Leonhard Hennen · Julia Hahn ·
Miltos Ladikas · Ralf Lindner ·
Walter Peissl · Rinie van Est *Editors*

Technology Assessment in a Globalized World

Facing the Challenges of Transnational Technology Governance

Springer

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Contents

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Introduction: Technology Assessment Beyond National Boundaries

Leonhard Hennen, Walter Peissl, Julia Hahn, Miltos Ladikas, Rinie van Est, and Ralf Lindner

Modern societies are immensely permeated by technologies and thus also dependent on them. Increasingly, this is also true for countries in the global South. As a result, questions about the interdependencies of technology and society, the possible mutual influences and the social governance of technology are becoming a global challenge. In addition, innovation cycles have become shorter and shorter, and more new products and services are being offered at shorter intervals. Many of these new

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technological processes, products and services are provided primarily unchanged on global markets, encountering societies with different cultures and socio-economic conditions.

1 A Brief History of Technology Assessment

Since the 1970s, attempts have been made under the label of "Technology Assessment" (TA) to scientifically investigate the possible effects of technological innovations and, based on the findings, to advise civil society and political actors in this regard (for an overview see, e.g. Grunwald, 2018; Vig & Paschen, 2000). From a scientific point of view, TA is an interdisciplinary activity that responds to the emergence of new scientific and technological developments, artefacts, processes, services, societal problems and concrete policies, and attempts to identify the possible effects on different areas of life. Particular emphasis is placed on unintended consequences—the non-obvious is to be made visible through interdisciplinary exchange, often involving stakeholders and those affected, and is thus made accessible for evaluation.

There is currently no generally accepted definition of TA, but the definition used in an international project on TA[1] methods can be regarded as a sound basis:

> 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, S. 14)

This very general definition contains many aspects of modern TA. It goes beyond "classical" informing (science to policy) and acknowledges that values and interests influence technology development. Bringing stakeholders and the broader public on board through TA processes also helps open up issues to public debate and to set public agendas. This endeavour needs interactive settings and communicative skills to bridge different perspectives and disciplines.

However, beyond a formal discussion, the mission of TA is clear: It is about reflection on technological progress, which should be used to enable a scientifically elaborated knowledge base for political decision-making, and social discourse on questions of shaping futures in an increasingly technology-dependent world. Since technological development is global, reflection on technological progress and governance needs to take a global perspective. However, a particular challenge is that the social embedding of global technologies can lead to regionally, culturally and socially different impacts. The effects of new technologies cannot be assessed independently of the socio-economic environments they are used in, as there are no universal deterministic impacts of a specific technology. So, the particular challenge for global TA is to analyse global technologies, which are often uniform—with generic challenges

[1] TAMI (Technology Assessment in Europe. Between Method and Impact) was a European project from 2002 to 2003 focussing on providing a basis for discussions on the methods and impact of TA. For details see: https://www.itas.kit.edu/english/projects_grun02_tami.php.

for human beings and the environment—but at the same time to appreciate their interdependent embeddedness in socio-cultural and socio-economic conditions.

Another challenge is that TA is primarily an element of policy advice, and policy systems vary widely internationally. An example of this is provided by the different forms of institutionalisation of TA in Europe. Although all full-member countries of the European Parliamentary Technology Assessment network (EPTA)[2] follow the same, or very similar, models of parliamentary democracy, a colourful diversity of institutionalisation forms and preferred methods is evident. On the one hand, these are historically justified, but on the other, they are mostly highly functional and tailored to the specific parliamentary system.

The beginnings of institutionalised TA can be located in the Office for Technology Assessment (OTA) in the USA in the 1970s. In the founding law, the foundations for and the demands on TA were formulated in a way that can still be regarded as valid:

> To establish an Office for Technology Assessment for the Congress as an aid in the identification and consideration of existing and probable impacts of technological application. […] As technology continues to change and expand rapidly, its applications are […] increasingly extensive, pervasive, and critical in their impact, beneficial and adverse, on the natural and social environment. Therefore, it is essential that, to the fullest extent possible, the consequences of technological applications can be anticipated, understood, and considered in determination of public policy on existing and emerging national problems. […] It is necessary for the Congress to equip itself with new and effective means for securing competent, unbiased information concerning the physical, biological, economic, social, and political effects of such (technological) applications. (United States Senate, 1972)

From the beginning, the need for policy advice was central: Congress wanted to better exercise its control function vis-à-vis the executive branch, but was increasingly confronted with studies that contradicted each other and lacked decision-related information (see, e.g. Herdman & Jensen, 1997). The OTA relied on interdisciplinary, strongly scientifically oriented in-house expertise and the most comprehensive presentations possible. From the beginning, the OTA tried to enhance the readability of its reports with the help of professional scientific writers. After 23 years of practising TA for Congress, the OTA was closed in 1995. For a long and fruitful period, the OTA served as the blueprint for TA internationally. “The OTA Legacy”[3] describes the history of the OTA and presents all 700 reports.

Soon after the founding of the OTA, the discussion about TA started in Europe. After lengthy discussions, several PTA institutions were established around the mid-1980s, beginning in France, Denmark, the Netherlands, the European Parliament, Austria, the UK and Germany. The European Parliamentary Technology Assessment (EPTA) network emerged from these foundations. The second wave occurred towards the end of the 1990s and a third in the first decade of the twenty-first century. Thus, EPTA now includes 25 parliamentary TA (PTA) institutions. Since the US Government Accountability Office (GAO) became an associate member in 2002, EPTA has extended beyond Europe. This process of global networking of PTA has

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2 https://eptanetwork.org/.

3 www.princeton.edu/~ota/.

continued, with the admission of members from Japan, Mexico, Chile, South Korea and most recently Spain and Lithuania.

In the 50 years since the first foundations of TA, both the social framework and the political conditions for parliamentarism have changed. Thus, PTA has also evolved. An overview of the institutionalisation of PTA and its development, especially in Europe, can be found in Vig and Paschen (2000), as well as Cruz-Castro and Sanz-Menéndez (2005), and more recently in Ganzevles et al. (2014), Est et al. (2015), Klüver et al. (2015), Nentwich (2016), and Peissl and Grünwald (2021).

Even though its institutional focus still lies in the area of PTA, TA has differentiated, addressing governments and establishing itself in academia. A chronological sequence of different concepts and approaches to TA shows that OTA's expert-oriented classical TA concept, with interdisciplinary project groups to develop "unbiased information" as a basis for options for action, quickly developed further into participatory TA, primarily in Denmark and Switzerland. Participatory TA (pTA) recognises the social nature of technology and thus the importance of its inherent values. Therefore, it includes a wide range of stakeholders and the general public in the TA process (Durant, 1999; Hennen, 1999; Joss & Bellucci, 2002). Other approaches, e.g. from the Netherlands, were particularly fruitful for academic discourse on the further development of TA. Constructive TA (CTA) envisages an active role for TA as an actor as early as possible in the technology development process, mainly to introduce social issues (Genus, 2006; Rip & van den Belt, 1986; Rip et al., 1995; Schot, 2001; Schot & Rip, 1996). The concept of real-time TA, introduced in the USA in the 2000s, attempts to do something similar by early integration of social science knowledge into scientific and engineering ventures (Guston & Sarewitz, 2002).

2 Technology Assessment and Its Relatives

In the international context, a particular success story is Health Technology Assessment (HTA). HTA developed almost simultaneously from classical TA and pursues the same fundamental goals in terms of policy advice on an evidence basis, albeit restricted to medical products, interventions, therapies and preventive measures. The formal definition of HTA reads like this:

> HTA is a multidisciplinary process that uses explicit methods to determine the value of health technology at different points in its lifecycle. The purpose is to inform decision-making to promote an equitable, efficient, and high-quality health system. (O'Rourke et al., 2020)

The specialisation in health technology made it possible to reach a consensus on methods and procedures and anchor them in the HTA community. An international community emerged early on, now represented by the International Network of Agencies for Health Technology Assessment (INAHTA), and Health Technology Assessment international (HTAi). INAHTA has a membership of 50 agencies with 2100 staff from 31 countries, and HTAi has 82 member organisations, and over

2,500 individual members from 65 countries worldwide. A detailed history of the development of HTA and its organisations is described by Banta et al. (2009).

In contrast to the precise requirements posed in HTA, the world is confronted with many highly complex issues, from managing and preventing conflicts to mitigating global warming, dealing with increasing inequality which threatens the social fabric on a global level, or new pandemics that threaten both our health and the global economy. In all these challenges, Science, Technology and Innovation (STI) plays a vital role as an essential factor in either causing or mitigating the problem. These challenges are severe and require rapid coordinated action on a global scale. Many technological developments require urgent global coordination, from digitisation to gene editing, nanomaterials, artificial intelligence (AI) and robotics.

However, while global interaction in economic and technical terms has increased, we are faced with a lack of global governance. To address the global challenges and govern the global development of technology, it is imperative to identify, assess, discuss and regulate the impacts (e.g. societal, environmental, ethical or legal) of STI in a timely manner. As this is the main focus of Technology Assessment, TA can help support the global governance of technologies, find alternatives to problematic applications or promote key technologies' positive attributes.

While similar activities exist in many areas of the world, the term "TA" is often unknown. These other "TA-like activities" range from research into the relationship between Science, Technology and Society (STS), to more project-oriented consultancy in environmental issues, such as the Environmental Impact Assessment (EIA). STS research to understand and clarify the relation of science, technology and society splits in two basic directions—first, scientific understanding of the nature and practice of S&T and, secondly, (similar to TA)—investigating more deeply into the impacts and control of S&T, focussing on risks and benefits that might concern values such as peace, security, community, democracy, environmental sustainability and human values.[4]

Responsible Research and Innovation (RRI) has been developed and strongly promoted in Europe under the patronage of the European Commission. RRI takes up several approaches and methods of TA and aims at creating 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" (von Schomberg, 2011). A considerable effort was made to understand the innovation process under the frame of RRI, and to further advance its implementation with the help of concrete criteria and tools through numerous European-funded projects (Owen et al., 2021). Even though the new European funding frameworks (e.g. Horizon Europe) have shifted focus towards "Open Science", the more conceptual levels or "dimensions" of RRI remain relevant, including for TA. These dimensions are procedural in their approach and include anticipation, reflexivity, inclusion and responsiveness (Stilgoe et al., 2013). Several discussions on whether RRI is a critique of TA (van Lente et al., 2017) or whether TA should take on the role of a lighthouse for approaches such as RRI

[4] Further reading: https://sts.hksharvard.edu/about/whatissts.html.

(Nentwich, 2017) have taken place. Further, activities in EU projects (RRI Practice[5]) have aimed to expand RRI to countries outside of Europe, such as India, China or Brazil, which in turn raises questions of the value basis of the concept and how this varies in different national contexts (Wong, 2016). This of course is also a key question for a global TA.

Additionally, Foresight has evolved as an often- and widely used tool for strategic planning and long-term decision-making. According to a well-established definition, Foresight is a systematic, participatory, future intelligence-gathering and medium- to long-term vision-building process aimed at enabling present-day decisions and mobilising joint actions.[6] Its roots go back to the early 1980s and took off in the 1990s, as European and then other countries sought new policy tools to address problems in their science, technology and innovation systems (Miles, 2010).

Finally, impact assessment is a way of dealing with the concrete effects of technological interventions in nature and society. A large international professional community focussing especially on environmental impacts is organised in the International Association of Impact Assessment (IAIA).[7] Environmental Impact Assessment (EIA), as a widely standardised tool, deals with the environmental implications of concrete planning processes, mainly on a regional level. Through the evaluation of many projects and their regional focus, it soon became apparent that, in addition to environmental impacts, it was above all the effects on the social fabric and socio-economic status that had to be taken into account. So, the Social Impact Assessment (SIA) evolved. SIA is seen as a field of research and practice that addresses everything associated with managing social issues throughout the project lifecycle (pre-conception to post-closure). SIA has transformed from a regulatory tool to being the process of managing a project's social issues, used by developers, financiers, affected communities and environmental licencing agencies (Vanclay, 2020).

