democracies, the inclusion of citizens or stakeholders seems like a 'natural' part of this. In this view, each individual citizen is the agent able to determine their own course of life, therefore they should be consulted about decisions that potentially affect their lives (Wong 2013). Yet, this legitimization of engagement within liberal democracies seems too limited to provide a foundation for engagement beyond the West. Here the question arises what other normative (or cultural) approaches can be found to support engagement. This becomes especially important in the context of new forms of knowledge production and wide-spread effects of S&T across borders as well as for TA. Documents addressing a global level of engagement, such as the report by the United Nations Educational Scientific and Cultural Organization (2015), refer to the importance of including citizens, especially in light of global challenges. This connects to the aim of a global level of TA. Engagement, as an essential part of TA, would also have to be a key aspect included in a global approach. Further, it can be assumed that some form of engagement, understood in a wide sense as communication, debate or participation, takes place in any society dealing with S&T developments and policies. If TA is to move towards a global level, it will have to identify and account for the forms of engagement taking place as well as find new ways of engagement. Experiences in participatory or Constructive TA can provide a basis for this.

In the context of this thesis, the case studies in China and India provide us with first insights and substance regarding the (ideal) understandings of engagement in the different national contexts as well as what is currently taking place. Further, we can relate this to the understandings of TA in the specific national setting and where new potentials for TA may lie. Moving towards a global TA means understanding these country-specific settings and what arguments are made regarding the possible benefits or difficulties of engagement. We can also understand how these are changing in the context of globalization developments and what role TA should play here. This entails designing appropriate processes for engagement in various settings as well as a

promoter of these activities as a way to come to better S&T decisions even in diverse settings. Further, this also includes finding ways to resolve or at least address possibly very different reasons for engagement as well as methods or outcomes. Country specifics can require diverse approaches to engagement and how outcomes in turn feed into decision-making may also vary. A global level of TA should be able to take this into account while still ensuring quality criteria (e.g. certain transparency, fair processes, etc.) that apply across settings. By looking at engagement across the countries it is possible to better understand why or why not engagement takes place in S&T decision-making. A comparison and relation of the countries to one another along key aspects important for engagement can help identify parameters relevant for a global TA. This marks a step forward of the findings of the specific cases (Germany, China, India), their comparison and how this can be useful towards a global TA.

S&T Priorities and Societal Challenges

Main factors in S&T priority setting are the perceived societal challenges and goals. As we have seen in all cases, (grand) challenges for countries and their population are used as a frame to legitimatize and select which S&T developments are especially worth developing (through public funding). This of course is then relevant for engagement as one could argue forms of inclusion are needed in order to actually align societal challenges, needs and expectation with S&T priority-setting. Yet, as we have seen in the cases this varies and often decisions on which S&T developments to foster are expert-led.

In Germany, key documents such as the High-Tech Strategy of the Ministry of Education and Research show that the country's increasingly ageing society (societal challenge) requires strives in robotic technologies to care for elderly people (S&T priority). The overall positive understanding of S&T innovative advancements in the documents also shows in the link between (maintaining) competitiveness and prosperity as societal goals and the need for S&T. Ambitious goals such as the energy transition towards renewable sources are connected to overall strives towards sustainability or responsibility for future (German) generations. Over the last years, this has also led to increased demands for engagement in Germany as a way to better align these priorities and goals with the actual needs and expectations of the wider public or stakeholders. This emerged over time, also because of public debates and conflicts on technology developments or large infrastructure projects. Ideally, engagement should help identify what people expect from S&T developments or where possible (ethical) boundaries lie. Further, engagement is seen as a way to align large scale developments, such as the German energy transition, with citizens' or stakeholders' perceptions and demands, framing these kind of endeavors socio-technical developments. In the Germany, with increasing engagement, it is important to note that the danger of this inclusion becoming mere "lab participation" (Bogner 2012) and remaining disconnected from the outside world and therefore from political priority setting or actual societal concerns rises. This results in engagement without real world effects, either political or societal, making this an issue for TA and its aim of reaching impact, especially in more established TA countries such as Germany.

In China, we also find priorities framed along societal challenges. Rapid growth and economic development have been connected to the well-being of the Chinese population, even though dominant characteristics like scientism and developmentalism prevail (Zhao and Liao 2016). China has gone from an agricultural economy to a service one, mainly in the area of

manufacturing. Over time, the importance of an innovation-oriented country based on the importance of indigenous innovation as a way rely less on foreign imports of expertise or technologies has become a key element of S&T policies as represented for instance in the current Medium- and Long-Term Plan for S&T (2006-2020). This all has also influenced the way engagement is understood in the Chinese context. As we see in the interviews, it is often described as science popularization or communication. A tradition of and channels for engagement are lacking, overall resulting in a missing 'culture of engagement' and top down approaches to priority-setting. This of course isn't beneficial for "opening up a process of technology choice" (Stirling 2008: 279) to a wider group and offering plural input to S&T priority setting. Still, in China we do find more current discussions of the "new normal" in which economic development should enter a new phase towards more sustainable growth and be better in line with societal demands. Here S&T innovations play a key role to move towards qualitatively better growth regarding social distribution and environmental impacts. This aims at aligning S&T developments better with Chinese societal needs and expectations. Even though this "new normal" is overall concerned with economic developments and mainly implemented top down, it does show a certain shift towards societal aspects, which may in turn need to be assessed via engagement. Overall, concluding from the interviews, the strong top down and expert-based structures in China remain dominant, yet it seems there is a certain awareness that wider forms of advice based on, among others, the inclusion of wider areas of society, are necessary. In this way, there is a tension in which economic development and prosperity, a lack of public debates and pressing (societal) effects of S&T (e.g. pollution) that in turn seem to require new approaches.

From the very beginning of India as a sovereign country, S&T has play a key role in its democratic understanding. Therefore, S&T development, as the documents show, is regarded as a key tool to foster economic growth, societal wellbeing and push through national interests. National security, nuclear power or space programs are essential elements of the notion of big science in India. A Nehruvian understanding of S&T as large scale scientific endeavors, expert-led decisions, 'scientific temper' as a part of citizenship as well as top down management was part of the ideal after Independence and is still dominant today (Pandey et al. 2019: 158ff.). Here we see that S&T priorities are tied to the overall well-being of India as an independent country as a whole. In the past way of decision-making, based on this Nehruvian ideal, judgements were left to experts such as scientists and engineers. This also resulted in a lack of political awareness of the relevance and importance of the wider public's inclusion into decisions. Engagement, similar to China, is therefore often understood in terms of one-way communication: experts inform the public on S&T, possible risks or benefits. Issues of illiteracy in India as well as very different education levels make this a challenging task in itself, which also has implications for wider forms of engagement. We do find demands to achieve social justice through S&T in India (this can be based on a Gandhian ideal of inclusive S&T), also as a way to bring together S&T developments and needs of people, yet it seems that a "deficit model" (Wynne 2007: 101) of the S&T and society relationship is still predominant today and a certain institutional unwillingness prevails. This is related to issues of diversity or dispersed levels of literacy, which add difficulties to conducting engagement.

If we look across the countries regarding the understanding of engagement in S&T priorities and societal challenges, we find considerable differences especially between Germany and China or India. In all cases S&T advancements are connected to more general societal issues or goals. In

this way, a frame for priorities and funding is provided which is aligned with society and its self-understanding (e.g. as an independent, globally competitive country concerned with the well-being of its people). Yet, this doesn't necessarily translate into an inclusion of the wider public in S&T decision-making. In Germany, nowadays we find increasing demands for and activities in engagement connected to S&T priorities. These are often done with the aim of understanding perceived risks and benefits as well as which aspects are most significant for people. This is not necessarily morally motivated in the sense of engaging because it is the right thing to do. Instead the German case shows that past conflicts regarding issues such as nuclear waste or large scale infrastructure projects (as also described in part 5.1) have led to a (harsh) 'waking up' of a past technocratic top down model towards an awareness of the benefits of communication and consultation (Grunwald 2018b: 65ff.). This also reflects in the changes in TA in the German context, which in its beginnings was mainly an expert activity aimed at providing (scientific) assessments and now has a growing role, for instance, in transformation processes. We see that engagement activities in Germany are fairly advanced and take place in many different forms. Yet, one could argue that in order to actually include the wider public or stakeholders in S&T priority setting, engagement should be aimed at enabling these groups to actually co-participate in setting research agendas. Here we find room for improvement regarding engagement activities in Germany: how to design processes and actually include their outcomes in the development of S&T priorities and agendas, not as "political participation in decision making but participation in ascertaining the available knowledge and evaluating it in the light of social values and interests" (Hennen 2012: 39).

Compared to Germany, in China and India we see that awareness and practice in engagement is still overall missing. We find a general lack of awareness of engagement in both countries, which can be traced back to various aspects. In both countries we find an overall top down, technocratic approach to S&T decision- and policy-making. Priorities and research agendas result mainly from expert-led discussions and decision-making. This of course also reflects in the relationship between science and society, which seems to be mainly one-way in both countries. The interviews show that science communication or popularization are therefore the main activities in the context of engagement. In India, this is also due to issues such as illiteracy and limited access to technologies for some (rural) parts of society. Whereas in China an overall lack of third party actors (such as NGOs) result in little public debates. Of course, many more aspects influence the relationship between science and society and the limited political awareness for the importance of inclusion, yet these were predominant in the country case studies. Diversity and plurality in India as well as developmentalism and scientism in China make engagement a challenging issue in both countries. In this setting, it remains to be seen whether "technologies of humility" (Jasanoff 2003) and different ways of dealing with complex, ambiguous contexts will arise as (public, economic, environmental) pressures within as well as from outside the countries grow.

In Germany, increased engagement does arise from the aim to include various groups to improve the way decisions are made, but also to incorporate needs and expectation or ethical considerations in S&T developments. In India, diversity in many aspects would require engagement in different regards: as information as well as inclusion. Still, political awareness and willingness are needed. A shift towards a "new normal" in China may increase awareness for qualitative aspects and specific needs of a wider public as well as possible limits to S&T developments according to sustainability. As we see, in all three countries there are specific

arguments to be made for engagement. The inclusion of the public for instance in S&T agenda setting in Germany would enable foci according to actual needs and in line with ethical considerations. In China moving towards more sustainable S&T developments could include engagement as a way to design this. India could use engagement to better include diversity aspects into making S&T accessible. This of course can require very different forms of engagement methods which are appropriate to the specific needs as well as the preconditions and can range from consensus conferences to online discussions. This is explored in more detail in section 7.1 in the recommendations for the different countries. This also leads us to a further key aspect for engagement in the countries that emerged. As we have seen engagement can and should play a role in S&T priority setting. Yet, in addition to this, the overall political system and cultural aspects also shape the potential and form of engagement in a given setting.

Political System and Culture

The surrounding political system and cultural aspects shape engagement and the forms in which it takes place. In China, India and Germany we find factors that play an important role for the level of engagement activities and how they are understood. This can be seen as the surrounding general political system, for instance whether a pluralistic democracy or more top down structures for decision-making. Also, this shapes cultural aspects and whether public debates on S&T developments are common or if most decisions are based on expert opinions. As we see from the description above, S&T priorities are framed along societal challenges. Yet, whether these challenges are defined and influenced by a wider public or by mainly experts and decision makers also depends on the surrounding system and political culture. For engagement this is a key aspect as it can help understand why or why not engagement takes place as well as which forms may be best suited for the specific setting.

In Germany, the emphasis on individual rights and freedom and the basic democratic structure as an undebatable norm create a direct link between the inclusion of the public and decision-making, also making the claim for participatory TA (Joss et al. 2002). As a representative democracy, in Germany this is usually done through elections, yet over the past years demands for a wider inclusion have become louder. These have come from various groups, either from the public sphere, civil society, stakeholders or political decision makers and include a variety of issues. Regarding S&T decision-making for instance, past and current coalition agreements or S&T strategy papers stress the importance of engagement as a way to gain approval of S&T developments and to ensure a certain openness of the public towards these (Federal Ministry of Education and Research 2010). This has shown in various projects funded among others by the Ministry of Education and Research regarding topics such as energy, Citizen Science, digitalization or high-tech medicine. We can identify a relatively high political awareness nowadays that forms of engagement are necessary in today's Germany as well as a rather strong civil society and public who can conduct these processes or take part as legitimate actors. Still, even though we find a now fairly advanced understanding of the importance of engagement (also as a reaction to past conflicts and disputes) and several activities, the culture of inclusion in Germany still lacks knowledge and mechanisms for incorporating these inputs into political decision making (Hahn et al. 2014).

Similarly, in India as the largest pluralistic democracy world-wide, we find the political basis for the inclusion of a wider public, yet it remains an overall expert-oriented system. As described

above, S&T is a key element of India's democratic self-conception and was regarded as a way to become fully independent by enabling economic growth and societal wellbeing. This led to the conception of big science, including large undertakings and top down decisions based on expertise. Still, other approaches like the Gandhian understanding of science as decentral and locally-adapted also remain cultural aspects which influence debates on access, equity and inclusion. This demonstrates tensions within a pluralistic diverse country like India. On the one hand, S&T policies are focused on fostering high-level advancements with a strong focus on expertise. On the other, developments are needed to fulfill basic needs, also by incorporating local specifics as well as adapting governance and methods to these diverse settings. Here a balance between competitiveness and inclusiveness is needed, along indictors of access, inclusion and equity, which "links societal development with science and technology policy" (Chaturvedi and Srinivas 2015: 95). Engagement has an essential role to play here in better aligning the expectations and needs of a wider public with S&T developments; through this shifting the overall political environment and culture. This would have the potential to reconcile the current structures with the ability to include various people and stakeholders.

Also, in China we find that S&T decisions are often made in a top down and expert-oriented way. Science popularization as a predominant understanding of engagement in China showed in the interviews. Here the main focus is on the one-way education of the public on S&T and not necessarily on the inclusion of their needs and expectations. Even though we find disputed issues (e.g. environmental or GMOs) in Chinese society (Zhang and Barr 2013; Zhang 2012), overall scientism and developmentalism are still the dominant culture that determines mainly technocratic approaches to priority-setting and policy-making in S&T. The public is often seen as in need of information and education and not necessarily required for providing input regarding decision-making. Overall, the spheres of science, policy and society are mostly (kept) separate. Looking at the overall political system and culture, the question arises whether engagement methods such as consensus conferences can actually be usefully "imported" into the Chinese context, since it doesn't necessarily have a tradition of open debate, which would be required for such a method. Further, questions regarding "authoritarian deliberation" arise, and show that what "distinguishes China is that governance-level participation is developing in the absence of regime-level democratization" (He and Warren 2011: 271). At the moment in China, activities regarding the collection of public opinions take place through online platforms, which is seen as a useful way also due to the size of China and the growing importance of smartphones in people's everyday life. Here we find accounts that debates do take place, other, then perhaps, face-to-face.

Reflecting on the interviews and looking at engagement across the countries, we see that there are very different levels of awareness, methods and experiences between the German, Chinese and Indian political system and culture. Further, by contextualizing the understandings of engagement in the countries we can come to more differentiated approaches to country specific needs. As mentioned above, different political systems raise diverse questions for engagement, which range between inclusion in a representative democracy, conducting engagement in a highly diverse setting, to issues of authoritarian deliberation. Thinking towards a global TA, this also means that merely importing engagement methods into different countries wouldn't actually provide valuable input for TA. As, for instance the World Wide Views project (as described in section 4.2) showed, conducting a European model of engagement (aimed at consensus via direct discussions) isn't necessarily a useful way forward as it tends to disregard

local or national specifics and needs as well as debate cultures. Of course, wide experiences with methods such as in Europe are valuable to countries in which awareness for engagement seems to emerging. Further, for TA conducting engagement in these 'new frontiers' it will be important to continuously reflect on the possibilities but also the limitations of these endeavors and where an adaptation of methods and formats isn't aligned with normative foundations of TA anymore (as discussed in section 6.2.2). Still, experiments in countries with emerging engagement can give insights into other ways of conducting engagement (e.g. in a diverse setting like India). Here comparisons of concrete engagement measures between countries could also be used to identify suitable criteria, which go across individual methods to include wider aspects such as transparency or input to political decision-making.

Across the countries described here we see that some form of engagement or inclusion of a wider public is important regarding S&T and does take place in different forms and intensities. Their globalized and encompassing developments make it necessary for countries, especially those relying highly on S&T, to find ways to negotiate priorities and paths in (more) inclusive ways. For a global TA, this means to think about engagement along a continuum, not necessarily in a development sense, but as a way to represent different levels and where needs, aims and difficulties in individual countries lie, also as a way to learn from one another.