Several activities at different levels are dedicated to the tensions, interdependencies and opportunities between technology and society—both in the relationship and its governance. They all have alliances, platforms, organisations and networks that aim to establish professionalisation, exchange, further development and visibility for the respective approaches. Of course, this also applies to TA. In addition to the EPTA Network[8] mentioned above, the TA network (NTA)[9] of the German-speaking countries is particularly noteworthy. In this network, 55 institutional members from Germany, Austria and Switzerland work together. Within the context of these networks (e.g. EPTA, NTA), and wider international cooperation in projects such as GEST,[10] PACITA[11] or RRI Practice, the wider importance of a global perspective for TA activities has become more and more distinct over the years. Technologies

[5] https://www.rri-practice.eu/.

[6] http://www.foresight-platform.eu/community/forlearn/what-is-foresight/.

[7] https://www.iaia.org/about.php.

[8] https://eptanetwork.org/.

[9] https://www.openta.net/.

[10] https://www.itas.kit.edu/projekte_deck11_gest.php.

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

develop globally and have worldwide impacts; grand challenges go beyond national boundaries, and assessments should take this into account.

3 The Need for Technology Assessment to Go Global

The first discussion on global TA was initiated with the book "Constructing a Global Technology Assessment" (Hahn & Ladikas, 2019), which examined science and technology policy systems, decision-making frameworks, priorities and values as well as TA(-like) activities in various countries, such as Australia, China, India and Russia. This discussion highlighted the existence of a "TA Habitat" (Hennen & Nierling, 2015) as a prerequisite for the creation of a global TA. The Habitat refers to the elements that are needed in order to have a functioning TA in the national context, that can then be assimilated in the multilateral context. In detail, it revolves around the decision-making structures, the public accountability system, the existence of problem-oriented or hybrid research activities in the academic sector, public awareness of STI issues and a wish to articulate societal implications in policy-making.

More importantly, this first discussion arrived at an agreement on the parameters that would help delineate the functions of a global TA. These include:

Political System: with a wide range from multi-party to one-party systems, from liberal to authoritarian, from socialist to capitalist, from social welfare-oriented to free market-oriented, etc., the political system of the country affects the type of TA that can be undertaken. Disregarding extreme political systems that are not conducible to any type of TA, the prevalent view is that any system that allows freedom of expression and includes willingness to accept open debates is a good candidate for inclusion in global TA. This also presupposes willingness to accept different perspectives, and not simply to accept, or not, the most public forms of TA.

S&T Governance System: refers to the administrative setup around the STI decision-making process, and in particular, how centralised or decentralised this might be. The European Union's multi-national (or transnational) governance provides a good example of a multi-national organisation that can perform successful TA at central level. The UN's Intergovernmental Panel on Climate Change is another example of TA-type activity at centralised global level.

Socio-economic Development Stage: refers to national STI priorities that are closely connected to development needs and require particular types of technological development. For instance, frugal innovation, i.e. low-tech innovation that is evident in less developed regions, requires other approaches to assessment than the high-tech innovation sector that TA usually focuses on.

National Values: refers to norms of behaviour and cultural specificities that are key ingredients in every STI debate. These must be analysed and understood in order to identify their impact on decision-making and their role in developing a global TA.

Next to such conceptual thinking, the globalTA Network[12] was founded with the aim to concretely develop cooperation among researchers and institutions active in research and advice on technology policy, and to establish long-term working structures for a global TA. More than 30 members from across the globe represent TA(-like) activities from non-profit institutions committed to developing a global framework for the assessment of the impacts of technologies, facilitating global cooperation and supporting anticipatory governance of new technologies in line with the UN Sustainable Development Goals (SDGs). This book is a project of the globalTA Network. The contributions here result from thorough discussions among members of the network, in a process that has already strengthened its co-operative links and potential. The next step is to analyse systematically the framework conditions, opportunities and challenges for setting a global TA into practice. The book can thus be regarded as a conceptual endeavour for further activities in the globalTA Network.

4 The Book and Its Contributions

The contributions to this volume share an understanding that the development of S&T, including its social and environmental consequences, can no longer reasonably be dealt with solely on a national level. With a view to the economic, social and environmental challenges ahead, and the growing interweaving of economic and socio-cultural life around the globe, they regard globalisation as a reality in the making and hold it to be a political task for the next decades to react to the urgent need for democratic and open transnational modes and processes of global governance. Indications of militant and aggressive nationalism, and authoritarian attempts to prevent nation states and civil societies from open global interchange and socio-political discourse are virulent and have been shocking the world again as work on this volume was completed in early 2022. The contributors to this book are however convinced that these tendencies do not offer any viable way to secure the future of the globe. They hope in all confidence that in the long run these tendencies will not prevail against the civil, cultural, professional, scientific and political communities that constantly strive for open and equal interchange on just solutions for global problems, leading to legitimate transnational decision-making. Holding that such efforts towards processes and structures of global interchange and understanding are all the more urgent, the present volume is a step in this direction in the field of science and technology policy, and specifically in TA as an instrument through which to base political decisions on the best knowledge available, and on inclusive democratic deliberation on norms and values that can guide decisions.

Triggered by ongoing exchanges within the globalTA Network on the need and options for better global cooperation in the field of TA, the volume explores what globalisation means and can offer for our common efforts, and which parameters

[12] https://globalta.technology-assessment.info/.

have to be taken into account when jointly working for a global TA. This includes the recognition of different cultures and understandings of scientific policy advice, and hence different concepts of TA. It includes a reflection on the relevance of processes of globalisation for both the mission and practice of professional TA practitioners. It also includes a reflection on salient problems and fields of advanced development of technologies and the possible contributions from TA. Finally, it includes a reflection on structures of global discourse and decision-making, and ways for TA to respond to these and bring our debate on ways and modes of improved cooperation to the next level.

The volume starts (**Part I**) with an overview of the global state of play in our professional community and the relevance of TA in international governance. In the contribution by *Julia Hahn*, *Nils Heyen* and *Ralf Lindner* we—the global TA community—try to validate our knowledge of practices of TA-related activities worldwide. Based on interviews with colleagues from the globalTA Network, the chapter describes and highlights current and relevant developments of technology assessment (TA) across several countries and clusters these according to main areas of activity or modes of institutionalisation. The focus of this chapter is on twelve (mainly) non-European countries which are part of the globalTA Network: Australia, Brazil, Chile, China, Czechia, India, Poland, South Africa, South Korea, Slovakia, Russia and the USA. This provides an overview of the heterogeneity of socio-political systems which TA may relate to, and modes of institutionalisation that characterise TA activities around the world. At the same time, a TA core becomes visible: addressing potentials and risks of emerging technologies, reflecting ways of doing responsible research and innovation, inclusion of stakeholders and the public in assessment processes, and others. The supplement of the book provides brief Country Reports that serve as an information pool to the overview chapter. In these briefs, colleagues from the respective countries reflect on the state and challenges of national TA activities.

Shifting from the national to the international policy-making level, *Miltos Ladikas* and *Andreas Stamm* identify TA's role in the existing STI multilateral system and localise it within existing global decision-making structures. The paper shows that a wide spectrum of TA methodologies is employed at the United Nations and multilateral agencies in their efforts to analyse the significance of new and emerging technologies for development. The paper concentrates on the United Nations Conference on Trade and Development (UNCTAD), where TA is specifically commissioned as an aspiration for the achievement of its development goals. It is especially the activities related to the UN SDGs that promise options to overcome the numerous challenges that TA faces when applied in developing countries. The chapter concludes with a discussion of possible models for organising TA on a global level and discusses the significance of the Intergovernmental Panel on Climate Change (IPCC) as a role model for an independent and effective global TA.

Part II of the book is dedicated to three challenges that TA faces when trying to go global. *Leonhard Hennen* and *Rinie van Est* explore the dimensions and problems of globalisation, as discussed in the scholarly literature of the last decades, to provide a general reflection on the meaning of globalisation in the field of science and technology governance and identify the challenges of transferring TA activities to the global level. Globalisation is understood here as an articulation of "reflexive modernisation", and thus features to a high extent "reflexive" problems of governance-making, such as systematic uncertainties of knowledge and cultural diversity of relevant values and norms. Great economic interdependencies as well as inequalities, together with the fact that technological and environmental risks are largely of global character and transcend the reach of national policy-making bodies, make up the challenges of globalisation. TA is presented as an instrument tailor made for reflexive governance, and thus as a natural support for politics under the conditions of globalisation, if it manages to strengthen its global character.

TA as a democratic mode of policy advice has a strong relation and commitment to the public sphere as a space to express and discuss common concerns and collective social interests. *Rinie van Est* and *Leonhard Hennen* reflect on the challenges implied in relating TA's activities to a global public sphere. The chapter's reflections follow the "all-affected" principle, which implies that TA should take into account all kinds of people that are affected worldwide by science, technology and innovation (STI). It first examines the relationship between TA and public spheres that deal with the societal significance of STI from a national context, because both are mainly approached from the point of view of national political decision-making. The authors then reflect on public spheres in a context of globalisation and describe how TA institutes, networks and activities are organised beyond national borders. The exploration of the link between public spheres and TA in a global context leads to a sketch of a blueprint for the future of global TA.

One of the main challenges for global TA is transferring the concept of TA as democratic policy advice from its origins in the Western world to developing countries which not share the same cultural and political background and mainly do not have the same economic capacities. *Ravi Srinivas* and *Rinie van Est* draw some lessons for the transfer of TA from the example of India. The chapter provides an overview of the TA landscape in India, as an example of TA in a developing country. The authors start with a reflection on the role and relevance of TA for developing countries in general. Focussing on the development of S&T governance in India, where most TA-like activities and practices are organised by and for governmental agencies, five examples of formally institutionalised governmental TA-like activities are given: governmental TA-like capabilities for technological foresight in general, for agricultural, medical and pollution abatement technologies in particular, and finally the only government-organised participatory TA, regarding the introduction of a genetically modified eggplant. In addition, three informal TA-like grassroots activities are described. Concluding by reflecting on the TA landscape in India, some lessons are drawn for the role and conditions for TA in developing countries.

Part III of the book provides an exploration of four selected fields of technology, respectively, policy-making problems—climate change, biotechnology, artificial intelligence and the COVID-19 pandemic—that clearly show the need for and the challenges of global governance, as well as global cooperation and interchange regarding the scientific analysis of the social significance and effects that emanate from these fields and develop into global policy-making issues.

Climate Change can be regarded as the most serious challenge for global policy-making and is an ongoing exercise in finding ways to globally shared strategies for solutions. *Peta Ashworth* and *Elliot Clarke* explore the structure, practices and methods of the Intergovernmental Panel on Climate Change (IPCC) as a legitimate scientific institution, and its interplay with the global political decision-making forum of the United Nations Framework Convention on Climate Change (UNFCCC). By examining the successes and shortfalls of the IPCC process and comparing these with TA theory and practice, they investigate whether such an institutionalised process of co-design between governments and researchers could serve as a potential global TA model. They identify central challenges of the IPCC process related to questions of political impact, pursuit of consensus, trust and accessibility of information. The authors argue that there is potential for each of these problems to be addressed using existing analytical TA frameworks, resulting in more authentic and accepted outcomes from a global governance perspective.

Biotechnology involves the use and manipulation of living organisms such as plants, animals, humans and biological systems or parts of this, to modify their characteristics in order to create desired organisms or products. Biotechnology is a field that touches on many aspects that are central to TA and have been in its focus since the 1980s. By presenting three key topics in biotechnology—genetically modified food and crops (GMO), synthetic biology and human genome germline editing (HGGE)—*Sophie van Baalen, Ravi Srinivas* and *Guangxi He* show that a central feature of biotechnology is that the science is evolving globally and the products it brings forth are traded across the globe. But as is typically the case for modern technologies nowadays, there are major differences between the regulation and governance of the academic and industrial sectors across countries. These stem from different needs and interest per country, as well as differences in traditions, cultural differences and public perceptions. As global governance is fragmented, with little scope for harmonisation, global TA of biotechnology can bring clarity, better understanding and enable better governance. In order to do so, an integrated global TA framework should consider international trade, differences in risk assessment, cultural variation and different value-systems between countries, as well as differences in countries' capacities in R&D and coordination of public engagement efforts.

Based on a large scale of technology application scenarios, *artificial intelligence* (AI) is expected to have disruptive impact on economies and societies. *Lei Huang* and *Walter Peissl* argue that breakthroughs have been made recently in basic research on the fundamental technologies, so that AI is showing greater potential to become a general-purpose technology. In the domain of TA, research on AI and its potential impacts has been considered early. The research questions, which include impacts on the workforce as well as on societal communication and democracy, and fundamental issues such as responsibility, transparency and ethics have drawn widespread attention from TA studies. The chapter presents a scholarly discussion of AI topics in the context of TA, based on a qualitative analysis of AI policy databases from the Organisation for Economic Co-operation and Development (OECD) and the European Parliamentary Technology Assessment (EPTA) network. The analysis concludes that enhancing global cooperation in TA will contribute to addressing fundamental ethical and societal issues of AI, which in turn broadens the knowledge base and helps to pave the way for more inclusive and just use of AI.

A recent case showing the need for concerted global governance to increase social resilience to crisis is the COVID-19 pandemic. *Marko Monteiro*, *Florian Roth* and *Clare Shelley Egan* examine the governance of health technologies during the COVID-19 pandemic. They reflect on three interrelated challenges that need to be addressed in future assessment approaches for achieving systemic resilience: problems of *scale*, *trust* and *politics*. The chapter focuses on digital surveillance technologies and vaccines; two cornerstones in the efforts to mitigate the spread of SARS-CoV-2 around the globe. Tracing apps were introduced in many countries, but their effectiveness has been constrained by issues of data privacy, insufficient interoperability and digital inequalities. In parallel, a global research race enabled the development of different vaccines with unprecedented speed, building on innovative biotechnologies. However, vaccination worldwide was marked by disparities in access and controversy. The authors conclude that governance and assessment should be built around strong international coordination and cooperation, without limiting local experimental learning and innovation. Further, public trust should be considered as a necessary condition for the success of any technological innovation in the health context. As trust in policymakers, academia and industry is strongly context-specific, global governance should also be sensitive to the diversity of social and cultural contexts. Finally, to improve overall systemic resilience, global power imbalances should be addressed in all phases of the innovation process.

The concluding chapter (**Outlook**) draws tentative conclusions from the findings of these contributions with regard to possible future ways to organise TA on a global scale. These considerations comprise a discussion of possible organisational shapes that can support the global interchange and sharing of TA capacities and increase its political relevance and operability on a global level. Beyond such medium- and long-term aspirations, the outlook reflects on more short-term practical steps that could be taken within the globalTA Network to improve interchange of knowledge and expertise, engage in joint projects and mutually foster analytical and methodological capacities.

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Technology Assessment in a Globalized World

Tracing Technology Assessment Internationally—TA Activities in 12 Countries Across the Globe

Julia Hahn, Nils B. Heyen, and Ralf Lindner

1 Introduction

This chapter describes and highlights current and relevant developments of technology assessment (TA) across 12 countries within the globalTA network[1] and clusters these according to their main areas of activity. Overall, we understand TA as 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). This involves various approaches and methods, including scientific assessments, policy analysis, and participatory processes, which are used to understand the societal implications of technology and innovation in a multitude of dimensions, thereby taking into account the different cultural contexts in which technology development unfolds. TA as a term is not necessarily used alike in different national contexts. Instead, other approaches such as ELSA/ELSI (ethical, legal, and social aspects/implications), Responsible Innovation (RI) or Responsible Research and Innovation (RRI), sustainability studies, societal effects of science and

[1] https://globalta.technology-assessment.info/.

Contribution to: Technology Assessment in a Globalized World—Facing the Challenges of Transnational Technology Governance.

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technology (S&T), etc., may be more common (Hahn & Ladikas, 2019). Looking at different national contexts allows for a detailed view of these activities regarding the interrelation of S&T and public/political/societal settings, and to frame these as TA or "TA-like". By tracing current TA or "TA-like" activities in selected countries across the globe, this chapter highlights several developments, initiatives, or methods, which are relevant for a global perspective on TA. In order to remain in the scope of this volume, the focus of this chapter is mainly on non-European countries, especially because the European TA landscape has been extensively described and analyzed elsewhere (e.g., Hennen & Ladikas, 2019). Since the globalTA network unites researchers and institutions from around the world working in the area of TA, members of the network were invited to share practical insights into their activities. This provides a unique impression of TA-like activities in Australia, Brazil, Chile, China, Czechia, India, Poland, Russia, South Africa, South Korea, Slovakia, and the USA.

The starting point for this chapter was to conduct interviews (JH, NH) with globalTA network members in each of the 12 countries, which enabled discussions about current activities and developments. The interview partners then provided brief reports outlining the situation of TA in their respective national settings (see Country Reports, in the supplement of this volume). The Country Reports all follow the same structure including, (i) the country-specific context, (ii) specific highlights of TA activities (e.g., projects, technologies, and methods), and (iii) outlook and challenges regarding TA in the national setting, and the potential for a global level of TA. Based on these Country Reports, this chapter clusters and localizes the country-specific TA activities (Sect. 2) and reflects on what can be learned from this global analysis (Sect. 3).

2 Mapping of Country-Specific TA Activities

The Country Reports were analyzed and clustered with regard to the various modes of institutionalization of TA. We build on the three main areas of parliamentary TA that have been identified in the European TA landscape (Hennen & Ladikas, 2019, 62): politics (committee model of TA), science (office model of TA), and the public (interactive model of TA). These areas show various manifestations of TA practices, strongly characterized by specific political cultures, yet TA institutions are often active in all three areas. For the global context, we expanded the TA activities to be considered, focusing not only on parliamentary TA. This expands the original TA landscape from the European context to consider TA activities in an international context that are not necessarily termed as "TA" and are embedded in different institutional settings. In addition, in a context in which TA is emerging there may not be an institutionalized form (yet). Corresponding with the definition of TA as an interactive and communicative process, this broader view enables a range of different actors and activities to be considered. We used the three areas (politics, science, and public) as

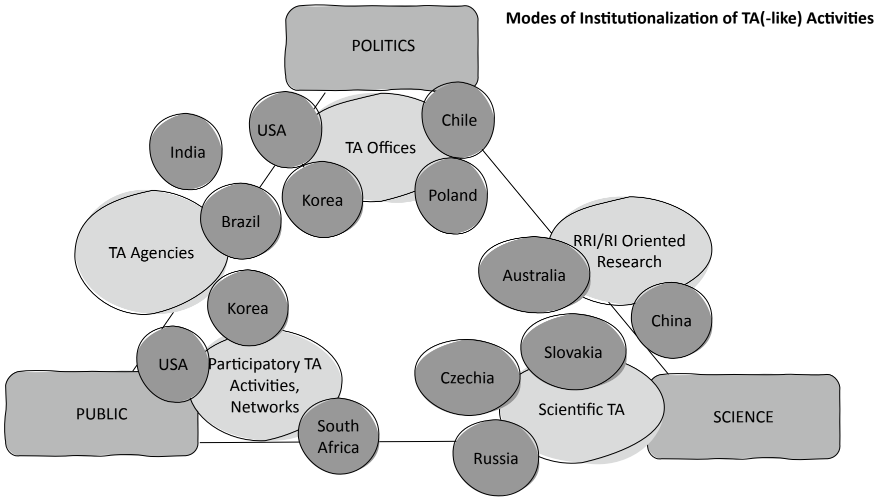

Fig. 1 Modes of institutionalization of TA (-like) activities in the 12 countries

a starting point, but considered wider areas of TA activities and application, such as research programs, networks, or government ministries.

Based on the expert interviews and Country Reports, we identified five main areas of TA activities—or five modes of institutionalization of TA—in the 12 countries (see Fig. 1):

(a) A distinct TA office, which is the institutionalization mode closest to Politics, whether in the form of government ministries or the parliament;
(b) Research funding programs of government ministries that are oriented toward responsible (research and) innovation (RRI or RI), localized between politics and science;
(c) Scientific institutions conducting TA, which is the institutionalization mode closest to science with its main function in research and education;
(d) Participatory TA activities and networks, which often include NGOs, think tanks or other civil society actors, therefore, being close to public; and
(e) TA agencies or government ministries that are oriented toward the public and can, therefore, be located between politics and public.

Figure 1 shows where the country-specific TA activities described in this chapter can be located in terms of institutionalization. In some countries, a variety of TA activities take place, thus these countries are located in more than one area of institutionalization. This is a first account of clustering TA across different national contexts, and deeper analysis of the specific socio-political contexts, institutional settings and formation of TA in each country would be a necessary next step in order to gain a more in-depth picture. Yet, this first clustering can provide some insights into the aspects that are important for TA to emerge and then institutionalize, and provides first indications of which actors may be important in these processes. In the following, we present some of these insights and provide more details on the localization of the country-specific TA activities, drawing on the Country Reports (Fig. 1).

Politics

TA's origins at the Office of Technology Assessment (OTA) as part of the US Congress in the 1970s, together with current networks such as the European Parliamentary Technology Assessment (EPTA) understand TA as an integral part of scientific policy advice and democratic parliamentary decision-making. This "Parliamentary TA" can be found in several countries examined here.

In the *USA* (cf. Guston, in this volume), for instance, there is a group of experts at the Government Accountability Office (GAO), which mainly serves the US Congress and is led by the US Comptroller General, with responsibility for auditing and evaluation. Some connections to TA can be found, even though this is mostly attached to the expert mode of practice, in the tradition of OTA. As described in the US Country Report, GAO has emerged as a small but well-regarded TA capacity which has provided reports on various technologies (recently 5G, CRISPR, climate tech, and health), as well as reports focused on more concise and decision-centered information and communication at the parliamentary and government level.

In *South Korea* (cf. Choi, in this volume), parliamentary TA activities have also been taking place in a formalized way for some time. The Ministry of Science is responsible for TA, and within the Korea Institute of Science and Technology Evaluation and Planning (KISTEP), studies and reports on specific technologies are published each year, with the results reported to the Presidential Advisory Council on Science and Technology (PACST). In this way, TA findings are potentially incorporated into policymaking and budget planning. Experts carry out TA analyses on the effects and issues of emerging technologies, and a Citizen Forum discusses implications and impacts (see "public" paragraph below). According to the analysis in the South Korean Country Report, the future of TA development should focus on simplifying the TA process in order to be able to evaluate more technologies per year, and on raising general awareness of TA through new media. The opening up and diversifying of methods such as the Citizen Forum can be seen as an important development in South Korea to widen the perspectives of parliamentary advice.

We also find a clear location of parliamentary TA within the political system in *Chile* (cf. Weidenslaufer and Roberts, in this volume). The Parliamentary Technical Advisory Service (*Asesoría Técnica Parlamentaria*, ATP-BCN) was created in 2007, and is made up of forty researchers and advisors from various fields. They support legislative committees on a permanent basis and provide assessment of comparative law, comparisons of public policies, and assessments of technical aspects subject to regulation and their societal relevance. As described in the Country Report, in Chile, there is a renewed interest toward science in the public debate (e.g., due to COVID-19). In turn, ATP-BCN has established networks and protocols with scientific experts and parliamentary decision-makers. In 2020, a new task force was created to promote TA methodologies and products among ATP-BCN researchers and advisors ("Scientific Legislative Advisory", ACL), showing an increase in TA as a scientific activity.