6.1.2 Ethics

S&T developments and their increasingly globalized form have also lead to wider ethical debates and even conflicts within societies (Brom et al. 2015). This expands ethics beyond the standard expert reflection to include lay people and a wider plurality of perspectives, which are expressed. We can say that the people involved in ethical debates on S&T in societies is larger and that different groups are becoming a more legitimate part of ethical discussions, at least in some countries. In this situation, the border to what is actually an ethical question is blurred; for some it may be an ethical question, for others an economic one (Ladikas et al. 2015a: 3ff.). For instance, is debating the importance of access to a certain medical technology a monetary question or an ethical one or both? Consequently, for uncovering a global level of TA as well as tracing TA(-like) activities in different contexts a wide understanding of ethics is useful. As described in section 4.1, the academic study of ethics is a wide field with long traditions. In this way, ethics is about universal claims, moral phenomena such as responsibility and finding arguments and justifications. In the context of this thesis and its overall aim of finding ways towards a global level of TA, it seems necessary to widen this academic understanding. This scope here isn't to find deduced (universal) arguments regarding moral questions. Here, in order to grasp the different ways ethical debates on S&T take place (or don't) in different countries, a more culturally and socially sensitive approach is needed. This requires the framing of these reflections as an activity instead of an academic field (Ladikas and Schroeder 2005: 407). Global ethics for instance is concerned with finding agreement on fundamental conditions for human flourishing for all. This lies between universal or common terms that also reflect each culture's moral codes and ways of behaving. This also entails translation efforts in order to move towards these communalities.

As we have seen in section 4.2, a broader understanding of ethics is also useful to see how these reflections become part of S&T decisions and policies. This can be in a formal way, meaning ethical debates have a set structure in which they take place (e.g. advisory bodies) or informally,

by lay people negotiating issues, which then also finds its way into decision making processes (Ladikas et al. 2015a: 4). Their voices are seen as valid and as an important addition to experts' views, also because S&T developments are affecting wider parts of society in more direct ways. For TA, taking up these ethical reflections is a key activity as it is a way to ensure for a deeper understanding of how S&T developments effect a specific society or group. For instance, through engagement processes these negotiations and debates can be uncovered and become part of the assessment and, ideally, then decision- and policy-making. By looking at underlying values or more specific S&T priority setting, a common approach to ethics can be attempted, that can account for local or national specifics as well as done at a global level. This doesn't mean coming to the same structures or processes everywhere. Instead, it should take into account the specific contexts, ethical debates or diversity of stakeholders in various countries. Based on this, certain ways forward can be developed which can ensure that different ethical reflections can be included in policy-making. These can range from common deliberation platforms on a global level to capacity-building for ethics advisory structures to societal impact indictors for S&T.

A challenge regarding ethics as part of a global TA is to actually develop these ways forward in a complex and globalized setting. Deliberation platforms and ethical reflection exist in certain areas, such as UNESCO with COMEST[137] (described in section 4.1.2), but coming to common action can be difficult and lengthy. Also, simultaneous effects of S&T around the world have changed the ways humans interact, thus also ethics. If initiator, action and outcome are not limited to the same actor, location or scale, then new levels of responsibility arise, which require a wider ethical approach. This includes that of lay people as it can offer contextual and socio-cultural specific kinds of knowledge, also essential for TA. As with engagement, we find ethical reflection and debates across the countries in different forms and to various degrees. Looking at the case countries, the decision-making processes seem to influence the kind of ethics that take place and thus present a relevant frame for understanding ethics across the countries better.

Openness of Decision-Making Processes

An important element regarding ethics we find in the cases are the prevailing decision-making processes. As with engagement, we can see that in the countries China and India, top down, expert-led decision-making is prominent, but that public debates can also play a key role. For ethics we find formalized 'professional' forms across all three countries, which are integrated in decision-making processes. Yet, for lay ethics to take place, a certain degree of openness of these processes is needed. Wider ethical reflections and debates can take place in a meaningful way if decision-making processes can, in part, account for these. Of course, in all countries decision-making is formalized through institutions and actors appointed to make these decisions. For lay ethics the question is whether next to these formal ethics, wider debates and ethical reflections take place and influence decision-making to a certain degree. This form of ethics "may find expression in spontaneously emerging public debates and controversies, but can also take shape in organized forms of public dialogue or consultation" (Stemerding et al. 2015: 105) and in this way will affect the processes of decision making. Here we see an overlap

[137] http://www.unesco.org/new/en/social-and-human-sciences/themes/comest/

between engagement and ethics in the sense that a country with more activities in engagement will tend to be better equipped in incorporating ethical reflections of a wider public.

Ethical debates on S&T have formalized, institutionalized forms in Germany, which include independent bodies such as the Ethics Council or numerous ethics committees in health and clinical trials. These can be legally required and take on ethical issues in scientific areas such as stem cell research, big data or cloning. Next to these formalized ethics we also find a strong civil society with organizations taking up the ethical implications of various S&T developments and debating these in the public sphere, in some cases also putting pressure on political decision makers. Overall, debates on ethical issues of S&T often result in a process of weighing basic individual rights and freedoms against the potential common good of S&T. A strong point of reference regarding ethical considerations is sustainability, which has become an importance factor for German debates over the past years (Hahn and Scherz 2019). This sets a normative or ethical framework for the protection of the environment as well as future generations. Numerous applications of sustainability in different areas such as industry can be found making the term somewhat dispersed. Yet, it has become a key element of ethical debates, also in the context of S&T developments. The expression of lay ethics can be found in many engagement processes as outlined in section 5.1.3. Therefore, in Germany the development and recognition of lay ethics, even if not necessarily termed as such, is fairly established within the processes that are taking place, overall there seems to be a degree of openness of the decision-making processes to include these. This is also tied to TA, which as an established form of advice, provides input from lay ethics next to expert knowledge. For lay ethics and TA, it will remain a challenge in Germany to find forms of inclusion of these diverse reflections as addressed above regarding engagement.

Ethics in China is mainly in the realm of experts and official bodies, which coincides with the dominant top down and therefore more closed decision-making structures. Awareness of the importance of science ethics is growing, especially regarding research integrity, intellectual property rights, but also that the benefits of S&T should continue to spread throughout society. After huge strides in agriculture, for instance, supply of wide parts of the population with basic nutritional needs was ensured. Recently, current developments in food technologies or GM foods have created public concerns, even conflicts regarding health or environmental issues. Here we see tension arising between the strong notion of developmentalism and scientism in China, the assumed political legitimacy for decisions for these technologies and the concerns of a more aware public (Hahn et al. 2019). This tension for instance lies between uncompromising proponents of GM foods, a common assumed ignorance of the public and extreme opponents rejecting GM foods (范针 2013). As other examples of cloning show, ethical concerns aren't necessarily based in Chinese cultural or historical specifics, but can be 'imported' from other countries (Zhang 2012). Overall, as ethics in China is still mainly an expert business, questions of lay ethics are often difficult to answer. Even though there is a lack of experience and expertise with including different actors in ethical reflections and debates, an emerging awareness of the relevance of adding these 'other ethics' can be observed. For example, activities targeting top level scientists to raise their awareness and commitment regarding ethical issues are taking place as referred to in the case study interviews. The aim behind this is that by bringing it on the agenda of the scientists, wider ethical reflections can be initiated. In a system of scientism this can prove to be a useful approach. Here we could state that the processes are opening up to a

certain degree. Further, this can be an entrance point for TA: to address the rising pressures from the public side, even if often limited to a specific issue or technology, and propose ways of taking up these ethical debates or conflicts as part of the decision-making process. For this, political awareness and will needs to be increased in the Chinese context. Of course, this is a challenging task and TA itself should also reflect on this process in order to make sure its processes are able to take up lay ethical reflections in a meaningful way.

Similar to a mainly one-way understanding of engagement, ethics in India also remains in the realm of experts. Big science and an overall top down structure also mean experts are regarded as the main actors for providing input for decisions, also in terms of ethical reflections. Even if S&T policy decisions may aim to develop S&T towards solving societal challenges (e.g. food technologies for providing nutrition to an ever-growing population), if stakeholders aren't included, (new) issues, such as inequalities or limited access to technologies, may arise. The tensions in India between big science and fulfilling basic needs become apparent when (ethical) decisions on the priorities of S&T are left mainly to experts (Pandey et al. 2019). In India, the ethical reflection of S&T often takes place in expert committees, for instance for clinical trials. Lay ethics as described in section 4.1 doesn't seem to be relevant for many actors in Indian S&T, which comes from an understanding of the public as lacking the abilities to comprehend and reflect on S&T developments. Of course, issues of illiteracy or largely diverse groups are important when trying to initiate lay ethical reflections. How this can be done in practice also has implications for engagement processes, which need to be resolved. This has to begin with a basic awareness of the importance of including stakeholders or a wider public as a part of ethical reflections. At the moment in India, as concluded from the interviews, it seems that the expert model of ethics is regarded as a useful model, which can also be a starting point for expanding ethics to include different actors. This could mean that experts, if they regard lay ethics as an important contribution, could collect different ethical considerations from various groups and moderate processes of how this could be included in S&T decision making. Access, inclusion and equity, if taken seriously as key aspects of S&T policies in India, would imply such a way forward in order to open up processes of decision-making. In a way, this would move towards a Gandhian approach as a first step in including different voices in the current (top down) structures (ibid.). This also shows the importance of TA in India to take on a key role here and lobby for the inclusion of lay ethics within the ethical reflection, even if, for now it may mainly be via experts. Currently, issues of scientific social responsibility are coming up from high level governmental sides (e.g. Prime Minister) as described in an interview, which are concerned with using S&T developments for better fulfilling basic needs. This indicates a movement towards more awareness or openness from the political side regarding some inclusion of lay ethics into decision making, even if this is still limited.

As we see, China and India seem to have similar understandings of ethics as mainly expert-led and conducted in more formal arrangements such as specific committees. This, of course, again suits the overall decision-making structures in both countries. There aren't clear connections between ethical reflection and engagement, yet, we can conclude from the interviews that in both India and China there seems to be a growing awareness and openness that S&T priorities and societal needs should be better aligned, meaning that decision-making needs new forms of input. This seems to be a similarity overall: arising S&T debates, even conflicts, and the limits of an expert-based system to fully address these. In Germany, we also find established forms of ethics, yet in the context of concepts such as sustainability, issues of responsibility and

accountability have become more and more relevant over the years. Nuclear waste or the energy transition are issues that require the inclusion of wider lay ethical considerations; this seems to be fairly well received on the political level and defines a key role for TA in this context (Hahn and Scherz 2019).

We see that in both China and India, even though they are politically structured very differently, the limits of an expert-oriented ethics approach are becoming more apparent. In China, public debates on GMOs require more than just scientific reassurance of the safety of this development. In India issues of access or equity as orientation for S&T policies need the inclusion of lay ethics as well. Similarly, to engagement, the experiences in including lay ethics in the German context can help inform ways forward in India and China, even if these need to be adapted. In turn, Germany can learn from the inclusion of diverse groups, as would be required in India, and help widen a mainly high-tech oriented perspective to include alternative approaches.

Concluding from the empirical data of the interviews, the documents examined as well as the reflections along ethics and engagement presented here, a global TA should continue in this direction. This includes examining lay ethics in different contexts, since, even in very top down and development-oriented systems such as China, emerging public ethical debates (at least regarding specific technologies) can increasingly be observed. This could, on the one hand, result in a democratization of S&T debates by including a wider scope of actors in ethical reflections or on the other, in narrower approaches in which lay ethics is kept in carefully controlled spaces. Here TA will again have to reflect on its role in these emerging spaces and whether this coincides with its interests in increasing reflexivity. Also here, it can be useful to think along a continuum of lay ethics, which can help understand better how these ethical considerations are taken up in various countries and to which degree.

6.2 Technology Assessment Habitats

Based on the accounts given above regarding ethics and engagement, we can also better comprehend how TA is understood or practiced in the different countries. As TA is a process including scientific, interactive and communicative aspects, its overall aim is to help form public and political opinions regarding societal aspects of S&T developments. Therefore, as argued in chapters 3 and 4, ethics and engagement are essential parts of any kind of TA. By uncovering how these are understood in China, India and Germany we therefore gain insights into TA and its potential in these national contexts. As also mentioned above, even though we only find limited knowledge of TA in China and India we can use the findings on ethics and engagement to identify what TA-needs may be or where it could be located within the national system and even how it perhaps relates to more general priorities and values. Using “TA habitats” as an overall concept is helpful in order to better understand why or why not TA (or TA-like) activities take place in certain settings and, perhaps more importantly, to uncover what is needed in order to expand TA in its different forms (as presented later in section 7.1). The socio-political environment surrounding TA, the structures, institutions and processes and how they relate to each other influence the degree of TA activities. Moving towards a global level of TA also implies reflecting on what environments are needed for TA on a more conceptual or general level. As described by Hennen and Nierling (2015), certain socio-political aspects (e.g. institutions,

processes) make up a habitat, which can either be beneficial for TA or hinder its development. Further, these aspects also frame what form of TA is best fit, for instance, whether TA should be more networked in order to raise awareness and show relevance or integrated into existing institutions (ibid.: 53ff.). Therefore, this idea of the TA habitat is a useful way to understand the proximities for TA and what is needed in the future. As shown above along aspects such as S&T priorities, the political system and culture or openness, these surrounding structures and ways of doing things have influence, also on TA. Further, the current development level of TA or similar activities and how institutionalized they are can offer insights into what future needs may be.

Looking across the countries and the existing activities as well as how TA is understood and how this compares to each other can help us come to more concrete recommendations for Germany, China and India towards expanding their forms of TA (section 7.1). As mentioned before, this cannot merely be an exercise in importing different TA methods into diverse settings, but the current socio-political habitat should shape what forms of TA and how can be useful. This in turn presents a further step towards a global TA as it can be an example of how to go about understanding, reflecting and adapting TA(-like) activities in different countries across the world.

6.2.1 TA Across the Countries

After examining engagement and ethics in the countries and comparing this to one other along key aspects, the different TA habitats are described the following to bring together how TA(-like) activities are currently taking place in Germany, China and India. This is done in order to summarize the findings from the cases and in order to relate these different habitats to each other. By doing this, we can understand better how TA or similar activities are taking place and, more importantly, what future needs are. The reflection across the habitats shows a range between established and emerging TA environments and TA's roles in these as well as a step towards recommendations for the specific countries (section 7.1). For a global TA level this is needed in order to establish common ground as well as identify if, where and how mutual learning can take place.

Widening Established Assessments

In Germany, we find TA as a well-established term which includes practices of policy advice. Especially forms such as Parliamentary TA have specific institutions and processes in which they take place. TA institutions range in their orientation from more technological to ethical or societal foci. In Germany, the overall TA landscape is fairly advanced regarding policy advice as well as research on TA methods or impact itself, as described in section 5.1. Throughout the years, more actors from the area of S&T itself have begun including TA in their repertoire (Hahn and Scherz 2019). On the one hand this ensures a lively TA community with various perspectives, on the other it means that very different actors can be considered as engaging in TA activities. We can find TA as policy advice, as part of Parliamentary TA or in projects done for federal ministries or the European Commission. For Germany, large-scale undertakings, such as the energy transition, are highly relevant for the relationship between policy, S&T and society and have changed interactions towards more inclusion in the past years. TA has to examine and provide advice on the transformation of socio-technical systems, which entails various issues such as engagement in planning processes or acceptance issues. Here we find a newer form of

TA engaging in transformation processes (Grunwald 2018b: 72ff.). This can also be found in projects dealing with sustainability, a key issue in Germany. TA here goes beyond advising, to actually engage with actors with the goal of, for example, co-shaping behavior or consumption patterns or co-designing more sustainable mobility. Engagement and public debate is a further distinct characteristic of TA in Germany. As described in chapter 4 and section 5.1.3 the inclusion of a wider set of society in questions and debates on S&T has become increasingly demanded, especially in Western countries such as Germany. TA can have different approaches here, though these might overlap in practice: inclusion of the public or stakeholders as one element of the overall assessment to better understand ethical aspects or initiating of participatory elements in order to involve these actors in decision-making processes. This also crosses into activities of incorporating stakeholders in actual S&T development processes, with the aim to come to better, more fitting technologies that can actually meet the needs of people.