In *Poland* (cf. Soler et al., in this volume), the Bureau of Research of the Polish Parliament (*Biuro Analiz Sejmowych*, BAS) was established in 1991, and is the leading national institution specializing in legislative aspects of TA. The Polish Association for Technology Assessment (PTOT) works on the development of new TA concepts and the improvement of research methods and tools. The various activities of TA, mainly in academic fields, are brought together through PTOT.

Besides this clear location within the parliamentary system, there are TA (-like) activities in agencies and think tanks with close proximity to ministries and government. In *India* (cf. Srinivas, in this volume), the Technology Information, Forecasting and Assessment Council (TIFAC) is an organization under the Department of Science & Technology. It has developed the "Technology Vision 2035" (a strategy paper describing S&T focus areas) and has supported innovation-related programs dealing with intellectual property rights, technology development, and commercialization. Yet overall, according to the Country Report, activities in India cannot necessarily be classified as "Technology Assessment". "Technology evaluation", "impact assessment", and "techno-economic study/assessment" are some of the terms used in various documents and in the mandates of various institutions and programs. The government has supported Health Technology Assessment (HTA), but in general, there is a lack of a specific agency to coordinate, standardize methods and help with capacity building efforts.

Monteiro and Matenhauer Urbinatti describe an overall crisis in the positioning of science and technology within society in *Brazil* (cf. this volume), which in turn has effects on the opportunities for TA activities. The Country Report mainly describes HTA activities, which are a specific form of assessment focused on health products, clinical aspects, and cost-benefit analyses of drugs or health applications, and as such represent a very different community than TA. The current situation with COVID-19 vaccines is an example of HTA which shows challenges. Chinese Coronavac vaccine has become an issue of dispute between the Federal Government and the State Government of São Paulo. This argument has centered around issues of the origin of the vaccine, its efficacy, and conspiracy theories, anti-vaccine movements, and misinformation. The Russian vaccine Sputnik V was also controversial in Brazil regarding the regulatory process, and featured in political disputes between government agencies. This focus on HTA activities also indicates a more restricted understanding of TA and the activities taking place. Overall, in Brazil, interrelated developments have had severe effects, also regarding TA (-like) activities. Large budget cuts to research and an increase in denialism and critique of scientific expertise have led to a division of science and society, while calls for opening up science and technology policy aim to increase legitimacy. The analysis by our Brazilian experts shows how hugely problematic it is to establish TA-like activities in Brazil, due to highly contested socio-political disputes.

Science

Another important area for TA (-like) activities across the 12 countries is science and research in the respective institutional settings. It seems that this is the main area of interest for emerging TA activities, where these are not institutionalized (yet).

Academia can be a key player when initiating TA activities in countries without established (parliamentary) forms of TA. Within several Country Reports, we find activities which are relevant for TA in academic education and in network building and research.

According to the *Russia* Country Report (cf. Kazakova and Gavrilina, in this volume), TA initiatives can be found in the largest technical universities, such as the Bauman University (BMSTU) in Moscow. Here, TA education is integrated into the pilot master program, "Social Analysis of Technological Innovations and Risks", which aims to provide practice-oriented training and knowledge on sociotechnical processes. Also, courses on sociology of technology or engineering ethics are implemented into the engineering curriculum. BMSTU and the technical universities of Moscow, Saint Petersburg, Tomsk, and Perm have initiated the "TA and STS in Russia Association", which brings together institutions, enterprises, and government analytical centers. Overall, a main challenge for TA in Russia is a missing balance between the development of economies and technology across the Russian regions. This raises issues of lack of access to basic infrastructure and information on environmental effects. Further, the cultural and ethnic diversity of the country is a challenge regarding the understanding of public perceptions of technologies. A lack of transparency regarding decision-making in the technical processes creates uneven distribution of knowledge and responsibilities in society. This requires comparative and contextualized views of technologies and their potential benefits and risks.

In the Country Report from *Czechia* (cf. Soler et al., in this volume), we learn that there are no real established TA institutions, but that research activities are of importance, especially in European TA-related projects. The Technology Centre of the Czech Academy of Science (TC CAS) has been involved in several European projects, which in turn have changed public and policy-makers' views due to more representation of TA, and public engagement in S&T or research and development policy strategies. Similarly, in *Slovakia* (cf. Soler et al., in this volume), there is no clear TA institution, yet the Slovak Academy of Sciences (SAV) can be considered as an aspiring TA institution. Past TA activities on nuclear energy and human enhancement technologies were conducted by SAV, which lacks resources and capacities, yet is advocating for TA in the country. In general, in the three described Central European countries (Poland, Czechia, and Slovakia), there are institutions that conduct TA-like activities, but these remain mainly uncoordinated.

Another area of relevance to TA is RRI activities, which can be found as part of funding programs in research organizations, or as governance frameworks. For example, the Chinese Academy of Science and Technology for Development (CASTED) participated in the Horizon 2020 European research project "Responsible Research & Innovation in practice"[2] and introduced RRI as a governance research concept to case studies in *China* (cf. Huang, in this volume). Overall, TA, RRI, and sustainable development have been included in research, especially regarding areas such as research ethics, open science, artificial intelligence (AI), or the digital economy. According to the China Country Report, the fast development of S&T in

[2] www.rri-practice.eu.

China has put issues of research ethics and integrity at the center of attention for many stakeholders, such as scientists, businesses, the government, and the wider public. Therefore, approaches such as RRI or TA, as well as Open Science, are regarded as useful tools for researchers and policy-makers in China.

According to the *Australia* Country Report (cf. Lacey and Fielke, in this volume), Responsible Innovation (RI) is also an important approach. The country's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), has adopted RI as one of its future science platforms, which represent new research programs and funding. This was based on previous work on R(R)I in European contexts and projects, and has developed a ten-year impact pathway for delivering RI for Australian S&T development. Applied research capacities in RI and its application are advancing, yet the outcomes of applying RI approaches especially through "blue sky" research investments are still open. Its seems that bringing together findings from a wide array of projects to better understand what has worked and what can be taken up by different stakeholders remains a challenge.

Public

The localization of TA in a more public sphere can be found in several of the 12 countries in the form of participatory activities, and wider networks that include different TA-like or adjacent institutions. In *South Korea* (cf. Choi, in this volume), participatory elements are included in parliamentary TA processes. A Citizen Forum is implemented to discuss the impacts of technologies and provide recommendations. Before finalizing TA reports, the Korea Institute of Science and Technology Evaluation and Planning (KISTEP) holds an open forum, during which the results, and TA in general, are communicated.

In *South Africa* (cf. Mugabe, in this volume), both expert-led more top-down activities as well as multi-stakeholder participatory biotechnology assessment can be observed. The South African Agency of Science and Technology Advancement (SAASTA) launched a program in 2003 named South Africa's Public Understanding of Biotechnology (PUB), which aimed to increase public awareness and understanding, and promote public dialogue on the socio-economic and environmental impacts. Overall, TA seems to be in its early beginnings in Africa, but according to the South Africa Country Report there is a demand to include it in STI policy processes. It seems that in African countries there is an increasing body of scientific knowledge and technological innovation, which in turn shows the need for TA. To improve awareness, capacity building, and sharing of information and experiences, it is necessary to establish an African TA network, strengthen institutional coordination, and improve policy frameworks.

Participatory and network activities can both be found in the *USA* (cf. Guston, in this volume). For instance, Expert and Citizen Assessment of Science and Technology (ECAST) is an initiative which aims to revive more participatory forms of TA. Further, an emerging field of "Public Interest Technology" can be observed, which sees TA as an important part of its potential contributions. The Public Interest Technology University Network plays an important role here, with more than 40 members, and small grants that support TA-like projects.

As observed in the *Australia* Country Report (cf. Lacey and Fielke, in this volume), we also find participatory activities within the framework of RI, which are aimed at risk/benefit assessment as well as the uncertainties of S&T in light of advancements for society. For instance, there has been research to combine Indigenous Knowledge and AI for the improvement of environmental management in Northern Australia, which shows a specific example of participation and TA at a regional and community level.

3 Reflections

Reviewing the country-specific descriptions of TA activities across the globe illustrates the high heterogeneity of socio-political systems, modes of institutionalization of TA, and TA practices in the 12 countries discussed. Overall, it appears as if approaches aiming at the "public" are more dispersed and fluid and less institutionalized when compared to TA manifestations in "science" and "politics". In an attempt to further identify similarities, differences and patterns between TA institutionalization across the analyzed country cases, we first look at the topical substance and the intended impact of TA and TA-like activities. Subsequently, a more bird's eye perspective is taken on the broader structural conditions within which TA institutionalizes and is performed.

In all 12 Country Reports, the TA core is clearly visible: researchers in different settings are addressing the potentials and risks of emerging technologies, exploring ways to perform RRI, analyzing issues of trust and acceptance by the public and different stakeholders, investigating science and technology governance, etc. Another communality lies in the technologies with which the socio-political systems are confronted, whether this is AI, digitalization, health, or biotechnologies. In all 12 Country Reports, we find descriptions of challenges associated with sociotechnical issues and different ways and levels of approaching them.

In terms of the mission of TA activities and their intended impact, it is interesting to see that a main focus of TA activities, both in Europe and globally, seems to lie on impacts. These include a) improving knowledge about the technological or scientific aspects of the subject in focus, b) forming attitudes and opinions with respect to agenda-setting in research or politics, or c) with respect to self-reflection and bridge building between different stakeholders. This becomes apparent when applying the typology of impacts developed in the TAMI project (Decker & Ladikas, 2004). In this chapter, three impact dimensions have been cross-tabulated with three issue dimensions of TA (Hennen et al., 2004, 63). The TAMI impacts can also be understood as intended impacts, or the mission of TA activities and institutions. The impact dimensions include raising knowledge (through scientific assessment, social mapping, and policy analysis), forming attitudes and opinions of actors (through agenda-setting, mediation, and re-structuring the policy debate), and initializing actions (through reframing debates, new decision-making processes, and decisions taken); the issue dimensions include technological and scientific, societal, and policy aspects. Table 1

Table 1 Types of impact of TA in 12 different countries

Issue/impact dimension	Raising knowledge	Forming attitudes/opinions	Initialising actions
Technological-scientific aspects	Chile (TA office) South Korea (TA office) India (HTA) Poland (TA office) Czechia (TA institution) Slovakia (TA institution) USA (TA office) South Africa (Academia)	Australia (RI program) China (RI orientation) Czechia (TA institution) Slovakia (TA institution) South Africa (Academia)	Australia (RI program)
Societal aspects	South Korea (TA office) Australia (RI program) India (TA agencies) South Africa (Academia)	Russia (TA education) Poland (TA office) Czechia (TA institution) Slovakia (TA institution) USA (TA network)	
Policy aspects	Chile (TA office) South Korea (TA office)	Chile (TA office)	

shows the classification of the country-specific TA activities into the resulting TAMI table. As is the case for the European TA landscape (Decker & Ladikas, 2004), most TA activities seem to address the upper left area of the TAMI table. This is not surprising, since raising knowledge and forming attitudes/opinions represent the key impact dimensions of both classical and participatory TA (Hennen et al., 2004).

In sum, the great heterogeneity of different country-specific settings in which TA takes place and is performed globally, cannot hide the fact that on a substantive and methodological level TA faces similar challenges.

The Country Reports also briefly describe the individual country backgrounds and political settings, which in turn are relevant for TA activities. This can be understood as the "habitat" in which TA takes place (Hennen & Nierling, 2015), which is structured by aspects such as the political system, S&T decision-making systems, socio-economic development stage or values (Hahn & Ladikas, 2019). Drawing conclusions from the comparative analysis of the cases has to be done with caution due to both the limited number of cases analyzed and the information provided in the Country Reports, as these are only a brief highlight of TA relevant activities and structures. However, while taking this limitation into account, a closer look allows us to point to a number of noteworthy observations and preliminary insights with regard to the relationship between TA manifestations and the broader institutional and structural contexts.