Currently, these can be described as the predominant TA activities in Germany. Well-established and institutionalized forms of (Parliamentary) TA provide a sound basis for TA outcomes to be part of political decision-making. Yet, this also depends on the goodwill of the political side as the funder and client. Within a representative democratic system such as Germany, the roles are clearly distributed: TA advises; political representatives decide. TA's main role here is that of a "*scientific observer and analyst*" (ibid.: 171) who distantly assesses and provides knowledge for decision makers. Yet, when we go beyond this form of TA, the roles become a bit more blurred. With increasing demands for the inclusion of a wider public, TA has to reflect how outputs can be taken up within the political system, which issues can be debated in a useful way, who should be included or perhaps shouldn't and how to design meaningful engagement processes. Here the role of TA may vary according to the specific context, as an initiator and organizer of engagement or as a mediator between different groups. In this way, TA appears as an "*intervening force*" (ibid.: 171) aiming to transform developments 'for the better'. Further, though efforts in initiating engagement, TA can also take on the role of an "*agenda-setter*" (ibid.: 172) attempting to broaden debates on S&T and raise awareness on possible (future) issues. As described in section 5.1.3, highly debated issues such as nuclear waste in Germany, require the development of unique processes specifically adapted to the national (legal, political, societal) contexts. Overall, it seems important to keep in mind that when TA increasingly initiates transformation processes, it should also reflect on the role it plays and how these interventions should take place.

We can state that the overall habitat for TA in Germany is quite advanced regarding structures, specific TA institutions and processes of policy advice. In Germany, there are political awareness and will (to a certain degree), conceptual and methodological work on TA and numerous projects building on long-term experiences. Therefore, the question of the ideal location of TA isn't as pressing, especially since institutions and processes are fairly set. Instead, a continuous development of TA, adapting to changing settings is highly relevant in Germany. One key aspect of this is the global level. Based on the wide experiences and fairly 'safe' institutionalized setting, German TA's challenge is to widen its perspective as well as methods towards this global level. This also implies an openness to input from other countries in which TA may not be as established, yet who can offer useful insights also for German TA. For example, moving towards flexible, networked forms of TA, next to the nationally institutionalized ones, as well as allowing for problem and solution orientation, which may not always be high-tech. Further, questions arising in other national settings, such as the issue of access and equity in India, even if not

seemingly apparent in Germany, can also be relevant to German debates and are disregarded at times. Through a wider global perceptive, potential blind spots in one's own TA approach become clearer.

Opening Up Assessments

Assessing S&T in China is mainly done in terms of its economic or innovative potential, i.e. scientific assessments. Overall goals of the Chinese system such as development, prosperity or economic growth correspond with this fairly technocratic approach. As the case interviews show, TA as a term is not well-known in China. Even its translation seems to be difficult, as the direct conversion into Chinese would only include a hard-scientific approach. Therefore, the societal aspects of assessment, important for TA, would have to be added to a direct Chinese translation of the term. Often concepts such as science popularization, which are concerned with informing on and communicating S&T developments one-way to the public, dominate the understanding of the relationship between S&T and society in China. This is connected to a general lack of public debates on S&T, with only a limited number of active civil society organizations e.g. in the area of environmentalism (Zhang and Barr 2013) (as described in section 5.2.3 and 6.1.1). Tracing TA in China reveals the strong reliance on experts, the top down decision-making structure and the still dominant emphasis on economic growth. As such, currently TA's role (or similar activities) can be described as mainly the "scientific observer and analyst" assessing from a clear distance. Also, we can find indications of TA as a "*tracker*" (Grunwald 2018b: 172) in the sense that possible innovation pathways are evaluated and opportunities of new technologies are assessed, mainly regarding quantitative criteria. Yet, current high-level policy developments like the "new normal" are showing a shift towards more qualitative indicators for growth. Further, there is also indication an opening up is occurring due to arising conflicts, for example on GM foods and the overall aim of maintaining a harmonious society. As the interviews show, a changing habitat for TA in China is visible, which requires different structures and processes than only the top-down ones. This in turn raises questions regarding which roles TA would have in this more open environment; whether TA could become more of an agenda-setter and broaden debates or raise awareness. Of course, as we have seen in-depth in the Chinese case study, the question of how this can fit into a mainly authoritarian and top down system remains. A further aspect in this opening up in China is regarding the ideal location for TA activities in the Chinese habitat. Especially in a mainly top down system, closeness to the political actors seems important in order to have access and ensure the relevance of TA outcomes. If located in central key places such as CAS, CAST or MOST, changes regarding their internal structure would be necessary in order to allow for more inter-connectedness and communication across other ministries or institutions. This more decentralized way would also help account for the large size of China, in which issues may differ across regions. Concluding, for TA in China it is therefore useful to be located at different levels, including on a high level to ensure direct advice. Yet, this could lead to tensions within the current system, as it implies changes to current established structures and practices.

At the moment, as we see from the interviews, the main role for TA(-like) practitioners in China seems to be help develop and shape an appropriate habitat for TA to further progress. First experiments with engagement exercises such as consensus conferences (as described in section 5.2.4), even if not taken up systematically, do provide experiences in how methods of TA function in the Chinese setting, including possible limitations due to a lacking 'culture of

engagement'. Also, large scale surveys or analyzing of online debates are taking place, which provide insights beyond economic or scientific aspects. This can then serve to raise awareness with decision makers, scientists or the public regarding the (growing) importance of assessing S&T according to a wider set of aspects. Some institutions have taken this on, CASTED for instance is trying to raise understanding of the importance of responsibility issues as well as the complex relationship between society and S&T. Here, it seems again the location is important as it can ensure access, yet questions of independence and credibility may arise.

We could view the TA situation in China as a 'catching up' to the realization of the wide and substantial societal, environmental, even cultural implications the rapid development also of S&T has had in the past years (Hahn et al. 2019). The past and still current system of developmentalism and scientism requires technological evaluation, innovation forecasting; i.e. an overall technocratic approach. Yet, public debates (even protests) or pressing environmental issues do require a "new normal" towards different forms of TA. This also coincides with basic Chinese values such as harmony or affluence (Ma et al. 2015: 77ff.). We see from this that the TA habitat in China is very different from Germany. In a well-established habitat, TA should be widened towards transformation processes, as described above. In a habitat which shows signs of opening up, to a certain degree, like in China, TA should include more characteristics, like raising knowledge or broadening agendas. A challenge for TA in China is therefore how to come to a more holistic approach, including societal aspects, and whether this can take place in the current system (or how much it may have to be adjusted). Looking at the Chinese TA habitat also raises questions regarding different normative foundations (also as part of this environment) (Wong 2013), which are relevant for TA and described further in section 6.2.2.

Enhancing Existing Assessments

Concluding from the interviews, we see that TA in India is fairly fragmented and unstructured. The habitat for TA is therefore very spread out regarding institutions doing TA-like activities and the processes and structures in which they are embedded. The term TA itself seems more known than, for instance in China, yet is often also understood as foresight or evaluation of S&T developments, so mainly TA as a scientific observer and analyst. Government TA(-like) initiatives are also characterized by a top down, technocratic approach mainly relying on expert input, similarly to China. This of course corresponds with the overall S&T policy structure in India, which is mainly focused on development, even though there are shifts towards, for example, inclusive innovation (as described in section 5.3.2). Organizations such as TIFAC do regard themselves as conducting TA, as they provide advice for the government on S&T, also according to identified societal needs. Documents such as their Technology Vision 2035 (TIFAC 2015) show a certain shift towards the inclusion of the various needs of different groups in Indian society and try to combine these with the S&T landscape. In a way, this takes up the discrepancies between different groups and the rapid technological or economic developments of the past years and attempts to include an approach which takes diversity into account. Even if the document continues to emphasize development and economic competition and relies on expert input, it does at least refer to the needs of different groups. We can therefore identify some characteristics of TA as an agenda-setter, even if fairly limited. Also, TA-like activities in India can be found in university institutes such as the Centre for Studies in Science Policy (CSSP) at Jawaharlal Nehru University, which researches S&T policy developments, yet remain fairly academic in their reach and scope, so mainly as scientific observers.

When tracing TA in India in the interviews it becomes clear that there is an awareness by certain actors regarding European TA discussions and activities yet the corresponding capacities are lacking in the Indian context (Pandey et al. 2019). This shows when discussing possible ideal locations of TA in the Indian system. As debated also in the interviews, TA within government agencies, as it takes place at least regarding expert advice on S&T, provides direct input for policy makers, yet this in turn may affect the autonomy of the assessments. Instead, an independent council which works with the government, but is not under the control of a specific agency or ministry is perhaps more useful. Further, in a top down structure like in India, a connection of TA to high levels of government (e.g. to the Prime Minister) enables more long-term assessments and an embedded understanding of the importance of TA from the political side. It seems there needs to be a balancing of TA between directly linked to the government and TA as more independent advice and research, able to provide alternative perspectives. In a way, this also reflects the wider issues between a Nehruvian big science approach (in which advice and decisions are left to experts) and a Gandhian ideal of local and specific S&T development, which in turn can also serve as a democratization force (as described in section 5.3.2). This also shows how TA has to function in different roles in the Indian context. As a capacity builder (for experts, policy makers as well as wider public), as a mediator between the government and identified needs of diverse groups or even as a "*referee* […] determining what "right impact" and "better technology" are" (Grunwald 2018b: 172). Further, TA in India should be an initiator of activities or even an intervening force, which can serve these different functions and transform processes to a certain degree. This connects to a perhaps different view of what TA should be in the Indian context. As Pandey et al. describe, TA should function as critical discourse and examine "the diversity of knowledges (along with modern scientific knowledge) present in India in relation to different epistemologies and ontologies and argues for knowledge […] and cognitive justice" (Pandey et al. 2019: 171). Here we see possible new impulses for TA in general, which explicitly address diversity and issues of justice and equity.

Reflections Across the Habitats

Understandings of TA across the countries vary between economic, scientific innovation terms (e.g. evaluation) and interactive, communication processes (e.g. participatory). Overall, scientific assessments within TA can be found everywhere and are universal in their methods and approaches; TA functions here as the distant observer. Presenting of technical options and possible consequences of these are common parts of the assessment of S&T. Yet, when it comes to, for instance agenda-setting or broadening and reframing of debates, the specifics and differences of each country come into play. Therefore, what is done in these areas and how, varies between countries and their habitats. In China and India, tracing TA has to be fairly open regarding the term itself (i.e. not commonly used) as well as its definition. TA-like activities are taking place in both countries, yet not necessarily in explicit or established forms. In Germany, we find a long-standing tradition especially of parliamentary TA with current more pro-active developments towards TA initiating and accompanying transition processes. This of course raises new issues regarding TA's role and responsibilities. In China, values such as prosperity or harmony also frame, on the one hand very economically-oriented priority setting, but on the other an emerging awareness that some form of aligning these with societal needs and expectations is relevant. India has traditional understandings of more inclusive, people-oriented approaches (e.g. Gandhian) even if these are mainly dominated by big science ones. By looking across the countries we see that any nation dealing with S&T developments, especially if these

are a substantial part of its self-conception and economic prosperity, has to somehow find ways of gaining advice for how these can be directed. As we again see, basic values of the countries also shape the priorities and legitimizations of S&T (sections 5.1.2, 5.2.3, 5.3.3). Debates around S&T in Germany are influenced by values of individual liberty and freedom, decisions on Chinese S&T priorities are led by ideals of prosperity and harmony and in India access and equity are continuous criteria regarding tensions in S&T development. What we see here is that these aspects can also be extended to include a wider public in decision making on S&T. Even though in different regions of the world we have diverse values, which range from individual freedoms (e.g. in Europe) to collective harmony (e.g. in China) an argument can still be made for the inclusion of the public or stakeholders when it comes to ethical reflections on S&T. In light of global S&T developments (as discussed in chapter 2) and based on the country cases described in the context of this thesis, it becomes clear that there are increasingly similar challenges for countries to deal with, especially regarding the relationship between S&T and society. Even if national habitats vary (substantially) regarding, for instance, understandings of TA or structures and processes, the need to find ways towards better aligning societal needs and S&T developments is continuously relevant on a national but also global level. Here TA offers useful methods, experiences but also reflections for individual countries, but also for ways forward on a global scale. Still, as we have seen throughout this thesis, the question of the normative basis of TA activities comes up, when extending it into different contexts. As mentioned, the different values identified in the countries can provide arguments for inclusion as well as for TA. Yet, we also need ways of setting limits to the expansion and adaptation of TA so it doesn't become arbitrary. This is explored further in the following reflection on normative elements of TA habitats as well as regarding parameters of global TA.

6.2.2 Normative Aspects of TA Habitats

From this we come to a more general reflection of the normative foundations as part of a habitat of TA. Regarding this, debates on whether TA can only function in liberal, pluralistic democracies are discussed by also presenting values and normative basis from other traditions, specifically Confucian thinking. The aim here is to begin discussing how a global TA can be grounded in different local or national traditions beyond the Western ones from which it arose (Grunwald 2018b: 37ff.). For a universal global level, it is essential to reflect on this, as TA cannot function in diverse contexts when only based on one line of thought or one cultural tradition. Further, the idea of continuums is presented here in order to move away from binary thinking (democracy vs. dictatorship) towards a more fluent and flexible model, which can include various forms of national habitats for TA. These continuums revolve around the main aspects surrounding TA, which are key for its existence, such as the political system, socio-economic development, S&T decision-making system or national values and correspond partially with the aspects described in above in the context of engagement, ethics and TA. They also offer a meaningful way to identify different (potential) forms of TA along the continuums as well as possible limits in which TA cannot function.

In general, on a global scale we find standards that are largely accepted and which offer a foundation for TA and its connection to human rights, separation of power and key aspects of democratic and inclusive societies (ibid.: 97). For example the Universal Declaration of Human

Rights of 1948[138] (also signed by Germany, China and India) establishes fundamental concepts such as liberty, dignity or equality and, even though it is not legally binding, has informed international treaties, economic transfers, country constitutions and human rights instruments. The United Nations Millennium Declaration of 2000[139] emphasizes these human rights claims referring to freedom, solidarity, tolerance, peace and adding the issue of sustainable development and respect for nature. This declaration agreed upon by the United Nation's general assembly again shows basics on an international level, which also set a very general frame for TA. For instance, if a country does not oblige to these minimum standards then TA cannot function there. Other international standards to be mentioned here as they are also relevant for TA are those on sustainable development such as the Rio+20 conference in 2012[140]. Here the Sustainable Development Goals (SDGs) such as no poverty, clean energy, sustainable cities or climate action were defined and instruments to tackle global challenges (as described in the context of technology facilitation in part 7.3) were initiated. These goals clearly stress the importance of guaranteeing "responsive, inclusive, participatory and representative decision-making at all levels"[141]. This of course resonates with interests of TA and actions in policy advice and public dialogue, again offering basic normative frame. Again, this shows us that, hypothetically, a country which acts outside of these normative standards also cannot have TA in a meaningful way. They therefore offer the fundamental elements of a TA habitat. Of course, in reality the interpretation of these principles such as human rights or freedoms can vary considerably according to cultural or political aspects and domestic practices of governments. Still, they do show us a minimal standard and with this give orientation and a set basis for a global TA. This is also relevant in the context of S&T for achieving sustainability goals and how TA needs "new models" (Ely et al. 2011) to support this, which (as discussed in section 3.3) is highly relevant for a global level. Concerning the normative frame for TA, these statements regarding human rights or sustainable development and the emphasis on the inclusion of people in reaching these goals can help us set the boundaries in which a TA habitat is possible, and in which it isn't due to the disregard of these principles. Having set these basic standards, it seems worthwhile to look a step further in order to, as mentioned above, come to more fluent understandings of how TA can be grounded in different normative foundations. The goal here isn't to wash over all cultures and contexts and to find theoretical arguments to adapt TA under any circumstances. This would clearly disregard the fundamental conceptions of TA and its interest in improving reflexivity (Grunwald 2018b: 89ff.) and the ability to align S&T developments with societal needs and expectations. Yet, as the case studies in China and India have shown us, TA-like activities are taking place beyond Western traditions and it is therefore useful to think in a more conceptual way about what it means to move towards a global TA in a substantial way.