Table 2 Liberal democracy score of 12 selected country cases

Score on V-Dem liberal democracy index	Country
Top 50% countries	
Top 20%	Australia, Czechia, Slovakia, Chile, South Korea, and USA
Top 30–50%	Brazil, Poland, and South Africa
Bottom 50% countries	
Bottom 40–50%	India
Bottom 10–20%	China and Russia

Source Based on V-Dem liberal democracy index 2021 (Boese et al., 2022; pp. 10–11)

The following interrelated factors have been identified that begin to explain similarities and differences between TA manifestations between the 12 countries:

- The key characteristics of the polity, including the degree and quality of democratic decision-making and basic structural features;
- The types and intensities of political conflicts about scientific-technological issues, including the role of science in society and in policy-related decision-making;
- The developmental levels of and opportunity structures for science, technology, and innovation in the respective political economies and the socio-economic make-up of the countries, including the steering capacities of the state with regard to techno-scientific developments and innovation.

With regard to the characteristics of the polity, the question of the democratic quality of the political system and the rule of law seems to be a potentially useful predictor of the degree of TA institutionalization, understood as the existence of fairly stable and formalized organizational structures and procedures within which TA is conducted. If the liberal democracy index of the V-Dem Institute is applied (Boese et al., 2022),[3] our 12 selected countries cover nearly the whole spectrum of the index score: six countries are among the top 20%, three are in the top 30–50%, one is in the bottom 40–50%, and another two are located in the bottom 10–20% (see Table 2).

While any correlation between TA manifestations and scoring on the liberal democracy index should be treated with caution, we can observe that low scores on the index correlate with low degrees of TA institutionalization, as is the case for India, China, and Russia. However, the opposite relationship is not supported by our selected cases: a high rating on the liberal democracy index is not uniformly reflected by high degrees of TA institutionalization. Instead, among the top 50% of

[3] The V-Dem liberal democracy index rates over 180 countries based on 71 indicators, covering aspects such as quality of the electoral process, freedom of expression, protection of civil liberties, and checks and balances between governmental institutions (http://www.v-dem.net).

the countries included in our study, significant differences in terms of TA institutionalization are evident. While South Korea, Chile, the USA, and Poland have established specialized offices or services generating TA-related knowledge for policy, TA remains largely informal and limited to academia in other countries of this high rated group.

Another potentially useful structural factor in understanding different pathways toward TA institutionalization refers to the general structure of the polity of the democratic systems among our 12 selected cases. It can be expected that particularly presidential systems are more inclined to establish parliamentary TA offices due to the stronger separation of legislative and executive powers, thus increasing the need of the legislature to have access to its own scientific advice infrastructure. This relationship seems to be supported by the example of the USA, where the first parliamentary TA office—the OTA—was established in 1972 (but was also defunded roughly twenty years later). Other presidential systems with institutionalized TA offices or services are Chile and Poland. In South Korea's presidential system, however, the TA facilities are part of the executive branch. These observations, together with the fact that a number of parliamentary democracies have established TA offices connected to the legislature, such as Austria or Germany, indicate that macro-institutional factors of the polity are a rather weak predictor of specific country pathways toward institutionalization.

While establishing relationships between basic structural features of the polity and TA has rather limited explanatory strength, linking TA to political and societal patterns of conflict over techno-scientific issues and socio-economic conditions related to science, technology, and innovation is likely to be more promising. Although significantly more in-depth knowledge is needed to arrive at generalizable insights in this regard, the Country Reports provide valuable evidence on the interplay of these complex framework conditions on the different trajectories of TA developments. For instance, the report from Brazil can be seen as an example of the challenges in any attempt to develop TA under the rule of an outright anti-scientific federal government. In Russia, the prospects for academic freedom and thus TA are considerably worse in view of the far-reaching and recently amplified infringements of freedom of speech, civil rights, and the rule of law.

In terms of possible pathways toward the institutionalization of TA, the Country Reports provide useful insights. A first, though not overly surprising observation, is that academia seems to be the "birthplace" of TA across all 12 countries. Thus, the realm of science and research develops and provides the foundational expertise needed for further uptake and institutionalization of TA. And in those instances where TA thus far has not reached beyond the science system, academia serves as an important reservoir of expertise needed for institutionalization at later stages. Moreover, even in those countries that are unlikely to establish formal TA institutions in the near future, conducting academic TA studies and offering training can provide important contributions to TA capacity building, and sensitizing actors about critical perspectives on the complex interplay between technology and society. Second, a number of Country Reports showing currently low levels of TA institutionalization, such as Australia, China, Czechia, Slovakia, and South Africa, all stress the important role of international exchanges with TA actors, and particularly the conduct of joint TA or RRI projects. While this observation clearly suggests maintaining and even increasing efforts for international cooperation, it also indicates a rather precarious situation for TA in these countries, as sustained funding is scarce or even non-existent. Third, in some of the countries with very low levels of TA institutionalization, specific variants of TA or neighboring approaches to assessment, such as HTA and Environmental Impact Assessment (EIA), are comparatively well-developed and highly institutionalized. This is the case, for instance, in Brazil, Australia, South Africa, and India. It remains to be seen if the existence of such related approaches might provide entry points for the institutionalization of TA at a later stage. For this to materialize, however, explicit connections to the STI policy field will have to be established. Similarly, some of the country cases report a stronger focus on RRI than conventional TA. While this might be an expression of deliberate emphasis on influencing research and innovation practices rather than generating orientation via TA-based policy advice, embedding RRI in STI policy might nonetheless help to pave the way toward TA, due to the many conceptual and epistemic commonalities between the two approaches.

The discussion of the interplay between structural context factors and TA institutionalization was a first step in improving our understanding of the different pathways toward TA. Undoubtedly, more comparative research on these issues will be required in order to provide answers on conducive and hindering factors of TA institutionalization across the globe. The emerging globalTA network could provide valuable contributions in such a collective research process.

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Technology Assessment in a Multilateral Science, Technology and Innovation System

Miltos Ladikas and Andreas Stamm

1 Introduction

The standard role of Technology Assessment (TA) has always been to serve the national policymaking community in its aims to devise a successful Science, Technology and Innovation (STI) policy. Even when TA became involved in public debates with wider stakeholder representation and initiated new methodological approaches to cover the needs of such debates, it remained within the realm of national debates about the effect of STI developments in a specific country or region within it (Hennen, 2002). But the current challenges that STI is required to resolve are, more often than not, international or even global in nature.

There is a common understanding that the main grand challenges that our societies face are not unique to a particular country, region or even cultural context (Robinson, 2007). Most of the grand challenges of our times (e.g. food security, climate change, pandemics, air pollution, soil degradation, depletion of fish stocks, ocean contamination, etc.) are global in nature. No country alone can deal with such enormous scales of intervention, and no solution can be effective at a local level of involvement alone. It is therefore inevitable to argue that global challenges require global solutions, which in itself means effective societal transformations and policy interventions on scales not previously seen in human history.

Contribution to: Technology Assessment in a Globalized World—Facing the Challenges of Transnational Technology Governance.

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At the same time, there is considerable uncertainty as to the best available means of intervention and the technological developments to be used, since the science behind large-scale interventions is incredibly complex and untested. The only certainty is that STI developments are urgently needed to deal with the challenges of our times, and there is clearly a need to establish a level of multilateral coordination and governance of STI. This in turn requires the expansion of national plans and assessment capabilities, including monitoring and evaluation of technologies of interest. In essence, the gap between the national and international levels of TA must be bridged, if we are to deal effectively with grand challenges. Multilateral cooperation in TA has the potential to enhance the outcome and impact of strategies targeted towards grand challenges, due to economies of scale, economies of scope and network effects.

However, while many arguments call for scaling up STI cooperation, national governments are still reluctant to invest public resources in existing or new transnational programmes. Different stances of national governments towards technological trajectories often hinder cooperative approaches. This is especially relevant when it comes to disruptive innovations that entail opportunities and risks which are not fully known. At the same time, STI developments have intended or unintended effects that transcend international borders and political contexts. Even under a shared ethics of responsibility, politicians and research implementers may come to opposite conclusions about what constitutes a responsible approach to new technologies. For instance, some actors and observers see break-through innovations, such as genome editing, as important and even strategic in addressing global challenges (climate change, food security, etc.), while others assess them as developments containing severe and unacceptable global risks (Ladikas, 2019).

Overall, which lines of research and technology development are considered as responsible is very context-specific and can lead to fundamentally different directions in the innovation process. At the same time, multilateral STI cooperation can only work as a catalyst for incremental and disruptive innovations to address global challenges, if a sufficient number of countries assess the same lines of research and innovation as responsible and acceptable for further development. This is exactly the focus of global TA and its main function in promoting the necessary multilateral STI cooperation (Hahn & Ladikas, 2019). However, before accepting that TA is an integral part of the pathway to resolving global challenges, it is necessary to identify TA's role in the existing multilateral system and locate it within the decision-making structures.

2 Technology Assessment in the United Nations System and Multilateral Organisations

2.1 TA in Multilateral Organisations

The foremost global STI governance structure is located within the United Nations (UN) system, which is also ultimately the natural place for the development of global TA. The history of the UN is intrinsically related to STI developments. Founded to keep global peace after World War II, it soon became the main debate and analysis centre for a wide range of technologies with direct effect in peace and development, prominent amongst them being nuclear power, food and agriculture technologies and medicinal technologies. Specialised agencies were created to deal in depth with technological developments, such as the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), and affiliated bodies dedicated to specific technologies, such as the International Atomic Energy Agency (IAEA). In addition, there are many autonomous multilateral funds, programmes, research and training institutes, and other subsidiary bodies that deal with STI issues, such as the Directorate for Science, Technology and Innovation of the Organisation for Economic Cooperation and Development (OECD). Although the evaluation and assessment of new and emerging technologies in relation to the remit of each organisation are central to their functions, there is no standard common methodological approach to achieve this. The common application of TA as in regular use at European institutes (e.g. European parliamentary offices of TA) is evident in many cases, but is rarely named as such. Examples include:

The World Commission on the Ethics of Scientific Knowledge and Technology (COMEST): an active forum of UNESCO that is mandated to formulate ethical principles that could provide decision-makers with criteria that extend beyond purely economic considerations. It is active in several STI areas, such as nanotechnologies, converging technologies and ICT.

The Advisory Services and Analytics (ASA) of the World Bank: tasked to support design of better national policies and build capacity, ASA provides analytical reports on critical STI developments in crucial areas for development such as energy and digitization. Much of the analysis is based on participatory TA principles.

The Office of Innovation (OIN) at the Food and Agriculture Organization (FAO): assists member countries in understanding innovation to drive socio-economic growth, ensure food and nutrition security, alleviate poverty and improve resilience to climate change. It instigates debates and provides technology assessment reports to governments in key areas such as digital agriculture.

The Directorate for Science, Technology and Innovation of the Organisation for Economic Cooperation and Development (OECD): develops evidence-based policy advice on the contribution of science, technology and industry to well-being and economic growth. It provides assessment reports in a wide number of technologies including artificial intelligence, space technology, genomics, energy, etc.

The International Atomic Energy Agency (IAEA): includes the "review missions and advisory services" that deal with extensive assessment of technologies aiming at nuclear safety and security, as well as assessment of nuclear energy applications in the health sector.

The Nature Futures Framework (NFF) of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): within the overall organizational aim to assess the state of various biodiversity and ecosystem systems, the NFF performs visioning exercises with scientists, indigenous peoples, the private sector, civil society organizations and decision-makers, using participatory TA tools.