Beyond the country specific examination, which is presented for Germany, China and India above, thinking about TA in various contexts also means looking at if and how it can be adapted to different value-systems, including political settings. For instance, the Chinese case raises questions, as presented in section 5.2.4.5, on what forms of engagement can be realized in a system which isn't pluralistic and not based on Western ideals of individual freedoms. This leads

[138] http://www.un.org/en/universal-declaration-human-rights/

[139] http://www.un.org/millennium/declaration/ares552e.htm

[140] https://sustainabledevelopment.un.org/rio20

[141] https://sustainabledevelopment.un.org/topics/information-integrated-decision-making-and-participation

us to questions on the normative foundations of TA: Which basic values can provide a basis and legitimization for TA activities and where are limits? The aim here is to present initial thoughts on this by using discussions already taking place regarding TA and democracy (Grunwald 2018a), but also looking at other possible framings of TA, which become especially relevant within a global context. The goal here is to reflect on questions regarding the normative basis for activities in engagement or TA. This cannot be done comprehensively in the frame of this thesis; ultimately each country engaging in TA(-like) activities will have to continuously reflect on this according to their own values. Further, a global TA approach will have to conceptually as well as practically consistently work on reflecting and finding ways forward in the context of different values and normative foundations throughout the world. And it will have to define the limitations of expanding TA. Pointing to extremes (e.g. grassroots democracy vs. authoritarian dictatorship) isn't necessarily helpful in this regard. In order to move forward towards a global TA, it seems unsatisfactory to stress differences (there are plenty) and extremes in the socio-political settings surrounding TA – whether it can only function in liberal (Western) democracies and therefore cannot work in dictatorships. Of course, the question 'how far' TA can or should be adapted into different socio-political contexts is important and should be reflected on according to criteria coming from TA's cognitive interest in enhancing reflexivity and conceptual dimensions like anticipation, inclusion and complexity (Grunwald 2018b: 92ff.), (also see section 3.1). This would then provide the possible boundaries outside of which TA cannot function in a meaningful way. Yet, here it seems worthwhile and important to look for value foundations of widespread ideas or claims (such as framing S&T priorities according to societal needs and inclusion of citizens for aligning these) in different contexts and how these can inform TA. As we have seen from the case studies, countries tend to attach their S&T priority setting to societal challenges (even if these can vary from the actual needs of people). By looking at values, we can come to a better understanding of common ground as well as the degrees or limits of adapting TA methods in different settings. On a basic level, common ground can of course be found regarding scientific assessments on technical options or possible consequences. These include scientific criteria that are largely universal in their applications and outcomes. Yet, even then questions on what technical options to assess for whom or when come up. This then means going beyond the scientific level to include social mapping or reframing of debates.

As we see from the case studies presented above, the lines between the various socio-political settings aren't clear cut. The extremes of liberal, pluralistic democracy and authoritarian dictatorship do not represent the reality of all the different forms in between. For example, what constitutes as a liberal democracy has a common basis in individual rights and freedoms, rationality or independence. Yet, the actual inclusion and engagement of individuals in decision-making processes can vary considerably among pluralistic democracies (e.g. direct citizen referendums in Switzerland or representative elections in Germany). Looking at the traditional socio-political setting of TA, we find it is inherently democratic (Grunwald 2018a). Even though the beginnings of TA (e.g. Office of TA at the U.S. Congress) were characterized by somewhat technocratic and expert-led approaches, TA developed different forms, which allowed for a wider inclusion (e.g. Participatory TA, Constructive TA) corresponding with democratic ideals. For TA in Western countries, it was and remains essential to deliberate on unintended consequences of S&T in order to provide advice for more robust decisions. In this way, the process quality of TA (according to criteria such as interaction/inclusion or transparency) is also part of a democratic ideal. Of course, in reality TA is also used strategically in power structures

by different stakeholders, yet this doesn't undermine the normative basis of TA as a democratization project. The question then arises, whether TA can only function in Western democratic contexts. As for instance Grunwald (2018) argues, even if a TA study in a dictatorship would correctly use methods of foresight or scenario building and develop option strategies, it would still be exposed (by the TA community) as a false labeling because of a lack of inclusion and transparency. In this sense, TA needs to ensure its normative basis and cannot be a mere value-neutral tool, but has to continuously position itself, also regarding debates on democracy itself.

If we assume that, as argued throughout this thesis, a global TA is needed, which is based on local, national assessments, but can also take up a global perspective, then we also have to look at other normative foundations beyond Western ones. As we have seen global challenges and developments make global responses necessary, in this way a global level of TA has a universal claim. As Wong (2013) examines along the example of Geoengineering, such a globally applied technology requires the engagement of people across borders and value systems. This then entails looking beyond a Western pluralistic democratization model based on, for instance, individual freedoms. The question here is what other values or normative basis can support TA, for instance regarding one of its central elements: the inclusion of ethical reflections of the public or stakeholders.

Inclusion or engagement in Western countries emerges from ideals of liberal, rational, self-determining and independent individuals. Because each individual is free, they should be consulted regarding any decision that could affect their own lives. And because there is individual freedom, each person is the best and essentially only one to determine the course of their life. Yet, these ideals cannot be found across all ethical, cultural, social or political traditions. Therefore, Wong uses the example of Confucian thinking regarding the specific, globally relevant technology of Geoengineering to show a different normative foundation for the inclusion of people, which, in turn, can also be extended to TA. At first, the liberal values supporting public engagement seem foreign to Confucian thinking, in this way this "presents a prima facie challenge to view public participation in geoengineering decision-making as a universal moral requirement, and invites us to reconsider the normative significance of this form of public engagement in Confucian societies. Yet, […] the role of the public remains normatively significant in geoengineering governance and the ethics of geoengineering from a Confucian perspective" (ibid.: 350). As we see, in global S&T questions it seems worthwhile to look closer at these different normative foundations also regarding decision-making.

If we 'translate' TA into a different context outside of the Western one, for instance into a society based on Confucian tradition, we are forced to reconsider its normative basis as well. In Confucian thinking an individual is situated within the relations to others; they are part of a social web of various relationships (e.g. family, social roles), which also determines their development as a person. In this sense, basic ideals are relational and developmental as well as virtue-based. Here, "proportional equality" (ibid.: 358) means that equality is related to people's dues. This sets this thinking apart from more individual-focused Western traditions. In Confucian thinking, a virtuous person should be more responsible than others when it comes to deciding, making this quality or role unevenly spread in a Confucian society. It seems that this thinking goes against inclusion or engagement, at the very least it doesn't seem to offer any moral foundation for it. Still, if we are to move forward regarding global TA with elements of

engagement, then these should somehow also be rooted in or connected to local or national contexts beyond Western liberal-democratic ones. Wong (2013) does turn our attention to contemporary Confucian philosophy, as arguments have been made to see engagement as a necessary element of human flourishing. In this thinking, the virtuous and therefore capable leaders should remain in the political sphere, not imposing on the ethical realm regarding questions on what is good for the people. This in turn would have to be taken up by the people themselves. In Confucian thinking, participation is likely to be seen differently; it will not necessarily be seen as neutral, but instead guided by a specific Confucian vision of good and bad. So, even though engagement and inclusion are often grounded in ideals of personhood and individual freedoms and responsibilities, following Wong, we do find "that contemporary Confucian political philosophy does have its own resources for justifying the moral importance of public participation" (ibid.: 363). For Confucian thinking and its conception of autonomy and freedom, there is no strong argument against the intervention in individual lives if this is regarded as 'good' from a Confucian perspective. From this, we see that if we look at different values or normative foundations as a basis for engagement or TA, these can also feed into a global TA, even if they provide different reasons for including the public. Whether in societies with emphasis on individual freedoms or on relational connections, including a wider array of perspectives in order to come to decisions is often also a process of weighing options (and therefore values), which may then favor either the individual (e.g. value of freedom) or the common good (e.g. value of harmony).

As this example of Confusion thinking shows, including various normative foundations or socio-political framings should be part of a global TA approach as it shouldn't be bias towards specific values, such as liberal democratic ones. It should instead be able to balance and reflect on different thinking and traditions while remaining 'accountable' to its reflexive core. Addressing Responsible Innovation (RI), which is comparable to TA (see section 3.2), Wong raises the issue that "neglecting the important questions about plausible *alternative* normative foundations of RI will also prevent us from seeing the problematic consequences that could be detrimental to the development of RI in a *global* context" (2016: 155). If approaches such as RI or TA do not want to remain within specific context or habitat, they must explore different foundations or perspectives. One such perspective can be that of "decent nonliberal peoples" (ibid.: 155ff.), which questions whether RI (or TA) can only function in liberal democratic settings, in turn asking if nonliberal countries cannot have TA or RI or only if they introduce liberal democratic values into their society. Based on criteria of decent nonliberal states as being non-aggressive, securing some basic human rights or guiding law by a common good idea of justice as defined by (Rawls 1999), Wong argues that it would seem unreasonable to disregard the capacity and willingness of nonliberal states to include aspects of acceptability, sustainability or desirability of S&T in their decision-making processes. Further, 'forcing' Western liberal democratic values onto them could raise imperialistic issues. From this we see that a global TA must take other normative settings seriously, also in order to avoid a hierarchy of values in the sense of which ones should be included and which shouldn't or which ones take priority over others. This also entails that a global TA approach requires more in-depth understanding on different non-Western values and normative foundations and their relevance for TA in different national settings.

If we reflect on this and add to it the findings from the interviews, it becomes clear that a more inclusive view of the socio-political framings and normative foundations of TA is needed, in which the focus is on more fluent varieties of these settings across different countries. In

practice, TA needs to be incorporated into existing structures and processes, but it should also actively shape these. This, as described above, defines the habitat in which TA can and does take place. Beyond the specific reflections of the countries above, the more conceptual level of normative foundations also feeds into this and provides a basis, even if it isn't always explicit. Therefore, looking more concretely at the habitat of TA should also include uncovering the normative basis to give various foundations for a global TA, while at the same time reflecting on and identifying limits of the adaption of TA. This more fluent view of aspects of TA habitats is explored further in the following.

6.2.3 Parameters Towards a Global TA

Building on the previous (engagement and ethics along key aspects, TA habitats in the countries and comparisons as well as normative framings) we come to the conclusion that these are key issues for a global TA, yet are continuously changing and can vary at any given time. For a global TA this means finding tools to account for these habitats, which can incorporate these dynamics. Also, across countries we find various habitats, in which we need to be able to identify the communalities and differences and even limits when moving towards a global TA frame. Therefore, a more fluent and useful view of these settings or habitats is along continuums, which encompass numerous forms of TA and their relationships to surrounding political and societal conditions (Hahn and Ladikas 2019: 222ff.). This is also connected to ethics and engagement, as mentioned above, which should similarly be thought of along continuums, enabling a more nuanced view of the variety of forms taking place. The idea of continuums is useful for a global TA approach since it is more flexible and offers numerous points along which TA can take place and which shape its habitat. For instance, various forms of more bottom-up or top-down systems can be included; from the Chinese one-party structure with arising awareness for inclusion to Indian expert-led advice, yet diverse settings to established forms of advice to transformative processes in Germany. Additionally, it enables us to identify the limits of a continuum, outside of which TA isn't desirable or cannot take place due to basic interests of TA enhancing reflexivity in policy, public debate or technology development. In this way, a global TA should determine parameters and through this also set limitations in which it cannot function, since, as Grunwald writes: "Technology assessment in a dictatorship would be a castrated version" (2018b: 97). Important is that these continuums are a way to grasp the nuanced varieties in different settings by identifying what different forms along various continuums exist in a given country and which influence TA's habitat, also on a global scale. This is also a key aspect since it can ensure that TA isn't conducted in arbitrary ways, which would lie outside of the habitat or the normative foundation.

Initial thoughts on continuums revolve around different countries' political systems, S&T decision making systems, the socio-economic stages of development or national values (Hahn and Ladikas 2019: 222ff.). The most general continuum of a political system encompasses pluralistic democratic settings as well as one-party systems or decent nonliberal states to authoritarian governments. As we have seen, TA can take place, potentially in different forms, throughout these systems, which makes this a useful way forward in better analyzing and understanding the varieties of political settings as well as identifying where limits of TA's habitat could be. For a global TA, this would also mean including elements of political economy in order to analyze the different national surroundings and what they imply for TA. Another continuum

is the S&T decision-making and governance system, which, of course, is relevant for TA and the advice it can provide. As we have seen in the case studies, this can vary regarding institutions, their position in the overall national system and whether there is a single or more federal decision-making structure. For a global TA, this can also become relevant regarding decision-making possibilities on an international scale. For instance, the UN Climate Change Convention shows a step towards a common agreement of many countries including regulatory elements. We see that this continuum would range from local to national and ideally to global, on which a global TA approach would have to function on all levels. This could include bi- or multilateral TA collaborations on specific technologies as well as TA on globally significant issues such as climate change.

The socio-economic stage of development is a further important continuum as it also influences TA. The Indian and Chinese case studies show that the social and economic development of countries is highly connected to S&T. The rapid growth and development of some countries was only possible with S&T advancements. Yet, basic needs such as water or food may still be lacking and in turn should be key topics for TA in that country. Therefore, the stage of socio-economic development influences what kind of TA is needed with which focus and can range between low- and high-tech solutions in one given country. On a global TA scale exchanges between countries regarding these different solutions and their assessment could be useful as a form of mutual learning. More developed countries could also benefit from frugal or low-tech approaches as these may offer more sustainable solutions.

As we have seen above regarding the normative foundations of TA, national values play a role in shaping what kind of TA does or can take place in different countries. Therefore, a continuum along different values (e.g. from individual rights to group harmony) as presented in Figure 7 can be helpful in order to, for instance, identify what the predominant values are in a certain S&T debate. As mentioned above, weighing options also implies balancing different values, which takes place in any decision-making on S&T developments. Further, values such as justice can be linked to access or equity if seen along a continuum. This could help connect claims of justice in Western countries to demands for access and equity in countries such as India, for example.

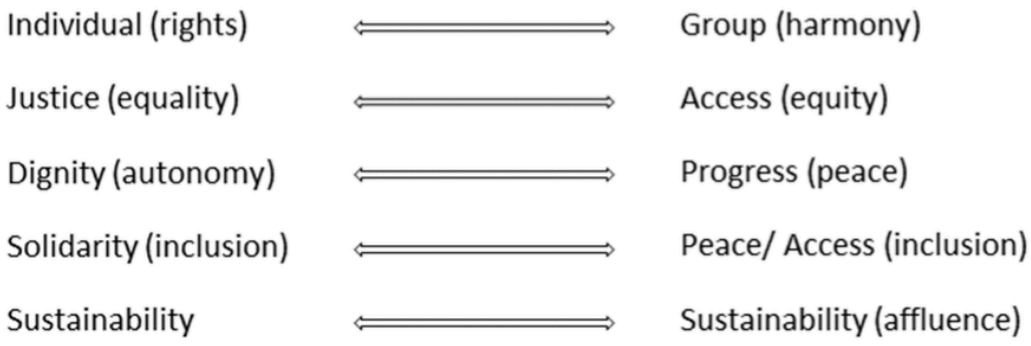

Figure 7: Relations Between Main Values (Hahn and Ladikas 2019: 230)

For a global TA, this value continuum is helpful as it enables us to bridge apparent gaps between different values, without ignoring differences. A global TA, as also argued above, has to be locally and nationally grounded in values providing a normative foundation, but at the same time needs to be grounded on common elements such as engagement or lay ethics. Important is that a

global TA doesn't brush over differences, it cannot be about creating cultural homogeneity. But, it should explore how different values can create a basis for TA; as described above, how, for instance, Confucian thinking can actually provide arguments for inclusion like norms based on individual freedom and rights.

These continuums present a starting point for conceptually approaching a global TA. Through the contextualization of TA on the various national levels, including its (potential) location in the S&T systems as well as priorities and underlying values, we can add substance to these continuums. We then see that TA in China, for instance, takes place in a complex setting of priorities derived from Confucian values such as virtue and harmony, in a political and economic setting somewhere in between radical market-driven and top down planning economy. All along different continuums. Germany offers established forms of TA in a wide variety. Yet, processes of including the public through engagement and transformation processes create tensions within the German representative democratic system, which TA has to take into consideration. India's challenges concern very basic needs as well as access and equity or diversity, yet the country also strives towards big science, which still remains a priority. Here TA has to find ways towards resolving these tensions, for which the continuums can be a helpful tool. Figure 8 shows a way to identify where each of the countries lie along the different continuums, which overall shape the TA habitat. Based on the insights from the cases we can see what the TA habitat is like in the countries regarding key aspects such as the political and decision-making systems, development stages, values or engagement and ethics. This of course cannot be an exact and set position as this is fluid and represents the findings from the specific studies done at a certain moment in time. Still, it helps us picture and exemplify where the current status is and what needs there are, for instance what to recommend the countries regarding the development of their TA habitat (see section 7.1). Also it can show us where more problematic areas lie, for example for China as a system with authoritarian characteristics, which may move outside of a feasible TA habitat.

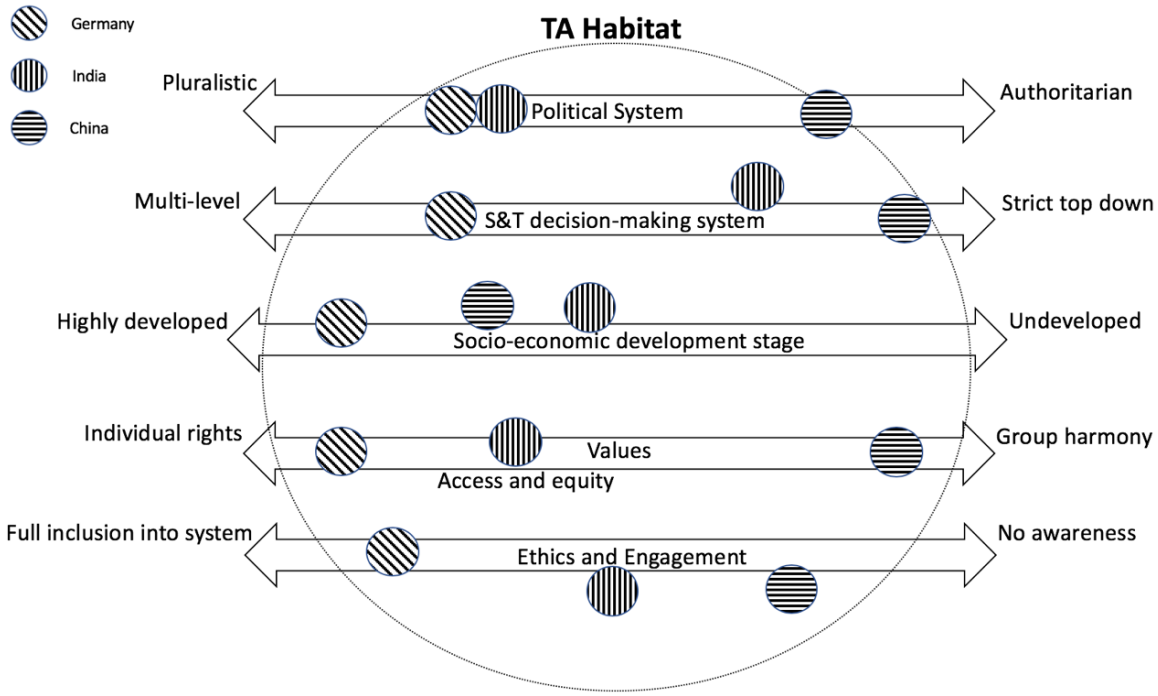

Figure 8: Germany, China and India along the Continuums (own figure)

This leaves us with a point of departure. Identifying similar values, understanding how TA works (or could work) along different stages of political or socio-economic continuums helps find common ground as a basis for global TA. Overall, TA's aim should be to make S&T developments 'better' for society; according to its needs and expectations. By providing insights and descriptions into the national contexts we can see how this is done in practice as well as what is lacking from a national perspective. Next to this necessary nationally-specific TA, it also gives us a better understanding of where common ground can be towards a global TA. This leaves us with the areas which need to be further researched for a global TA. The cases presented in this thesis only represent a first step in this direction. More country analysis along continuums and reflections on practical experiences of TA 'on the ground' in different settings as well as searching for connections to global contexts is needed in the future. Initial thoughts on this are discussed further in the next chapter, also regarding TA in other countries as well as possible existing structures which offer possible connecting points for TA's global level.

Chapter 6 provided us with a comparison and reflection on the similarities and differences across the cases. This was focused on ethics, engagement and TA as these marked to key notions of the empirical work presented in chapter 5. Key aspects such as the connections between S&T priorities and societal challenges, the political system and its overall culture as well as the openness of decision-making processes set the frame in which these comparisons were described. From this the concept of TA habitats was taken up as a way to better understand the needs for each countries and that even though the socio-economic situations or general values may vary, there seems to be an overall need for assessments which can include social, cultural or ethical aspects. Following this, normative foundations for TA were discussed. This is an important aspect in moving towards a global TA, as through this TA is also moving outside of its traditional liberal-pluralistic democratic setting. This doesn't just require an import of TA

methods into different habitats, but entails adaptation of it, to a certain degree. For this, TA also needs to explore which values and lines of thought it can be connected to and where limits may lie. These findings and discussions then bring us to possible parameters of a global TA, which were explored in this chapter. These can be thought of as continuums that in turn constitute the TA habitat of a specific country, which was exemplified for the country cases above. From this we come to more concrete recommendations for the countries themselves as well as for a global TA as presented in the next chapter. This shows us in more detail the implications of a global TA and where we should focus our efforts.

7 Implications for a Global Technology Assessment

In this chapter, initial recommendations for the individual countries are presented which offer a starting point for further establishing and developing TA in the German, Chinese and Indian contexts. Models of the overall relevant aspects and what forms of TA(-like) activities emerged in the case studies are developed as well, which represent the current TA habitats in the countries. They also show a range of widening, opening up and enhancing TA aspects, which highlight the main areas of development for the next steps of national TA. In a further step the three case studies are complemented with insights from other countries or regions such as Russia, Australia or the European Union, which provide reflections on various TA habitats. This of course is not as extensive as the three cases presented in this thesis, yet it does provide first thoughts on what can be learned from these countries for a global TA. This then brings us to more general initial recommendations for a global level of TA, including existing initiatives such as the UN Technology Facilitation Mechanisms, which show potential connections for a global TA.

Next to the crucial conceptual and national aspects discussed in the previous chapter 6, the more practical question of how to structure such an undertaking arises. On a national level, TA has its traditional addressees (e.g. parliament, stakeholders, public), yet on a global level this isn't clear-cut anymore. As mentioned before, TA remains important on a national level but should also include a global perspective in its assessment. Yet, with globalization and wide-spread effects of S&T developments an actual global level of TA would mean more flexible and networked structures which have the potential to address challenges in a for them appropriate response: globally. A parliamentary TA, for instance, has a clear addressee, it is focused on providing sound options for decision-makers. For a global TA the situation is different: it must account for the local and national specifics regarding engagement and ethics or the overall socio-political setting. At the same time, it must foster cooperation, mutual learning, capacity-building and conceptual reflection across national borders. Therefore, its addressee isn't as sharply defined and can potentially range from local stakeholders to national governments with bilateral collaborations to an international level. Another aspect is how TA adapts to the specific habitat. Regarding the scientific assessment, TA is similar everywhere. Yet, when TA activities are concerned with forming attitudes or initializing actions the local and national specifics become highly relevant and different everywhere. A global TA would have to be able to take this into account in some way.

On an international stage we have organizations such as UNESCO or the UN, which aim to address and solve global challenges and issues, also with the help of science and technology. Should a global TA be located here? What could TA's potential here be since decision-making powers are still left to national states? Ultimately, it will have to be seen if having a global TA institute as part of the UN structures is a useful approach. As for now, there are activities on this level, which can be relevant for a global TA. The country recommendations, insights from other countries as well as existing initiatives can be useful for identifying the implications for global TA and coming to recommendations.

7.1 Recommendations for Germany, China and India

The following provides first recommendations for TA and its development in the examined countries Germany, China and India. This is based mainly on the findings from the case studies, including the analysis of main S&T documents, national value systems as well as the interviews with key actors in the area of S&T policy and TA. These recommendations are food for thought in the sense that they don't provide a comprehensive map of how TA needs to be established or further developed in the individual countries. This should be done by local actors 'on the ground' in a time frame that makes sense as it depends on political and societal factors. Also, these shouldn't be one-size-fits-all approaches; as we have seen throughout this thesis, societal, cultural, historical, etc. aspects are all relevant. As we have also seen, there are differences even in the terms used for TA-like activities. Further, awareness levels of, for instance, policy makers, vary regarding the importance of an expanded approach to the relationship between society and S&T. Therefore, these recommendations aim to offer meaningful starting points for further work towards expanding TA across countries. This of course also supports a global level of TA by providing insights into how TA can be developed in diverse contexts and where differences but also communalities lie.

The Widening of TA in Germany

As we have seen in the accounts given in the case study on Germany, TA is increasingly including different forms of engagement, even if this is a newer development based also on past controversies and public disputes. In an established setting, S&T priorities are mainly set by the Ministry of Education and Research (BMBF) itself and TA provides direct advice to the parliament via a specific TA institution (TAB) as seen in Figure 9. Further, other TA activities can be found through the Innovation and Technology Analysis (ITA) of the BMBF itself, through the funding provided via the Helmholtz Association (HGF) as well as within engineering processes as well as part of Life Cycle Assessments (LCA). Yet, increasing globalization of S&T also imply demands for a global level of TA in which Germany should take on a leading role. This is especially relevant because we find wider forms of TA taking place in the German habitat. Engagement formats and the inclusion of lay ethics have been realized by different TA institutions for quite some time and have also led to a widening of TA's role. Next to a distant observer and advisor who includes input from engagement and lay ethics, TA in Germany has also taken on an important role in transformation processes (e.g. real world labs). These aim to initiate changes in behavior and patterns, especially in the context of sustainability, together with citizens or stakeholders. The normative frame of sustainability entails activities that aim to shape processes, going beyond strict assessment and providing options to decision-makers (Hahn and Scherz 2019). As the graph below shows, this requires a continuous exchange between the TA institution and citizens, whereby the roles may also become blurry. Therefore, reflections on these roles and adjustments are needed also regarded how this can be integrated into the existing system and what changes this may imply.

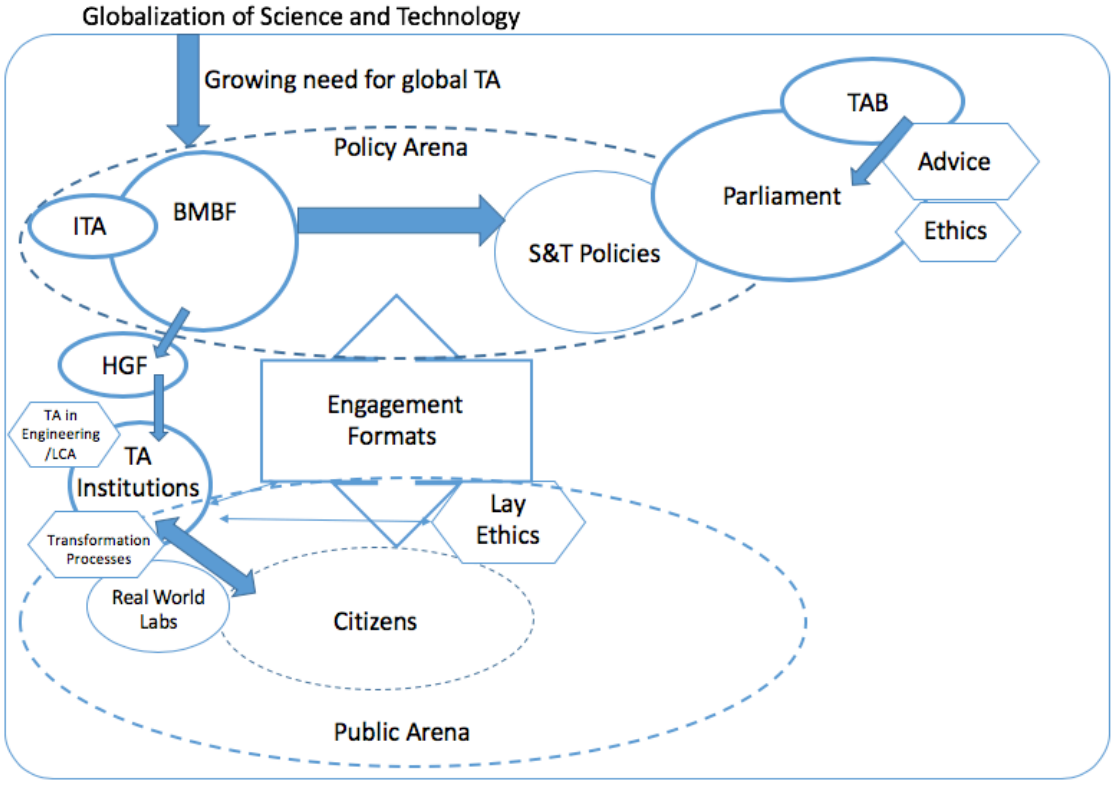

Figure 9: TA in Germany (own figure)

Based on this we can develop more concrete recommendations for TA in Germany, concerning future needs and roles.

Provide more meaningful engagement for the inclusion of lay ethics in S&T decision-making

TA in Germany should continue to reflect on the increasingly demanded and applied forms of engagement and how these can fit into the existing political system. A key challenge here is to find ways to incorporate the outcomes of such engagement processes into a representative democratic system in a meaningful way. These could function as elements to add to the current system by increasing the possibilities to provide insights for decision making (beyond elections every four years). Yet, here TA still has to conduct conceptual work (how to incorporate engagement?), provide advice (what kind of methods are actually useful?) and raise awareness for usefulness (why do we need such processes for better decision making?). This would also allow for a more substantial reflection of the aims and actual uses of engagement processes and whether they live up to often idealistic claims of democratization and empowering of the public.

Expand TA activities towards reflected transformation processes

TA in Germany should increasingly participate in transformation processes, which can initiate changes towards, for example, more sustainability. Examples such as real-world labs as described in part 5.1 are first experiments in this area. At the same time, German TA should also critically question how these are conducted and what their normative basis is. This also concerns the actors which TA collaborates with in this context. By moving away from more clearly defined relationships, such as with parliamentary TA, a reflection on new interactions (e.g. NGOs, stakeholders, political actors) is also required. This also connects to the forms of engagement and their incorporation into the political system. In transformation processes, engagement may

take on an increasingly empowering role (perhaps on more local levels as well) than in more traditional forms, which, also calls for active and continuous reflection.

Actively support and promote a global level of TA based on experiences and mutual learning

German TA should use its established experiences to inform and guide the development of a global TA, including networking and exchanges as well as conceptual work on this global level. This doesn't mean merely translating, for example engagement methods directly, but supporting the adaption of these to the specific national contexts. For a German TA perspective, this would also entail engaging in projects on concrete technologies in various countries and reflection beyond national contexts as well as networking activities in global platforms, which can enable mutual learning. This connects to what has also been proposed in other contexts. Regarding global ethics, Chaturvedi et al. (2015b: 172), suggest establishing common deliberation platforms for exchanges on a wide level, including joint research programs on global challenges in S&T. This coincides with activities being done on the UNESCO level in form of the Technology Facilitation Mechanism (TFM) as described in further detail below (part 7.3) Germany should become a key actor in this context to support and promote such an endeavor actively.

The Opening Up of TA in China

The Chinese case study reveals how decision-making on S&T and TA-like activities take place in the current habitat. The main actors, the Ministry of S&T (MOST), the Chinese Academy of Sciences (CAS) or the Chinese Association for Science and Technology (CAST) shape the policy arena regarding S&T as shown in figure 10 below. As seen in the graph this policy arena is dominant when it comes to decision-making and setting priorities. The public arena in China is smaller and organizations such as NGOs are active in a limited way. Ethical considerations and forms of engagement (e.g. protest or critical public debates) only take place on specific issues such as GMOs. Therefore, we can see an overall one-way line of decision-making. From the policy arena to S&T policies to the public. In general, feedback in the other direction is limited. Yet, the case study also showed that there is a certain opening up of awareness regarding the importance of societal aspects in S&T as well as approaches such as the "new normal". This shows where potential for TA lies, even if questions on its further development in a system like China arise (see section 6.2.2).

Many TA-like activities can be located within the Chinese Academy of Science and Technology for Development (CASTED), which itself is part of MOST. Here we find surveys, studying of online debates, stakeholder workshops, even a consensus conference as described in section 5.2. These show limited forms of engagement currently taking place in China, which in light of a certain opening up and with notions such as "new normal" may have to become more interactive, even if specific to the overall top down system in China.