All of these UN and multilateral agencies employ, amongst others, TA methodologies to analyse new and emerging technologies and provide policy input. Their remit is diverse but it is basically that of a typical government think tank with partial focus on STI issues. The work of these agencies is not coordinated centrally as they are independent entities with their own boards of directors/trustees with no evident connection between agencies. This can lead to overlapping focus and competing views that are published and promoted independently of each other, even to the same target audience. Moreover, the identification and positioning of TA within the work programme of these agencies is a complex endeavour with uncertain results. The reason for this is that TA is not explicitly mentioned as a guiding research process, even though there is a clear affinity of conceptual and methodological aspects in their analyses of STI issues.

2.2 The Role of TA in the United Nations Conference on Trade and Development

A particular case in the UN system where TA is well entrenched as a guiding principle is that of the United Nations Conference on Trade and Development (UNCTAD). The reasons for this unique approach go back to the early history of UNCTAD, where the role of technology in economic development was identified as a crucial factor in its efforts to support developing countries to access the benefits of a globalized economy in a fairer and more effective manner.

As early as 1949, Raúl Prebisch, Executive Secretary of the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), and Secretary-General of UNCTAD from 1964 to 1969, analysed the unequal economic relations between Latin America and the industrialized Global North. Growing disparities in economic growth and well-being between the two hemispheres were traced back to different trade specializations, with Latin America being confined to the export of mostly unprocessed mineral resources and agricultural products, while the Global North traded industrial goods with increasingly higher knowledge content and technological sophistication. One consequence of this unequal trade was the changes of price relations in the exchanged goods that benefit the Global North to the disadvantage of the Global South. In addition, the gap in usage of technology was found to increase in times of unequal trade patterns, as innovations are often driven by the manufacturing sector in the search for higher levels of productivity.

In Latin America, ECLAC promoted industrialization mainly by means of import substitution as a key strategy for lowering the development gap between the North and the South, whereby formerly imported industrial items should be replaced by locally manufactured goods.[1] At UNCTAD, a similar reading of the main reasons for unequal international development pushed the struggle for fundamental changes in international trade relations under the concept of the "New International Economic Order (NIEO)". Improvements in international trade relations would require a narrowing of the technology gap, since the application of state-of-the-art technology is a prerequisite for manufacturing items which may fulfil the needs of customers, both in terms of quality and prices. As an essential element of a NIEO, technology transfer was promoted by UNCTAD and defined as "*the transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service and does not extend to the mere sale or lease of goods*" (UNCTAD, 1985, Chap. 1, para. 1.2.).

One of the criticisms of these relatively early concepts of technology transfer is that it was relatively static and one-dimensional, overlooking the relations between international measures of licencing, knowledge-sharing for manufacturing sectors, and the conditions of the potential recipient countries. A more recent document (UNCTAD, 2019) stressed the interrelations between successful technology transfer, the absorptive capacities in national or regional innovation systems, and local innovation as the outcome of technology transfer. Once STI systems have become effective, they may lead to a higher rate of innovation and at the same time improve capacities on the ground to absorb technological knowledge coming from outside. The same document (UNCTAD, 2019, 31–34) emphasizes that the role of technology is no longer confined to economic growth and social well-being, but is also pivotal in addressing global challenges, specifically climate change, global health and agriculture.

The UNCTAD debate on the role of technology and the STI system in development has brought TA to the forefront. Assessing technological developments in terms of their capabilities to enhance economic and social growth in the Global South is pivotal in both choosing the targets of technology transfer and also investing in regional growth initiatives. As such, TA has been promoted, alongside foresight,[2] as the preferred research process to analyse the implications of new technologies, expand the national debates and promote policy options. This is clearly stated as an aspiration for the UN in its efforts to achieve its development goals (UN Economic and Social Council Resolution, 2019):

[1] A huge body of literature discusses the only relative success of the policies for industrialisation by means of import substitutions. Notable exceptions are the Brazilian company Embrear, today one of the internationally leading airplane manufacturers, and the coal liquefaction cluster in South Africa.

[2] It should be noted that UNCTAD documents often use the terms TA and Foresight interchangeably. A recent project attempts to clarify the conceptual differences between TA and similar concepts for application in UNCTAD (See, https://unctad.org/meeting/launch-project-technology-assessment-energy-and-agricultural-sectors-africa-accelerate).

> To conduct technology assessment and foresight exercises as a process to encourage structured debate among all stakeholders towards creating a shared understanding of the implications of rapid technological change. (p. 6)
>
> To explore ways and means of conducting international technology assessments and foresight exercises on existing, new and emerging technologies and their implications for sustainable development and building resilient communities, including discussions about models of governance for new areas of scientific and technological development. (p. 9)

3 TA and Global Challenges

The role of TA in the development of resolutions to global challenges is still unclear as it is rarely directly referenced in the debates. This is not surprising since, as we have seen, TA is not often acknowledged within the global STI institutional setting. There is nevertheless evidence that TA has contributed to the analysis of global challenges in multiple ways. The examples of climate change and agriculture in developing countries are indicative of TA's contribution.

3.1 Climate Change

STI is seen as key to alleviating the impact and adapting to the consequences of climate change, which affects developing countries disproportionately. Although there is considerable debate on the role of technologies in dealing with climate change, these do not cover the economic and social context in which most developing countries function. Nevertheless, the climate goals of the Paris Agreement approved by the global community in 2015, such as improving energy access and social well-being without a direct increase in the carbon footprint of society, are also on the agenda of developing countries. All signature countries have committed to contain greenhouse gas emissions in order to keep global warming below 1.5 or 2 degrees above pre-industrial times, and they have expressed their commitments in National Determined Contributions (NDCs) to United Nations Framework Convention on Climate Change (UNFCCC). In this manner, innovations in the energy field can be seen as absolutely key to this process, ranging from carbon capture and storage, through large-scale renewable energies and green hydrogen production, to effective mini-grids fed by solar and/or wind energy, and improved cooking stoves to serve the energy needs of rural communities (see e.g. Chen, 2018). TA has a pivotal role to play in the development of innovative solutions and also in the overall improvement of the global debates. An example of the latter aim is the World Wide Views project that attempted a first general methodology to initiate a global stakeholder dialogue on climate change (see Textbox 1).

Textbox 1: Worldwide consultation—World Wide Views on Climate Change

The World Wide Views is a multisite citizen consultation methodology used for global citizen consultations. The core of the method is to have citizens at multiple sites debate the same policy-related questions on a given issue on the same day. The method was developed by the Danish Board of Technology and other partners in the World Wide Views Alliance, which was established for this purpose, prior to the climate COP15 in Copenhagen in 2009. The aim was to develop a method that would provide participating citizens with balanced information and give them the opportunity to discuss the issues at hand with other citizens and at the same time produce results which are easily communicated to policymakers.

World Wide Views projects have so far focused on the themes of Climate and Energy (10,000 participating citizens in 76 countries), Biodiversity (3000 participating citizens in 25 countries) and Global Warming (4000 participating citizens in 38 countries). The questions put to the citizens are identified through a comprehensive consultation of policymakers and stakeholders worldwide in order to address the most pertinent, debated and disputed policy issues in the policy process which is addressed. The information material is designed to present citizens with the pros and cons of voting one way or another on the questions at hand. The information material is reviewed by a scientific advisory board and both the questions and information material is reviewed by citizen focus groups in different parts of the world prior to being finalized. Citizens discuss (with the help of professional moderators) and vote on the questions posed to them. The results feed directly into policy debates, which so far have been at UN conferences for Parties to the Climate and Biodiversity Conventions.

Source: http://wwviews.org.

3.2 Agriculture

Another global challenge involving numerous and complex STI issues is that of agriculture. A functional agricultural sector is seen as a fundamental element for the economic transformation of developing countries, and particularly Least Developed Countries. In its Technology and Innovation Report 2010, UNCTAD asserted that improving agricultural performance in developing regions depends on technology and innovation and rising agricultural production. This topic is of special relevance for developing countries, as the primary sector is still fundamental both for local food security in the Global South, and to create opportunities for income generation through the export of increasingly higher-valued agricultural and agro-industrial goods. Technology- and innovation-related challenges arise from the fact that the opportunities and risks of agricultural innovations have to be analysed against the fact that many small farmers and labourers depend on agriculture for their livelihood. Technological progress in line with the UN Sustainable Development Goals (see next section) is thus incompatible with technologies which drive further concentration processes forward and/or lead to the loss of income opportunities for labourers, especially women.

This is an area that has already seen a lot of TA activity across the globe (e.g. see IIED, 2007). For instance, following standard participatory TA approaches, socio-economic considerations have been incorporated in the analysis of GMO development in India (see Textbox 2). This represents a strong indication that the need to undertake TA exercises with wide stakeholder consultation in STI developments has been accepted by the decision-making bodies of the country.

Textbox 2: New participatory methodologies—Socioeconomic (SE) Consideration of Living Modified Organisms in India

A country-wide consultation exercise on socioeconomic considerations of Living Modified Organisms (LMOs), funded by United Nations Environment Programme, Global Environment Facility, was run by the Research and Information Systems for Developing Countries (RIS) and overseen by the Ministry of Environment, Forestry and Climate Change (MoEF&CC), Government of India.

The aim of the project was to develop guidelines and methodologies for SE assessment for LMOs as envisaged under Article 26.1 of the Cartagena Protocol on Biosafety. It involved the creation of a steering committee with experts from the Indian Council for Agricultural Research, the Indian Council for Social Science Research and a number of state agricultural universities. The consultation exercise that employed survey and workshop methodologies involved small and medium farmers from across the country on a number of crop and trait examples.

Based on the analysis of the needs of farmers and the opinions of the expert community, the project developed a SE assessment methodology that was presented and adopted by the MoEF&CC. As a result, the moratorium on GM crops in India (active since 2010) continues. The guidelines and methodologies in decision-making on GMOs are discussed at the Ad Hoc Technical Expert Group (AHTEG) under the Cartagena Protocol on Biosafety and represents powerful empirical TA research toward the effort to find consensus on what factors/elements should be taken into account for Socio-Economic Considerations of LMOs.

Source: http://www.geacindia.gov.in/resource-documents/10-Resource_document_on_Socio_economic_considerations.pdf.

In another instance, the standard TA methodology of a Citizens' Jury has been successfully applied to agricultural GMO developments in a Low Middle Income Country (see Textbox 3). This is another example of how well-established TA methodologies from developed countries can be used in vastly different socio-economic contexts with equally fruitful results.

Textbox 3: Participatory assessment—Citizens' Jury on GMOs in Mali

A Citizens' Jury on Genetically Modified Organisms (GMOs) was organised by the government (the Regional Assembly) of Sikasso, sponsored by the Swiss Development Cooperation and the Netherlands Ministry of Foreign Affairs. A steering committee consisting of representatives of fifteen local, national and international institutions (government, civil society, research, farmer organisations, IIED…) was responsible for the design, organisation and facilitation of the deliberative process.

The Citizens' Jury was designed to allow ordinary farmers, both men and women, to make policy recommendations after considering expert evidence from different sources. Its main objective was to create a safe space for communication and action in which small-, medium- and large-scale farmers could better understand the risks and advantages of GMOs, confront different viewpoints in favor of and against GMOs and formulate recommendations for policies on GMOs and the future of farming in Mali.

The Citizens' Jury recommendation to delay the approval of national legislation needed for the introduction of GM crops and initiate a debate on the future of agriculture was acted upon by the Malian National Assembly. In addition, a film was made about the process and outcomes of this Citizens' Jury (Titled "Paroles de Paysans") and was shown on national television channels in African countries (Burkina Faso, Mali) to strengthen the work of international civil society networks.

Source https://pubs.iied.org/sites/default/files/pdfs/migrate/G02367.pdf.