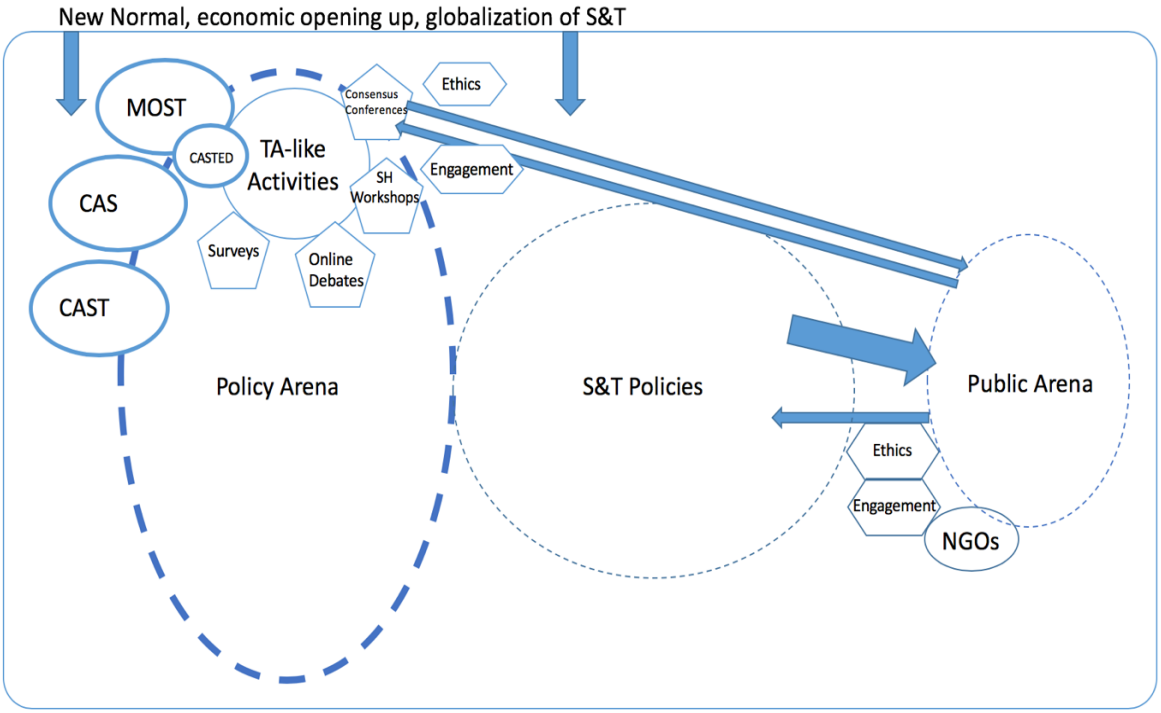

Figure 10: TA in China (own figure)

Figure 10 sums up current activities in a generally top down system, with only limited forms of engagement and inclusion of lay ethics. From this we can come to recommendations for China for future TA.

Move towards a more interactive, enriched exchange between society, policy and S&T by opening up methods of TA

The common used forms of assessing S&T in China mostly include evaluation and expert advice. Yet, we can identify a growing need and awareness of some to expand these methods in order to take emerging debates and even conflicts into consideration. The term technology assessment poses difficulties regarding Chinese as its literal translation doesn't include the societal aspects of assessment. For TA to open up in China it would therefore perhaps have to explicitly add these aspects to its terminology. Overall, this would entail a move away from a linear model of the relationship between S&T and society. Still, dominant perspectives of developmentalism and scientism shape the way society, policy and S&T interact (or don't). Yet, globalization of S&T and tensions regarding certain technologies (e.g. GMOs) necessitate new approaches. Of course, the overall top down Chinese structure as well as lacking development regarding public debates or political awareness may require different adapted forms of, for instance, engagement. Within the current Chinese system, it may be useful to enable 'pockets' of engagement and wider (ethical) advice, also based on values such as harmony.

This may also entail very different contextualization of engagement than in Western countries. In many countries such as Germany, the inclusion of the public is based on values of individual freedom and seen as a form of democratization (whereas it remains to be evaluated whether this is actually the case in engagement processes, or whether they often function as ways of gaining acceptance of decisions already made). In China, TA would have to create awareness

among all stakeholders (e.g. the public, policy makers, scientists) that different forms of exchange are needed and provide input on useful methods.

New forms of engagement and inclusion of lay ethics and co-development of common prototypes

The specifics of the Chinese setting require new forms of engagement, which, on the one hand can be integrated into the system and therefore provide input and, on the other entail a different approach to the relationship between society, policy and S&T than mere science popularization. This would expand the current emphasis on expert-led advice. Of course, this is a long and delicate process, which needs awareness building and will from all sides. Further, using normative foundations which emphasize harmony could help develop engagement methods which are specifically adapted to this framing and may differ from Western inspired ones. For TA in China, specific forms of engagement could include detailed surveys on perceptions of S&T, stakeholder workshops on concrete (local) issues or forms of citizen conferences that are sensitive towards methodological challenges in debates and exchange. Beyond this, it would be helpful to develop common 'prototypes', which can be methodologically diverse, yet provide insights for future activities, even beyond the Chinese context.

Participate in global TA activities and expand understandings of TA, also regarding normative foundations and Non-Western value systems

A global level of TA cannot develop and function if it is only based on Western values and beliefs. Discussions on the normative foundations of TA and the inclusion of the public are taking place and range from TA as a democratization project to authoritarian deliberation and everything in between as we have seen in section 6.2.2. An opened up form of TA activities in China could provide a global level with important insights into the functioning of TA in systems outside of the historical basis in Western countries. What does TA look like in a society with values based on the relations of people, instead of individual freedom? How can methods of TA adapt to understandings of responsibility and inclusion which are assigned to virtuous individuals instead of to each individual in society? Engaging in these questions within a global TA would also enable exchange on the possible limits of TA adaption and expansion regarding 'quality control' (e.g. questions of transparency or openness). This would also include co-developing common prototypes of TA methods as a way to provide concrete insights for mutual learning. China's role in this would be to engage in global activities and offer insights from the national and local Chinese experiences.

The Enhancing of TA in India

For India the case study showed us a diverse and yet overall top down dominated setting of S&T decision-making. S&T has been part of India's self-conception as an independent country from the beginning resulting in big science and expert-led advice. Correspondingly, as we see in Figure 11, the policy arena is large and, similar to China, there is mainly a one-way flow from policies to the public arena. The Department of Science and Technology (DST) shapes TA-like activities, for instance through organizations such as the think tank Research and Information System for Developing Countries (RIS) or the Technology Information Forecasting and Assessment Council (TIFAC). In India we mostly find professional forms of ethics and mainly the acknowledgement

by experts (e.g. in TIFAC) that engagement would be important, yet without the activities to go along with this. Universities, such as the Centre for Studies in Science Policy at Jawaharial Nehru University (JNU) are another player and as shown in the Figure 11 they provide academic reflection on S&T policies, yet with limited influence on these policies themselves. Overall, as we can see below the policy arena determines S&T policies including which priorities are set. Even if we find documents such as the Technology Vision (TV 2035), which includes needs of different groups of Indian society, how it was developed (by experts of TIFAC) without inclusion of these groups, shows the way decisions are made still remains mainly top down.

A key issue in India, as also seen throughout the case study, is diversity, which makes the local level important here. We do find activities here, as done by the Energy and Resources Institute (TERI), but issues of access, inclusion and equity remain highly important for India. It seems these are gaining more awareness, even if the policy arena is still dominated by big science ideals. Therefore, enhancing TA activities in India comes up as a key aspect as a way to move towards a more inclusive, less technocratic approach. This in turn can help address the issues of social justice and diversity relevant for the country, also as a way to enhance competitiveness (e.g. frugal innovation).

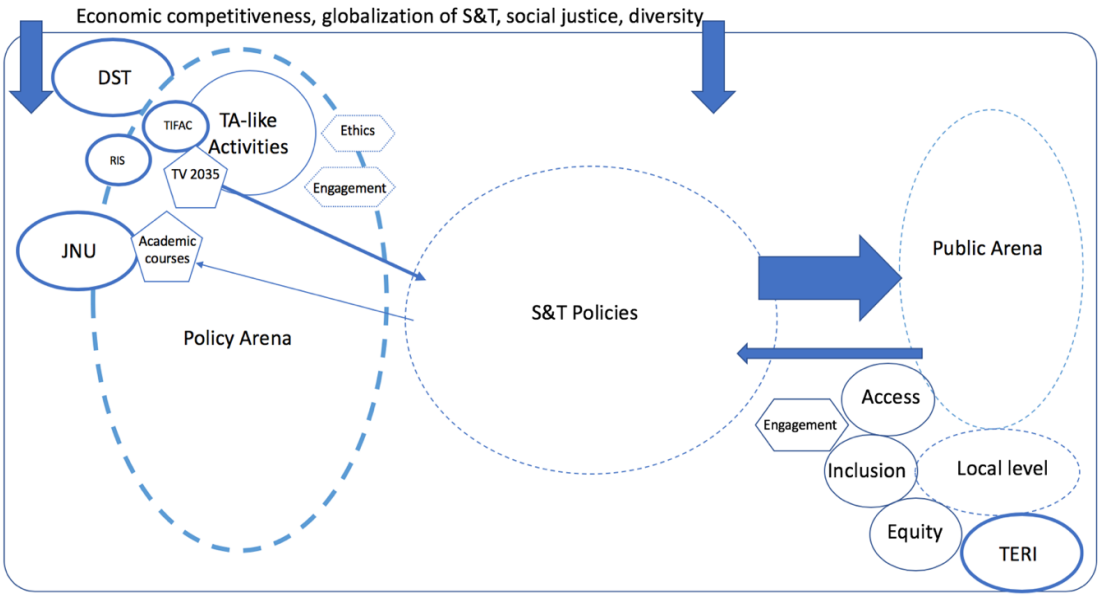

Figure 11: TA in India (own figure)

Initiate capacity building in interdisciplinary skills to enhance TA beyond technocratic approach

As the descriptions of India above show, many approaches and activities in assessing S&T are technocratic and expert-led. This of course has historical reasons, mainly the strive for big science in independent India, which led to an overall system based on top down decision-making structures. This is still the predominant view of many actors in the field of S&T and policy. Organizations conducting TA-like activities often remain within their own areas meaning that outside input (e.g. from stakeholders) isn't taken into consideration. Currently, we find university programs which analyze policy decision processes or government think tanks that create vision documents for future S&T priorities in India. Of course, we do find a contextualization of these priorities within societal needs, for instance the Technology Vision

2035 shows this along different group of Indian citizens. Yet, it seems that in India skills regarding interdisciplinary approaches to these issues are lacking. Therefore, capacity-building for wider and more contextualized approaches is needed for TA to further develop in India. This would, for example, require more university courses beyond specific disciplines (which can be partially found already), skills development in TA methods beyond expert-led input as well as exchange between India and more TA experienced countries.

Develop engagement processes that enable inclusion of lay ethics that can account for diversity and local specifics

The overall top down and expert-oriented approach also defines the relationship between society, S&T and policy, in which engagement processes aren't as common as they should be. Ethical reflections by citizens or stakeholders are important to come to more robust and sustainable solutions in S&T development and policy. Further, engagement processes in the Indian context need to be able to account for the country's diversity and local specifics. This can present a unique challenge for TA in India as it has to come to meaningful and useful methods for inclusion. Here, political will as well as societal awareness need to be enhanced. For this, TA can function as a facilitator or broker by lobbying and providing methods and approaches which are context-specific. This also means bringing the importance of inclusion on the agendas of various actors (e.g. policy makers, scientists, citizens) and linking this to existing activities (e.g. by NGOs) and connecting outcomes to (top level) decision makers. For this, TA needs to build on engagement experiences not only from TA itself, but also from other areas such as sustainability initiatives or local structures.

Participate in global TA activities and enhance understandings of TA regarding diversity, informal activities as well as access, inclusion and equity

In the current situation, India perhaps cannot take on a leading role in pushing for global TA approaches. Similar to China, awareness levels need to increase and experiences have to be collected regarding the possibilities (and limits) of TA in these national contexts. Yet, India can provide valuable input regarding local approaches and methods that can incorporate very diverse settings. For instance, a dialogue process across India would have to be locally adapted to diverse conditions, while still enabling some kind of reflection on a wider national level. Here, as with engagement in China, India should develop prototypes that can function in this setting and can give insights into a wider application, especially regarding 'diversity-sensitive' approaches. This would then also provide input regarding the limits of adaptation of TA. A global TA approach would benefit from insights about the possibilities of engagement and lay ethics regarding key aspects in India like access, inclusion and equity. Further, the importance of, for instance the informal sector in India, will provide insights for a global approach regarding innovation according to very specific needs and opportunities on the ground.

7.2 Beyond the Cases

Moving towards a global TA, the case studies presented in this thesis can only be the starting point. They exemplify what issues need to be addressed and perhaps resolved, for instance how TA habitats function in different contexts, how developed engagement and ethics are or how this relates to the overall socio-political surroundings. As mentioned before, this is a continuous

process and a global TA will have to constantly reflect on these aspects. Next to the in-depth cases on Germany, China and India, we can also find further accounts of TA in different countries or regions around the world based on the publication "Constructing a Global Technology Assessment" by Hahn and Ladikas (2019). These can give additional insights and help come to initial recommendations or ways forward for a global TA (section 7.3). Even though they are not as detailed as the cases above, they do provide unique perspectives from countries across the globe regarding S&T priorities, current or potential TA habitats, ethics and engagement as well as country specific perspectives for a global TA. As such, they are highly relevant for this thesis. In the following, key reflections from countries presented in the book are given to provide an overview and show how TA could be (further) developed. Additionally, the different national perspectives regarding a global TA are useful as they give us key issues that need to be addressed and included in a global level.

Outside of Europe we find little specifically titled 'TA' activities. The term is mainly used in the U.S.A. and Europe and has led to institutionalized forms there. Yet, we can find TA-like activities, similarly to China and India as described above, which give us insights into what is currently taking place and whether the need for TA is expressed. Looking towards Australia for instance, shows "that [even though] Australia had no central agency that coordinated TA functions, there was clear evidence of a range of TA-like activities being undertaken in the form of reviews and inquiries. However, they tended to happen in an uncoordinated or *ad hoc* way" (Lacey et al. 2019: 107.). Australia, with extensive national borders, a high number of urban coasts and a substantial reliance on natural resources, is geographically relatively isolated, influencing its S&T orientation. Overall, the political system is a constitutional monarchy with nation-wide elections every three years. For S&T funding the national government plays a key role, which frames S&T priorities as a way to increase productively and sustainable economic growth. This in turn can also be connected to Australian values, which reflect those of most Western democratic countries. These values include equality, individual freedom, justice, and, as Lacey et al. add, sustainability (ibid.: 95) Based on these, S&T should contribute to prosperity, such as economic development. Societal well-being is often also referred to, yet it remains unclear how this is assessed and decided on.

Engagement activities in Australia are often not formalized and take place in a variety of forms across the country, driven by local and state formal processes. Public debates are mainly focused, not on the technologies themselves, but on the capacity of these developments to influence the use of land or social change in general. Therefore, new forms of engagement which are more systematic and clearly address S&T throughout the development processes (e.g. constructive TA) would be useful for Australia. This of course, needs to be adapted to the specifics of the country, as it is, for example, large in geographic size, but with a fairly small population. As Lacey et al. state, this raises issues regarding resources or enabling meaningful deliberation (ibid.: 109). Further, the limited experiences regarding engagement in the country require exchange and capacity-building as well as specific cooperation on clear global issues and challenges. This sets the tone for the needs of Australia regarding a global TA. Overall, national agencies or institutions explicitly responsible for TA are missing and activities are currently mainly ad hoc and disconnected from policy levels. Therefore, a global TA approach could support more systematic and inclusive processes of TA with more influence on policy in Australia. For the country, learning from existing TA activities would imply "developing forms of assessment that support existing legal and regulatory frameworks with a view to providing

mechanisms for more meaningful and robust deliberation of the ethical aspects of science and technology" (Lacey et al. 2019: 109). In Australia we find a habitat with concrete needs for a more structured TA, which a global approach, including a platform for exchange and mutual learning, could address. In this way, a global TA could help support a TA habitat in Australia, which is able to address issues and challenges in a more comprehensive way.

Another interesting account in the context of TA is given on S&T activities in Russia. This is also relevant for a global TA as it shows us how S&T are framed and shaped in another country with a different political system and S&T history than Western ones. Therefore, insights on TA activities as well as needs in the Russian context provide more substance regarding a global TA beyond Western liberal-pluralistic democratic contexts. As the largest country by area in the world, the Russian Federation comprises eighty-five regions, each with its own legislative body ("Duma") and executive body. Also, Russia is divided into eight federal districts, all with authorized representatives. Today, S&T policy and development is still greatly influenced by the inheritance of the Soviet Union, which applied a top down technocratic approach to managing technology, the economy as well as society itself. As Cherepanova et al. state, "This rationality of technology and society management, even though usually deformed by ideology, was very prominent, as was evident in the technocratic planned economy. There was nevertheless one contradiction in this approach; the decision-making power was not held by technocratic engineers, but by technocratic party ideologists" (2019: 184). The end of the Soviet Union in 1991 also marked the end of the dominance of the Communist Party and resulted in a breakdown of the economy and the political system, including the S&T structures. A decrease of S&T output was immanent and still has influence today, also regarding an overall lack of public debate on S&T issues. Currently, it seems there is awareness in Russia that the old model in which S&T play a secondary role to energy-based (e.g. oil revenues) resources and economic growth isn't sufficient anymore. Further, societal challenges such as demographic change play a role. In this context, Russia has prioritized the development of a more effective S&T policy, focusing on sustainable development (including socio-economic aspects) or ethical evaluations of S&T (e.g. of the relationship between the social, economic and political). From this we see close connections to the values important in Russia. These can be summed up as humanity, justice, personal dignity, motivation of moral duties for one's own sake, family and nation, honor, integrity, will and faith in the good (ibid.: 193).