Overall, it is clear that when it comes to global challenges, TA studies and standard TA methodologies can be used in many cultural and socio-economic contexts. The examples show that TA has already been applied successfully at both national and global levels. In all cases, there was little to no adaptation of the standard developed country approach, thus denoting the capacity of TA to transcend borders.

4 Technology Assessment and the Sustainable Development Goals

A particular case of interest for the potential function of TA at the global level is that of the Sustainable Development Goals (SDGs). The 2030 Agenda for Sustainable Development, adopted by the United Nations' General Assembly in 2015, provides the main description of the challenges that humanity is faced with. This is broken down into seventeen SDGs, representing the aspirations of the world to achieve a sustainable and peaceful future for everyone. Each SDG is divided further into a set of specific targets (169 in total) that deal with specific issues in terms of poverty alleviation, improvements of health and well-being, inequality reduction, tackling climate change, reversing environmental pollution, etc. Figure 1 provides an overview of the SDGs.

It is worth noting that the development of the SDGs has been based on a set of specific principles. These take into consideration that grand challenges are universal (affecting all countries), interlinked (cannot be solved in isolation) and socially inclusive (all citizens are involved). In a more detailed description, the guiding design principles are (United Nations, 2015):

Universality: The new agenda is applicable to all country typologies, not only to developing countries. The SDGs allow for the concept of nationally adapted and differentiated approaches for implementing what is seen as a common and collective responsibility.

Integrated approach: The new agenda denotes that it is clearly insufficient to achieve the SDGs on a goal-by-goal or target-by-target basis. The SDGs require an integrated approach that identifies sets of development interventions that can unleash progress across multiple goals and targets—across sectors—at the same time. While accountability will continue to reside in a particular sector, understanding how

Fig. 1 UN sustainable development goals (*Source* United Nations)

to promote an integrated approach and policy coherence in order to inform better planning through cross-sectoral collaboration is key to success.

Leaving no one behind: The 2030 Agenda strongly embodies the idea of no-one left behind, and this is expressed in various SDG goals and targets which aim at universal achievement (e.g. zero targets: eradicate extreme poverty, eradicate hunger; systematic use of disaggregated data; quality outcomes based approach; and normative frameworks). This will require countries to work to reach the last mile. Countries will need to re-evaluate their approaches, development interventions and costs associated with leaving no-one behind.

The SDGs are therefore aspirations that have been translated into specific goals. However, the means through which to achieve these goals are not described in adequate detail. SDG No. 9, "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation", is the only one that directly deals with STI, but most of the SDGs require STI developments to achieve their goals. TA has a role to play in any effort to use STI in achieving the SDGs. Considering the wide spectrum of possibilities for implementing TA processes in this area, one can draw preliminary ideas from similar disciplines and their relationships to the SDGs. For instance, the International Association for Impact Assessment (IAIA) has accepted that the SDGs can be used as a framework for the integration of diverse assessment disciplines. In its view, SDGs can be incorporated into impact assessment in various ways (IAIA, 2019; Partidario & Verheem, 2019), e.g.:

- Use the global SDG framework as an instrument to increase the relevance of impact assessment in national development policy, programme and project decisions.
- Seek harmonization of national impact assessment regulations with SDG-inspired development policies and practice, ensuring that relevant criteria are used in decision-making processes.
- Support the adoption or adaptation of impact assessment guidelines to incorporate SDG principles and concepts; develop sector-based impact assessment guidelines aligned with the SDGs; and generate well-documented case studies that highlight the links between impact assessment and the SDGs.
- Translate SDGs into criteria that are specific to a particular project or plan context; addressing the critical risks and limits of acceptable change in the potentially affected ecosystems and communities.
- Avoid being over-rigid or overly prescriptive: not all SDG targets are relevant for all contexts. Considering sustainable development issues in the local setting will simplify the impact assessment scope.

At the same time, the World Economic Forum (WEF) has acknowledged the need to use the innovation capabilities of the fourth industrial revolution to achieve sustainable industrial development in accordance with the SDGs. The WEF's White Paper on the sustainability of production systems within the fourth industrial revolution has identified a number of relevant technological developments that must be assessed in terms of the SDGs (WEF, 2018). Examples are given in the areas of automotives, electronics, food and beverages, and textiles and footwear. Each of these areas is reviewed in terms of sustainable innovation potential that can be measured against the SDGs.

These are also interesting possibilities for TA. The exact positioning of TA in the process of achieving the SDGs depends on accurate identification of those SDGs that provide a useful reference framework to judge the impact of technological developments, and also on the availability of evidence at the global level that allows for a meaningful assessment process (Ladikas et al., 2018).

5 Technology Assessment in Developing Countries

When attempting to apply TA processes in the context and realities of developing countries, one must consider carefully the challenges that such undertakings involve. Current TA methods are based on experiences gathered in industrialised countries that naturally present great contextual differences to developing countries (see also Srinivas and van Est, this volume). For instance, the national innovation systems or production systems of developing countries are often much weaker, while their economies are much less diversified and often dominated by sectors that are technology-poor. The Gross Expenditure on Research and Development (GERD), including both public and private R&D spending, shows major differences. For instance in 2018, High Income Countries (HICs) invested 2.59% of their GDP in GERD, Upper Middle Income Countries (UMICs), including China, 1.64%, while Lower Middle Income Countries (LMICs) and Least Developed Countries (LDCs) spent only about 0.53% and 0.17% of their GDPs, respectively (World Bank, 2021).

Other important indicators of the health of the national innovation system show similar great disparities (see Table 1). For instance, in terms of scientific publications LDCs have an astonishing 1/178 ratio to HICs. This is a very important indicator for TA since the amount and quality of the national scientific production are crucial for the quality of the assessment. Interesting here is that, as with many other STI indicators, China is by far the most productive MIC, which brings it into equal footing with HICs.

Further disparities between developed and developing countries show that the number of researchers in R&D per million population is 4116 in a HIC, but 737 in MICs, while there is no data available for LICs (World Development Indicators 2021). In addition, public funding for higher education that can produce future researchers is low and there is a constant “brain-drain” situation that depletes the limited numbers of researchers emerging from LICs. The situation is similar in terms of innovation, whereby research in the private sector is very limited, and most active industrial research entities are subsidiaries of larger foreign corporations.

A clear exception to the general low level of STI research capabilities in MICs and LICs is the multilateral research institutes, such as the International Rice Research Institute in the Philippines, the International Livestock Research Institute in Kenya and Ethiopia, or the International Potato Centre in Peru. Donor-funded research centres also offer exceptional research capabilities, for instance, the West African

Table 1 Scientific and technical journal articles 2018 by World Bank country group

Country group	Absolute number of publications	Publications per 1 Million people
Low income countries	5308	8
Middle income countries (MIC)	1,106,517	192
MIC w/o China	580,254	133
China	528,263	377
High income countries	1,450,446	1177

Source World Development Indicators online April 2021

Science Service Center on Climate Change and Adapted Land Use in Western Africa, the Southern African Science Service Centre for Climate Change and Adaptive Land Management for Southern Africa or the Fundación Hondureña de Investigación Agrícola in Honduras.

TA must therefore accommodate to the local context, and function according to local needs and capabilities (e.g. see UK Parliamentary Office of S&T, 2011). Lack of research capabilities in many countries signifies a lack of quality scientific data on which to base the required assessment, but also a potential lack of experts to participate in it. At the same time, stakeholder participation, as it is undertaken in current TA processes, assumes an active civil society and a culture of non-restricted public debate that might not be the case in many MICs or LICs. However, this might not be seen as a lack of democratic credentials in the country. There are many reasons for a diminished debate or active civil society that range from cultural norms to funding prerogatives (Wakeford & Pimbert, 2004). In any case, the limitations faced by TA due to the specific national context will definitely restrict its usual scope and functions, but this should not be seen as a prohibitive setting.

Another aspect that should be taken into consideration when attempting to adopt TA practices in the developing country context is the differences in technology adoption processes. STI-intense economies are also early adopters of STI developments, since they base much of their economic success in competitive advantages deriving from speedy assimilation of new technologies. Most developing countries are late adopters, as they lack the structures for early assessment. This is where TA can play an important role, by functioning as a "horizon scanning" process that can identify STI developments that offer particular opportunities in the less developed economy context. Such developments might be akin to what is termed "frugal innovation", whereby simple or low-tech innovations can be more attuned to the needs of developing countries and thus much easier to assimilate in the existing context (Lelivend & Pesa, 2020).

6 Discussion: Future Challenges for Technology Assessment at the Global Level

As described above, multilateral STI analysis and policy advice is required to deal with many global challenges that face humanity. There is a need to generate new knowledge on the benefits and risks of STI developments and provide new perspectives and institutional structures in global governance. TA as a concept of problem-oriented research and policy advice is ideally placed for this purpose and has recently drawn interest from international organisations such as OECD and the United Nations.[3]

Beyond the basic institutional arrangements to develop a global TA, there are many additional topics to be addressed, which could be structured around four main areas:

Agenda- and priority-setting: There is no clear definition of what should be seen as grand, global or societal challenges which would need a fast and responsible response from STI. As not all topics can be addressed simultaneously, mechanisms would have to be found to define global TA agendas and priorities. There might be different ways of agenda and priority setting, for instance, and they may be either problem- and goal-driven, or science-driven. The SDGs provide the set of objectives to which the international community has committed and where STI solutions have to contribute. Ground-breaking innovations offer both opportunities and risks, which would have to be assessed internationally, e.g. artificial intelligence, or CRISP-CAS9 techniques.

Funding and spending arrangements: Depending on the challenge to be addressed and the underlying scientific basis, responsible and effective TA can in some cases be based on meta-level analyses of existing scientific work (as in the case of the Intergovernmental Panel on Climate Change (IPCC)). However, this may be different when technology paths are relatively recent and the body of scientific literature is not exhaustive. Need may arise to conduct limited original research, which would raise questions regarding funding and spending arrangements to assure both effectiveness and equity.

Stakeholder involvement: Literature on TA indicates that good TA practices must involve different stakeholder groups, be participatory and interactive. The relevance and feasibility of this approach for multilateral processes should be assessed in more detail. For most current TA processes, parliaments are the clearly targeted addressee, as parliaments decide upon the legal framework under which technologies develop. However, there are other actors to be considered, which also decide about rules and regulations (governments and courts), and the social acceptance of technology paths (trades unions, civil society groups). How to effectively reach different stakeholder groups at a global level is still rather uncharted territory.

[3] See Resolution adopted by the UN Economic and Social Council on 24 July 2018 on "Science, technology and innovation for development": https://unctad.org/meetings/en/SessionalDocuments/e_res_2018_29_en.pdf.

7 Conclusions: A Model for Technology Assessment at Global Level

The TA community has discussed extensively the various modes of institutionalisation of TA (Liebert & Schmidt, 2010; Decker & Ladikas, 2004). These discussions have focussed on specific national contexts whereby TA has been developed in the past forty years, mainly in western European countries (Hennen & Ladikas, 2019). Recently, there has been considerable interest in how TA could be institutionalised at a multilateral or global level (Hahn & Ladikas, 2019) and from the four models discussed in the conclusions of this volume two fit well within the global STI governance reality:

Institutional Networks across borders

To stimulate the internationalization of TA, existing national TA institutes may collaborate across national borders on various TA-related topics. This so-called Institutional Network option aims to establish an expert-and-participatory TA capability by connecting an appropriate set of independent, non-partisan and non-profit organizations in an international network. Examples of existing networks are EPTA and the globalTA network. Cooperation between institutes may vary from bilateral cooperation to cooperation on a global scale, like for example in the World Wide Views on Global Warming (WWViews) project.

Global TA linked to a global Decision-Making Body

National parliamentary TA organizations are often linked to a decision-making body, such as the parliament. This Decision-Making Body option can also be implemented on the global level, in particular with regard to UN institutes. In the field of global warming, the Intergovernmental Panel on Climate Change (IPCC) is an example of this model.