Regarding engagement and the inclusion of lay ethics we see a general lack, even if the changes in S&T policy in Russia are also influenced by for instance the European Union's funding programs, which aim to foster exchange between science and society. In the Russian context, the still prevailing strong technocracy in S&T policy-making as well as education emphasize technological and economically pragmatic solutions, not necessarily societal aspects. As mentioned, there is not much public debate on S&T topics and discussions usually take place among scientists and experts, excluding a wider public or civil society. Even though there have been attempts to involve citizens (e.g. regarding urban technologies in cities or online platforms), the general attitude is that S&T innovations are positive and lead to improvements in the further development of the country. From this, we see a need for TA is to provide a mapping of societal needs and expectations in order to better align S&T decision makers with the public.

TA in Russia has mainly developed as an academic philosophical discipline. This has limited the problem-orientation of TA to a theoretical level, excluding actual practices. Subsequently, TA in Russia is fairly distant from the government and its national policies. Still, there have been closer contacts established in recent years. Yet, it remains a long way to go for TA in Russia as the "tradition of collective responsibility or lack of personal responsibility, and the habit of avoiding important individual decisions are the remnants of centrally structured economies and strong top-down policies. The outcome is paternalism and a high level of trust in authorities, political leaders, scientists, people with specialised knowledge and strong influence. […] These reasons […] should help to understand the differences in the formation of TA in Russia" (Cherepanova et al.: 198f.). Nevertheless, we can find a certain opening up of this TA habitat in Russia. For instance, a recent statement of the President of the Russian Federation Vladimir Putin regarding digitalization, emphasized the necessity to understand the societal effects of applied technologies[142]. In this we can identify a certain shift from traditional top down, technocratic decision-making processes. Again, here we see that based on the unique TA habitat, made up of structures and socio-political contexts, further TA activities in Russia need to be specifically adapted to the country, in which an old technocratic planning model is still reminiscent, but which has needs regarding new ways of policy-making. This reflects in the following description: "it should be noted that certainly as in any other country, TA in Russia has its unique features. First, it is connected with the historically formed mentality of the citizens of our country. Since the time of the Empire, the (governing) power in the minds of the Russian people had sacral, almost divine meaning. Its criticism, in any form, was perceived as a violation. During the Soviet era, the Communist Party's leadership role was also never questioned […] Today we witness a shift of emphasis. The role of various communities and representative offices in the social and political life of our country has greatly increased. Participation is seen as a necessary factor in the decision-making of municipal and regional government" (ibid.: 216). This of course then relates to a global TA, which again can offer exchange regarding experiences in TA, regarding for example how engagement processes could be designed and conducted in the Russian context. Perhaps similarly to China, the strong top down approaches are opening up to a degree that can allow for engagement, even if in a very different context than for instance in Western countries. We see in the case of Russia that issues of responsibility and accountability are being considered more and TA should contribute to this.

Perhaps the most relevant for the context of this thesis are the accounts regarding TA in Europe or the European Union (EU)[143]. This is because Europe presents an alliance of different countries, but also values, cultures and political systems. As such, it can be regarded as a kind of 'small level global TA' and show how TA across countries can function. Of course, Europe or the EU are a union of fairly similar countries in a world-wide comparison. Even though we find differences in the countries, one can state that there is common ground regarding history, values, but also concerning the political systems (i.e. pluralistic democracies). This provides a set of starting points for TA across Europe, because key aspects can be presumed as similar. As discussed, especially in section 6.2.2 this isn't necessarily the same throughout the world. Also, TA is overall

[142] http://www.kremlin.ru/events/president/news/copy/56049 (in Russian)

[143] Europe and the European Union are used synonymously here. Of course, one, the EU, is the political and economic union of currently 28 member states, the other refers to the general region of Europe. Yet, for the purposes here, both can be used interchangeably as they represent similar values, culture, identity and political system.

well-established in Europe, providing a rich set of experiences to build on. Still, it seems worthwhile to examine Europe and its TA habitat here as it can give us substance to include reflections on the way to a global TA. The following descriptions are based on Hennen and Ladikas (2019). Over the years, the EU has established specific advisory arrangements, which include TA oriented ones across the individual countries. Based on this, we can speak of a 'European TA', which is connected to overall values and understandings of the relationship between S&T and society. Key actors on the level of S&T policy in the EU are the European Commission (EC), which forms the executive division as well as the European Research Council (ERC). The ERC is an independent institution to the EC and European Parliament and the European Parliament (EP) as the legislative branch of the EU. Within the EP debates on S&T take place and budget decisions are made final. Over the last years, discussions on how to align S&T and society in a better way have been taking place within Europe.

The socio-political surroundings of S&T, the framing of priorities and societal challenges throughout Europe are grounded on common values such as justice, equality, dignity and individual rights. From this, current debates on how to co-shape S&T developments to make them more socially robust, sustainable and ethically acceptable are taking place, oriented towards coming to S&T developments that are geared towards the common good. This shows a shift from understanding the public as the mere recipient of S&T decisions and developments to an orientation of S&T towards society, as an embedded part of it. It also shows a certain opening up of expertise in S&T policy-making, which is able to include a wider public. Based on the values mentioned above, individuals are able and should be included in ethical reflection and priority setting. Yet, this would mean "that the role of the citizen does not only comprise civil, political, and social rights, but also rights with regard to the development of S&T. Technological citizenship is related to the tendency of seeing aspects of life that were formerly non-political, as politically relevant now. The development, diffusion, and implementation of technologies is increasingly regarded as a political issue due to their immense impact on society. Lay people are not only affected by S&T as clients or consumers, but also as members of a polity (citizens)" (ibid.: 63). Over the last two decades, a shift towards more acknowledgement of citizens' ethical considerations and expectations regarding S&T can be observed on the EU level. This encompasses opening up policy-making by enabling engagement in a wide array to include various stakeholders in society. We find different forms of engagement throughout Europe, with specific characteristics fit to each country, which can range from wide consensus reaching goals to more specific focus group input. Still, it seems that overall this isn't aimed at reassessing the goals of innovation policies, instead it intends to reestablish acceptance and legitimacy of S&T decisions.

These brief accounts give a general impression of the overall habitat for TA in Europe. Overall, we can state that a steady and long-lasting exchange platform for TA, such as a TA forum, is missing on the European level. Still, we do find institutionalized forms of TA on the EU level in form of the European Parliamentary Technology Assessment (EPTA) network[144], which represents 12 parliamentary TA institutions as well as the EP and 10 associated members across Europe and beyond. Full member countries include Austria, Finland, France, Germany, Greece, the Netherlands, Norway, Sweden, Switzerland and the U.K. Associated ones include Russia, Denmark, Poland, U.S.A., Japan, Mexico, Portugal and Chile. EPTA represents an attempt to

[144] http://www.eptanetwork.org/

bring together various TA(-like) institutions, their experiences and through this advance parliamentary TA advice. As we see, TA here is understood mainly as providing advice to the parliaments. Throughout Europe we can find different forms of TA on the national level. For example, in countries like Norway or the Netherlands, methods strongly oriented towards consensus and interaction finding are common, in Greece, France or Finland we find committee models focused on the political sphere, while in Germany, Austria, Sweden or the U.K. we encounter office models with specific institutions with an emphasis on scientific approaches (see Figure 12). Here we also see that different nuances of TA have been adapted to various country specifics showing a rich variety of habitats in Europe, while at the same time, on a more general level, we find communalities such as values and connected to these the awareness and acknowledgement of the importance of the inclusion of a wider public in the development of S&T. This shows how a 'small version' of a global TA functions on the European level, in which we have nationally specifics as well as a common political as well as cultural basis to ground these on.

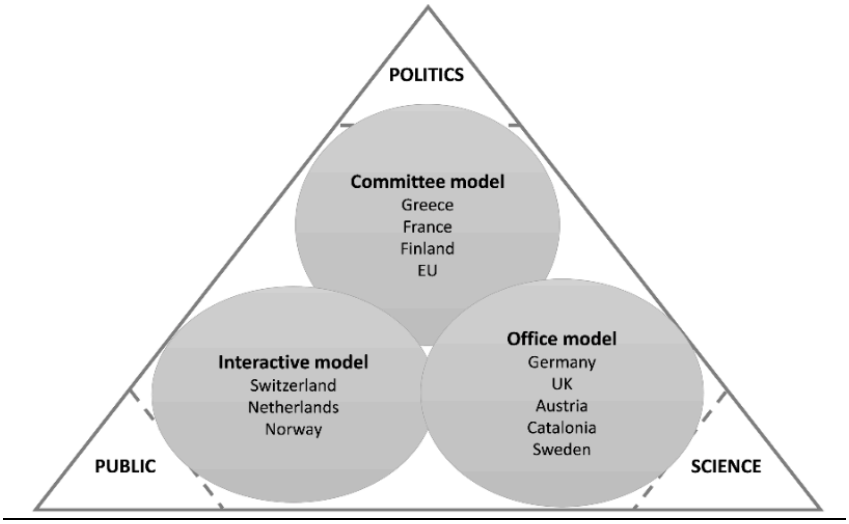

Figure 12: The Intermediate Role of Parliamentary TA in Europe (Hennen and Ladikas 2019: 62)

Regarding a global TA, the accounts given on the European TA habitat are useful as they "can be seen as a microcosm of a global development" (Hennen and Ladikas 2019: 73), which in the past was divided into Eastern and Western political systems. Today, as we can see common ground has been found, also regarding TA, which of course is also connected to the political union of European countries. Through this, a clear structure arises, including addressees on the national (e.g. parliaments) and European level (e.g. EP). Further, it required and still does, political and societal will to establish a 'European' TA including exchange and networking across the countries. This of course, cannot be observed on a global level at the moment. Here differences in political systems, cultures, values as well as structures for governance are much more complex, making common ground to base TA activities on more difficult to find. Still, as we have seen throughout this thesis, we do find the need for sound advice and the better alignment between S&T and society across very different countries. What this means on the individual national level may vary, but it does imply that common approaches and mutual learning and exchange is needed, similar to the European level. Even though we find structures such as the United Nations, there is an obvious lack of a global government, which could provide an anchor for a global TA. Still, we can point to existing structures which show potential regarding the

expansion of TA and can provide ways forward. In the following, recommendations towards a global TA are explored, also including the example of the Technology Facilitation Mechanism (TFM), which can give valuable insights regarding existing global structures.

7.3 Ways Forward for a Global Technology Assessment

After the recommendations for Germany, China and India as well as the accounts given for other countries and regions like Australia, Russia and Europe, we can identify how TA(-like) activities are taking place in different countries and even on a transnational level in Europe. From this we see that assessments of societal, cultural or ethical effects of S&T are needed on a wider scope and that reflecting on how this is done in various settings is useful. Especially from Europe, we learn that TA takes place differently according to the national contexts and specific conditions. Interactive models of TA are more common in countries with a distinct 'culture' of public debate, individual offices for policy advice can be found in systems with a focus on scientific approaches. And of course, these different models blend together in practice. Importantly, we see that on a European level there is exchange (e.g. through projects such as TAMI or PACITA) and networks in place (e.g. EPTA) that result in a certain European 'identity-building' or community of TA.

Remembering the overall challenges and corresponding implications for TA, such as the global effects of S&T, the interconnectedness of these developments, differences in contextualization as well as the importance of considering ethics and engagement in S&T discourses, we can see what is needed for a global TA. We can also understand that the findings and recommendations from the cases regarding engagement, ethics and TA itself, the reflections on the normative foundations of TA as well as the idea of continuums and parameters, which make up TA habitat, are all key elements of moving towards a global TA. Building on this, the aim here is to give initial tangible recommendations for furthering the move towards a global TA. These present next possible steps based on the findings of this dissertation and concrete needs for developing global TA further. Of course, we cannot assume that these recommendations will be directly translated into global TA initiatives. As mentioned and seen throughout this thesis, these kind of initiatives are complex, multi-actor undertakings and require, among other aspects, political will, corresponding efforts from actors across different countries as well as resources. This of course goes beyond the scope of this thesis. Still, the goal here is to give recommendations as food for thought based on the insights presented in the chapters above, that give inspiration for further research and activities. These concrete recommendations presented below address different levels, as exemplified in Figure 13, which are important for expanding a global TA. This is key on a conceptual and methodological level, which encompasses questions of standardized methods and formats as well as the further conceptual development of parameters for a global TA frame as explored in part 6.2.3. Another central level is the structural one, which tackles the infrastructures needed for global TA activities and which are able to foster exchange and a global reach. As a basis, the practical level of projects on concrete technologies, but with an explicit global perspective is addressed as well as identifying and understanding TA-like activities throughout different countries and cultural contexts as a way to build up in-depth knowledge. All levels feed into one another and are an essential part of furthering a global TA.

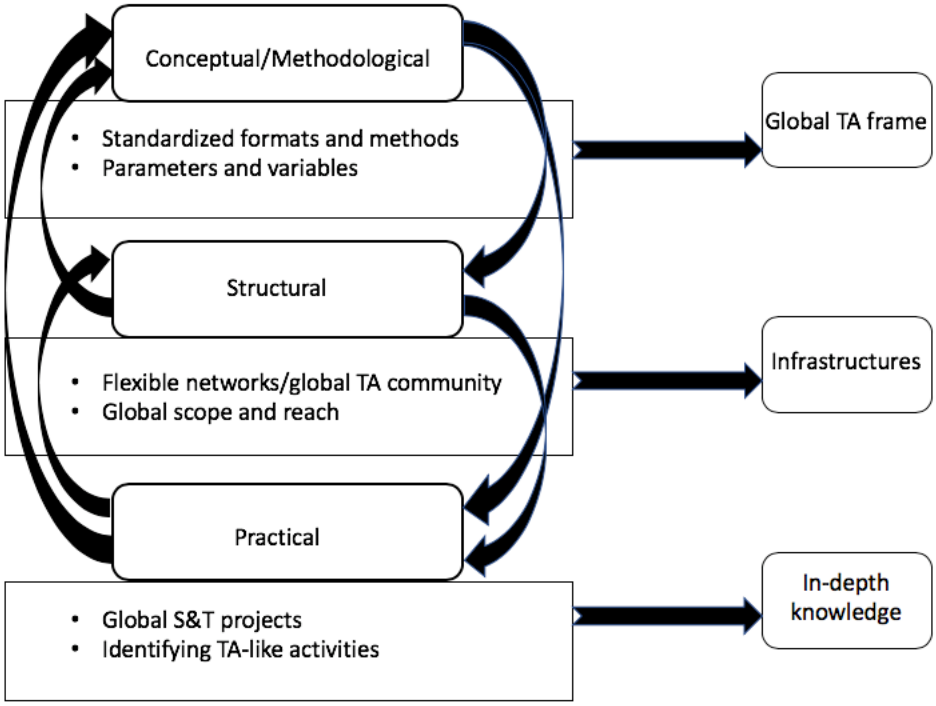

Figure 13: Different Levels of a Global Technology Assessment (own figure)

Create projects for developing standardized formats and methods of TA (methodological)

Based on European projects such as TAMI and PACITA (as described in chapter 3) we see the importance of furthering research on and development of TA formats and methods. Bringing together a wider array of TA practitioners to come to common agreements on the activities taking place in the area of TA is crucial and has to be expanded beyond Western countries. Projects offer concrete frames in which such standards can be developed in different contexts. This seems especially relevant since the application of TA in various habitats will lead to new questions regarding methods and potential impact of TA. As we have seen in the cases, this can, for instance, imply different engagement methods for diverse surroundings. Engagement along a continuum means that it can range from collecting opinions of people to the inclusion of a wider public in decision-making processes. For this there need to be minimal standards and a common basis which also define the limits of applying TA methods in different contexts; i.e. what is outside of the TA habitat (as seen in Figure 8 in section 6.2.3). In this context it can also be useful to develop and debate prototypes from countries as they present the specifics of the habitat in which they are applied but can also be used in other contexts. This offers opportunities to exchange and mutually reflect on methods and co-develop globally applicable ones. For this we could think about a TA project which focuses on methods and impact, but goes beyond the focus of previous European ones to include a wider international scope. Standardized in this context would mean that an array of formats and methods is developed, which can vary according to their applied context, yet follow basic quality criteria. This would also enable comparisons between formats and outcomes in different countries, that go beyond a strict one-to-one analysis, as done in the global engagement World Wide Views project (section 4.2.1), which applied a set format across very different contexts. Instead the, by all means challenging, goal here would be to adapt formats, foster exchange and identify communalities and

differences, which in turn can help us understand what specific needs of individual countries may be as well as what is required on a global level regarding formats and methods.

Develop parameters and their variables for a global TA framework (conceptual)

The parameters presented above (section 6.2.3) are only a first step in the attempt to come to a common framework for a global TA. As such they describe initial key elements needed for a TA habitat in order to better grasp the varieties that are present. Of course this needs to be further conceptualized and researched. One key aspect here will be to include 'quality criteria' within the parameters, which can account for "different understandings of democracy, different images of the relations between individuals and the collective [or] different value systems" (Grunwald 2018b: 222) and will also serve as important ways to identify the limits of expanding TA. Here, international standards, for example human rights mentioned in 6.2.2, can provide more general frames, but will not replace a continuous reflection and discussion, also within the TA community, as to the normative basis of TA practices. Doing this should also ensure that extending TA doesn't lead to arbitrariness and randomness in its use and application, but instead that TA practices remain within a frame or TA habitat which corresponds with its basic understandings. This then also means including the work on methods and formats, knowledge on TA activities as well as insights from experiences in concrete projects. For the parameters and their variables, we need further insights into which aspects are actually important for TA and how differently these can be relevant in various contexts. Going beyond these first thoughts implies more nuanced forms of the parameters, which can also enable comparisons between countries in relational ways. For a global TA, these parameters outline a way to grasp the wide varieties of TA(-like) activities taking place and to evaluate them in order to provide a common ground for a global level of TA. This also implies interdisciplinary research including, for instance, fields like political economy (e.g. as a way to analyze the different national contexts including economy, trade or distribution), human geography (e.g. to understand interactions and their effects), cultural studies (e.g. to uncover how contemporary cultures, also including S&T developments, relate to power structures) or social psychology (e.g. to analyze how actions are related to values, culture and social structures). As we can see this conceptual work on a global TA framework is multifaceted and requires common and interdisciplinary efforts.

Enable structures for networked, flexible TA activities on a global level (structural)

A key point for a global TA is the possibility to act in a networked and flexible way. As mentioned in section 3.3, a nationally-based and structured TA is not sufficient in light of global challenges. More interconnected and adaptable approaches are needed, which can enable TA to go beyond national frames, while still accounting for these. The recommendations presented here all require such a structure. Key for a global TA and for bringing this all together is the surrounding structure in which these activities can take place in a meaningful way. As we have seen in the descriptions of TA in Europe, cross-country TA is possible, yet requires platforms that can bring together work on methods and formats, outcomes from concrete global projects and conceptual reflections on parameters. In this way a (global) TA community in Europe and beyond can be created and supported, for instance by teaching TA (Grunwald 2018b: 207ff.) or by continuing forums for exchange such as international conferences (ibid.: 221). Coming to sustained, long-term, continuously active as well as flexible structures is perhaps the most ambitious aim of all as it implies structures that can encompass this global scope. Throughout the cases and the

descriptions of countries we find the need for exchange and mutual learning which can improve the activities taking place on a national level and add a global frame. Structuring such an undertaking requires a frame that can account for the local and national specifics as well as global interconnectedness. Further, the structure needs to be adaptable and able to incorporate changes. Of course, it is difficult to find such a structure on a global scale and perhaps for good reason. Still, demands for a new type of infrastructure regarding the ethical and wider societal reflection of a specific technology development can be found. As Jasanoff and Hurlbut for instance suggest the establishment of a global observatory for gene editing, which, as a network, "would be dedicated to gathering information from dispersed sources, bringing to the fore perspectives that are often overlooked, and promoting exchanges across disciplinary and cultural divides" (2018: 436). Here we seen that in order to reflect and assess technologies with (potentially) far reaching implications such as gene editing, this kind of structure would need skills and the sensitivity "to manage cross-disciplinary and cross cultural conversations, and [be] backed by the knowledge and networks needed to sustain an infrastructure that facilitates these conversations" (ibid.: 437).

Similarly, we can also find existing initiatives for global structures that are adapted for coping with and shaping worldwide S&T developments. One such an existing infrastructure, the Technology Facilitation Mechanism initiated in the context of sustainable development, even if not realized completely yet, can provide inspiration for enabling networks and the possible structuring of a global TA. The Sustainable Development Goals (SDGs)[145] present the main identified international challenges regarding sustainability as defined by the United Nations (UN). These 17 goals range from environmental issues such as oceans and marine resources or ecosystems and biodiversity to societal aspects such as gender equality or peace and justice. The goals, set in 2015, address all countries and are not specific to developed or developing ones. The agenda "Transforming our World: the 2030 Agenda for Sustainable Development"[146] defines the SDGs and the targets needed for their accomplishment. Of course, these SDGs have been criticized, for instance regarding the ambition of GDP growth while at the same time aiming for sustainability objectives. The issue of too many goals and targets (169 in total) has been raised as well. Still, this process of defining SDGs and trying to implement processes towards achieving them is relevant here, as it presents a global action (almost all actors involved in negotiations agreed on the SDGs), which has then taken shape in national and local contexts. All countries must adapt the SDGs to their national legislation and decision-making processes, design action plans, appoint budgets and coordinate their activities with other countries[147]. In the context of the SDGs and their implementation, an instrument was developed and launched in 2015, especially focused on S&T and mutual exchange. This Technology Facilitation Mechanism (TFM) is interesting in the context of this thesis as it presents a tool to "facilitate multi-stakeholder collaboration and partnerships through the sharing of information, experiences, best practices and policy advice among Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders"[148]. Announced

[145] https://sustainabledevelopment.un.org/?menu=1300

[146] https://sustainabledevelopment.un.org/post2015/transformingourworld

[147] For a detailed description on the goals as well as their history and implementation see: https://en.wikipedia.org/wiki/Sustainable_Development_Goals

[148] https://sustainabledevelopment.un.org/TFM

in the 2030 Agenda in Paragraph 70[149], the TFM was developed by an interagency task team on science, technology and innovation (STI) made up of stakeholders from civil society, the private sector and the scientific community. It is linked to global challenges and the importance of S&T to find solutions for these. As announced during the launch event, co-hosted by the Governments of Brazil and France, the Secretary from the Ministry of External Affairs of India Sujata Mehta stated: "If the world has to end poverty within a generation, if the world has to enable a life of dignity to every individual on the planet, if the world has to combat climate change and put itself on a sustainable pathway, then meaningful collaboration on developing and sharing technological solutions is not an optional luxury; it is a fundamental necessity"[150]. Here we see the direct link made between environmental and societal (global) sustainability and the importance of S&T for achieving this. Next to the task team, the TFM comprises an annual multi-stakeholder forum on STI for SDGs as well as an online platform (under development) for information on existing STI activities, mechanisms and programs. The latest forum took place in June of 2018 in the UN headquarters in New York and had sessions on various topics such as national STI roadmaps and capacity building, sustainable cities, food and water, sustainable consumption or industry 4.0[151]. Next to this, the TFM online platform aims to map activities, enable access to information as well as best practices and lessons learned on STI facilitation and disseminate open access scientific publications worldwide. An independent assessment of the online platform stated the importance of also providing offline technology transfer services next to online ones as well as a forum for matchmaking between technology suppliers and demanders and service providers and enterprises. The overall structure should be a platform for country-based networks, through which the networks themselves can use own resources and determine the pace and direction of growth. Further, the platform should in its initial phase focus on a few key issues arising from the SDGs, such as health or education, and through this attract key anchor participants for technology transfer[152]. It will remain to be seen how the online platform can contribute to a continuous and enhanced exchange and network-building. Further, the impact of the TFM on a local and national and especially on a global level will have to be assessed. Nevertheless, for now, the TFM model can point us to a useful direction of a structure which can account for global challenges, cooperation and exchange on S&T while also incorporating local and national approaches. It is institutionalized in the sense that it is connected to the UN with a fairly clear mandate to support the achievement of the SDGs via S&T developments in various countries. In this way, the TFM has incorporated TA elements, but seems more networked and flexible than 'traditional' forms of (national) TA. One can conclude that a global TA structure should be similar to or even integrated in the existing TFM model. The context of the SDGs provides a common goal for the TFM, which frames activities such as the forum or online platform. A global TA would have a wider and context-specific framing, which should also include issues of sustainability. Still, the structure of the Mechanism fits to the needs

[149] For a detailed history of the development of TFM see: http://sdg.iisd.org/commentary/policy-briefs/the-technology-facilitation-mechanism-tfm-conceived-in-rio-born-in-addis/

[150] https://sustainabledevelopment.un.org/content/documents/19493Intervention%20by%20Secretary%20M&ER%20Sep%2026%202015-India.pdf

[151] A full program with documentation can be found here: https://sustainabledevelopment.un.org/TFM/STIForum2018

[152] The full assessment report can be found here: https://sustainabledevelopment.un.org/content/documents/16505Full_Report_Online_Platform_Assessment.pdf

of a global TA approach, which has to account for local networked structures and their global connectedness. As such the TFM presents an interesting structure either for a global TA to connect to or as inspiration for a similar approach. Of course, it remains to be seen how the TFM will further develop in the future and what impact it will have. However, for a possible model of a global TA it remains a useful example.

Conduct global TA projects on specific technologies with worldwide effects (practical)

Complementing the conceptual work described above, TA also needs to continue to conduct projects on specific technology developments and their implications for society. This is the core of TA as a problem-oriented approach and ensures its relevance for policy-making and aligning S&T developments with societal needs and expectations. Of course we could name numerous technologies here that could be interesting as TA projects. And across different countries we can find many relevant ones. Yet, the aim here would be to complement these projects with ones with an explicitly global focus and frame. Conducting global projects on technologies which have effects worldwide would be a key element of a global TA. Of course this is an ambitious goal as it implies the collaboration of a large number of countries with very different starting points and knowledge on TA. Yet, there are some examples of global projects[153] attempting this even if they don't include all countries. Here, the aim would be to initiate further projects with as much of an international consortium as possible and a clearly global perspective. These initiatives would be about developing different assessments from across countries and reflecting on these within the project in a global manner, including comparisons, prototypes, common roadmaps, policy options or combined engagement processes. The technologies or issues interesting for such global projects are of course numerous. Important criteria would be their global effect and reach as well as their importance on a national level. An example here could be "omics" research[154], since it represents an important current research field with possibly major implications for individuals (e.g. research on humans), societies (e.g. structuring of health care systems or research itself (e.g. ethical standards). Further, in this kind of research we also often find arguments of competition among countries (e.g. 'if we don't do it, they will'), which makes it relevant on a global stage. A global TA project in such an area could take up these issues attempting to go beyond national foci and approaches to create global perspectives and methods to properly address this. Also interesting for such a global TA project are developments which necessarily reach across country borders. An example for this are large infrastructure projects such as the Belt and Road Initiative[155]. Here questions arise regarding large developments in different countries and correspondingly different socio-political systems and what methods could be used to make these more inclusive and aligned with actual needs and

[153] Examples are the EU-funded projects Global Ethics in Science and Technology (GEST) (see chapter 4 on ethics) or Responsible Research and Innovation in Practice (RRI Practice) (see section 3.1 on RRI) which represent consortiums with a number of countries beyond Europe and are focused on different technologies and their application as well as the context of research funding and conducting in different organizations.

[154] This refers to fields of research in biology with the ending -omics such as genomics or metabolomics, which are becoming more and more relevant.

[155] The Belt and Road Initiative is currently a development strategy of China introduced in 2013 and aimed at connecting various countries with China to construct a large market for flow of capital and talents as well as technologies. Investments in infrastructure such as railways and highways as well as construction and energy are all part of the initiative. It can be regarded as one of the largest infrastructure and investment projects ever as it will included more than 68 countries and 65% of the world's population once realized (http://time.com/4776845/china-xi-jinping-belt-road-initiative-obor/).

expectations. This then would also imply questions regarding political motivations and legitimatization processes. Including TA in such a project implies further developing TA in engineering processes, since it is essentially about developing and building infrastructures. The view here would be more along the lines of these types of developments as socio-technical systems as for instance done in the ENERGY-TRANS project in Germany (described in section 5.1.3). In this way, methods of TA in this area of engineering would be improved and TA capacities enhanced. Through such projects TA will further develop its concrete competences and experiences regarding global perspectives and assessments.

Enhance in-depth knowledge on specific TA(-like) activities in other countries (practical)

Providing more substance regarding the differences and similarities of TA(-like) activities in countries is essential for a global TA. As we have seen in the case studies and even in the brief accounts of other countries above, uncovering how TA(-like) activities take place, where they are located as well as how key actors see their ideal functions can enrich a global approach, which is culturally sensitive and adaptable. Only through these in-depth cases can we gain insights into the concrete activities and understandings of TA and what the needs of TA in a specific setting are. The cases examined in this thesis offer a first step in this direction, yet more work on this is needed. The various perspectives in the countries have to be incorporated into a global level which requires exchange on activities taking place. These should be focused on certain key aspects that make up TA such as engagement and ethics, but also the surrounding factors which influence it. Comparing these different perspectives should be done, similar as in this dissertation, in an explorative way in order to remain open to qualitative aspects. Knowledge on how TA functions in different countries and how this relates to others shouldn't be about comparing numbers, but should be focused on more substantial insights. Of course, as mentioned above, this needs to be based on certain basic standards of methods and formats, however how and why these unfold in different contexts should be the focus here. Then it becomes possible to reflect together on these varieties in order to provide a basis for a global TA, also connecting this knowledge to the further development of formats and methods.

Moving Forward

These suggestions build on the findings and reflections of this thesis; its conceptual reflections as well as empirical findings of the case studies. From the descriptions of current global challenges and corresponding developments of S&T and policy, accounts on TA, its methods and newer developments, reflections on the role of ethics and engagement for TA and global perspectives, in-depth examination of TA(-like) activities in different countries to recommendations on enhancing TA in various settings. Moving forward towards a global TA requires, as stated before and seen especially throughout the case studies, many efforts by an array of different actors which cannot be done all at once. Further, the 'starting points' in individual countries are very unique and diverse, as the especially accounts from the interviews show us. For instance, moving TA forward in Germany requires different actors or processes than in China or India. And bringing TA towards a global perspective entails joint efforts in various regards (e.g. methods, concrete projects or structures) as we see in the recommendations presented in the previous paragraphs. What is left here is to emphasize the importance of raising awareness of the need for TA (or similar activities) as a basis for political and societal will, and, remembering the quote at the very beginning of this thesis, as a way to

provide “good tools” regarding the increasing global scope of S&T and their widespread effects on individuals and societies. Here TA can also, through an explicitly global perspective, be attentive towards and assess global S&T developments from across the world and in turn interpret these for specific national levels. In this way, future topics and issues can be picked up as they appear on the global stage. This interactive and interrelated character is a key element in moving towards a global level. This thesis hopes to have provided arguments and insights why TA is a useful approach in this regard and how it can be adapted to meet current challenges in a more comprehensive way, as a ‘point of departure’ for a global TA. The research question posed at the start of this dissertation aimed to give the frame for exploring this, asking how we can move towards this global TA and what implications this may have. The resulting chapters, including the empirical work, addressed this in detail in order to identify next steps. Regarding future research, the recommendations developed in this section show us the main points of action: conceptualization of TA and parameters for better grasping its habitats, future needs and limits as well as methods and formats or research on specific technologies with global implications. In addition, further substantiating a possible structure of global TA which can account for different aspects and in-depth studies on TA(-like) activities across the world is key. This shows a certain balancing act, which perhaps TA as a problem-oriented approach has always had to deal with, but which is becoming more apparent with its move towards the global: To continue to conduct concrete projects on technologies and their social, cultural, economic, environmental, etc. effects in specific situations while reflecting on and generalizing these findings to further develop and refine a conceptual level as well (e.g. TA’s normative foundations, parameters and habitats). The latter has perhaps been a weakness of TA so far, as it has remained mainly in its Western ‘comfort zone’, but this conceptual reflection will be an essential part of moving towards a global TA.

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