Both models are viable possibilities for a TA linked to international governance structures. We have seen that TA-linked activities are evident in a number of bilateral organisational settings, so long as they focus on STI issues. And this is perhaps the pivotal aspect of any form of TA that transcends national boundaries. Analysis of STI issues for the development of policy advice can hardly be done without some form of TA methodology, whether of the classical expert types or the more recent interactive ones. Nevertheless, one should risk a prediction of an ideal organisational structure for TA, if it is to function at a purely global level and applied to global challenges. As the Decision-Making body model suggests, this could be similar to the existing IPCC structure (see also Ashworth and Clarke this volume).

The IPCC is an excellent example of global science for policy advice, with some observers considering it "the largest exercise in scientific cooperation ever embarked upon" (Pearce et al., 2018, 127). It has worked as an institutional role model which helped form the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in 2012 (Beck et al., 2014). Researchers and observers have proposed an institutional setting for several other environmental challenges, e.g.

food, water and anti-microbial resistance. There are four largely undisputed elements of success in the IPCC model of scientific policy advice (Pearce et al., 2018):

- Most of the work is done by a huge number of volunteer scientists from different parts of the world whose work is synthesized in reports of the three Working Groups (WGs): physical science (WG1), social and ecological impacts and adaptation (WG2), mitigation options (WG3).
- The IPCC has pioneered new ways of assessing scientific knowledge across a broad range of disciplines and interconnected topics.
- The findings of both its report outlines and final content are approved by government representatives, giving them high political authority.
- The high visibility of the work of the IPCC has contributed to keeping climate change on the international policy agenda over several decades.

The specific governance of the IPCC is the outcome of institutional co-evolution of the international climate policy regime and the scientific advisory sub-system. In 1986, the Advisory Group on Greenhouse Gases was set up by the World Meteorological Organization (WMO), the Environmental Program of the United Nations (UNEP) and the International Council of Scientific Unions. It soon became clear that this group was too small and underfunded to fulfil a meaningful purpose. Following complex negotiations between WMO and the US Government, the road was paved for the creation of the IPCC, which materialized in 1988, under the auspices of WMO and UNEP. Shortly thereafter, in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted by UN member countries. Between 1990 and 2022, the IPCC has published six Assessment Reports and a number of reports on specific topics.

Considering the relevance of the IPCC experience to a global TA exercise, some debates around the IPCC governance model seem of special relevance:

- How to prioritize questions around new and emerging technologies in a global science exercise? Critical debates have formed around the focus of the IPCC on precise climate change modelling, mitigation actions and the related risk that adaptation to already manifest climate change would not receive the necessary attention.

  This question is the essence of TA, and its main function as a means to assess the impact of specific technology developments in society, economy and the environment. As we have seen, global challenges require new STI approaches that can be applied equally well in different geographical, cultural and economic contexts. TA has been performing such comparative studies at multilateral level for a number of years and can effectively upgrade its methodologies to a global level of analysis (see the example of World Wide Views above, and Ladikas et al., 2015).
- How to assure a good mix of disciplines? As the initial focus of IPCC was very much on modelling future climate change, physical and other natural sciences were long seen as being over-represented at the expense of social sciences beyond economics.

TA is a multidisciplinary approach that has successfully integrated social science, natural science and engineering methodologies under its remit. A standard TA analysis will use knowledge created by any relevant discipline on the issue under consideration, and the final analysis will be based on multidisciplinary analysis. This is also evident in the expectation that final reports and policy options development are co-authored by representatives of all disciplines involved in the analysis (Hennen et al., 2004).

- How to assure an adequate representation of different world regions? Corbera et al. (2016) found that around 80% of authors and reviewers of successive assessment reports produced by the IPCC were from OECD countries. This leads to different priorities and assessments, such as framing Southern forests as "empty" spaces available to suck up the Global North's carbon pollution (Pearce et al., 2018, 126).

  As we have discussed above, TA is mainly active in western, developed countries, with a clear presence in every STI-intensive economy. It has nevertheless been applied successfully in a variety of developing country settings and has shown full capability to incorporate low income and low STI intensity contexts in its methodologies. This is particularly true for the interactive modes of TA, whereby wide stakeholder consultation is a prerequisite for the analysis and development of technology roadmaps (Ely et al., 2011).
- How inclusive or restrictive should assessments be conceptualized? For example, large-scale reforestation and bioenergy with carbon capture and storage (BECCS) can be assessed as a feasible climate change mitigation option via negative emissions, but all feasible trade-offs cannot realistically be assessed in the same report.

  TA offers an established process to research and identify the scope of the prospective exercises and determine which technologies are sufficiently relevant to be put on the agenda and assigned high priority. The exact delimination of what should be the object of the TA process will be based on the analysis of social, economic or environmental challenges to which the technological solutions should respond, either as a stand-alone solution or as an element of a comprehensive package of policy measures (Buetschi et al., 2004).
- How to balance global vs local: "between scientific knowledge that speaks of abstract global systems to a global audience, and knowledge that pertains more closely to local settings where the drivers and impacts of global change are more directly experienced" (Pearce et al., 2018, 128).

This is also an issue that TA has been dealing with in depth. Balancing out the needs of regional development as part of national-level development is a common focus of TA exercises, while more often than not, this upgrades to international (e.g. European) versus regional balancing. As such, TA has identified the need to translate scientific knowledge to lay language and has developed methodologies that aim at converting abstract theories to applicable technologies at local level (Hennen, 2002).

Overall, TA can make significant contributions to the international STI governance system. These contributions can take many forms, ranging from the establishment of a TA-like structure such as the IPCC (see also Ashworth and Clarke, this volume), or as part of the existing UN system, like UNCTAD. The future form will depend on many external factors, prominent amongst them being the political will to create such a global policy advisory institution. We have shown that TA has the experience and the tools to work effectively at a global level, which is evident in the existing TA activities that are undertaken, unwittingly or not, in many multilateral organisations. The TA community should respond to the tasks that global challenges are bringing, and the needs of the global community to promote common STI approaches to deal with them.

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Challenges for Global TA

Globalisation as Reflexive Modernisation—Implications for S&T Governance

Leonhard Hennen and Rinie van Est

1 Introduction

"Globalisation" refers to a process of growing interconnectedness of economies and affects trade relations, production chains and labour markets. However, globalisation is about more than economics. It includes significant socio-cultural changes, which induce as many challenges to policymaking and governance as the "global economy". These changes are technologically fostered by increasing options for real-time exchange of data, news, money, chats, advertisements and videos about all kind of subjects, from everyday problems and individual preferences regarding fashion, to problems of international justice and socio-economic inequality or the global condition of our environment. The changes connected with these developments have repercussions on every citizen of the world. The effects will be different for each individual; some effects will be welcome, others may cause conflicts, social upheaval or crises, sometimes of a global nature such as global warming or the COVID-19 pandemic, each of which has specific local and personal consequences. Thus, globalisation changes our life world and through this our reference system for individual and political decision-making.

It is the purpose of this chapter to provide a frame for more specific contributions provided in this volume on governance issues in science and technology (S&T), and in particular the role of Technology Assessment (TA), by giving an overview

Contribution to: Technology Assessment in a Globalised World—Facing the Challenges of Transnational Technology Governance.

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of developments in society, economy and culture that are related to the concept of "globalisation". Thus, by clarifying the meaning of globalisation, the needs, opportunities and challenges for developing global strategies, procedures and institutions of TA will be set against a general background of global interconnectedness and change. Technology plays an irrevocable role in this. "The pace of globalisation and that of technological change have in fact been strictly interrelated and, from a long-term perspective, it appears less important to establish which one should be considered responsible for triggering the other rather than to establish that they mutually enforced each other." (Archibugi & Iammarino, 2002) S&T are thus drivers as well as mediators and facilitators of globalisation. At the same time, they are a source of global problems and challenges as well as options to address these. In both respects, S&T are at the centre of global societal and political debates about the needs and opportunities for global governance and world politics. We will touch on the role of S&T when going through the history of globalisation and expanding on the main features and problems of our current global situation.

By a tour of the central issues touched upon in the discourse on globalisation, we hope to clarify the broad scope of questions and problems that challenge the necessary global attempts to govern the process of globalisation. Approaches to and concepts of science-based advice to policymaking such as TA are part and parcel of governance on the national level (Hennen & Ladikas, 2019; STOA, 2012; van Est, 2019). We argue that it is necessary for this policy intelligence practice to transfer its methods and institutional setting to a global level. This is a challenge in itself, and what kind of solutions will be found remains open. The main task is to support the reflexivity of global governance, its ability to learn and critically reflect on currently established routines, as well as to take into account uncertainties of knowledge, and ambiguities when taking action.

In the case of ambiguities, it is necessary to include a broad scope of differing and sometimes conflicting values in the process of identifying problems as well as viable and effective policies. The values to be taken into account imply a broad scope of accounts of what has and can be done, and a broad scope of visions of what the meaning and future of a "common good" at a global level might be. TA at a national level works in an inclusive mode, by trying to provide for participation of all relevant voices in deliberation on policymaking. To do this, TA needs to rely on and address itself to an attentive public and an active civil society as central parts of its "habitat" (Hennen & Nierling, 2015), which at best is in the making on a global level. Each contribution to this volume discusses different aspects of the challenge for S&T governance set by globalisation. This essay aims to make clear that the latest stage of what has been called "reflexive modernisation", which we understand as globalisation, needs "reflexivity" in answers to its challenges.

The paper starts with a brief discussion of the long history of globalisation in order to clarify what is characteristic of our current stage of globality. It then outlines some central features of what globalisation currently comprises and sketches globalisation as reflexive modernisation. Next, we present the ambiguities—in terms of goods and bads—of globalisation and the associated challenges of a "cosmopolitan" perspective on governance. We do this through a discussion of three fields or dimensions of globalisation. The final section discusses the relevance and implications of these trends for global governance and the role of scientific policy advice.

2 Globalisation—A Modern Phenomenon with a History

Globalisation encompasses a complex set of societal dimensions and thus is subject also to scholarly debates on its sources, drivers and features, as well as its meaning for and bearing on the future of culture and politics. Such controversies include debates on whether what we experience as globalisation is altogether new. Without being able to enter deep into this discussion, we briefly outline the history of globalisation since this will aid understanding of what it means to be “globalised” nowadays.

Pre-modern globalisation

Some hold that globalisation can be dated to antique times since in these pre-modern periods we can also find many examples of cross-border exchange or mutual influence in cultural, economic and political terms. Pre-modern Egyptian, Persian, Indian, Mongolian, Chinese and Roman empires connected great and culturally diverse territories or regions under one power regime, implying intensified economic and cultural exchange (Abu-Lughod, 1989). The development and global expansion of world religions (Christianity, Buddhism, Confucianism, Islam) can be regarded as a unification of world views and moralities held in different regions of the world. Some authors regard certain common features—such as individual ethical self-reflection—as a possible fundament of cosmopolitanism and moral mutual understanding (see the debate about the “axial age”, for an overview Bellah & Joas, 2012). Many of the fundaments of Western modernity are based in cultural achievements from other parts of the world and have been adopted in Europe as an effect of pre-modern interchange: “Coins, paper money and complex bureaucracy were legacies from China. Monetary policy and commercial credit came from Chinese and Arab mini-globalizations. The Arabic numeral system allowed double-entry bookkeeping, essential in accounting, while maritime regulation came from the East. These developments are central to systems such as capitalism and bureaucracy that define modernity and modern globalization.” (Martell, 2017, 61) Thus, modern globalisation owes a lot to pre-modern cross-border and cross-cultural exchange, although it goes far beyond historic phases in terms of its scope and the intensity of interconnectedness.

Capitalist globalisation

In addition, the modern state of globalisation is based in fundamentally new material and cultural fundaments of modern societies—such as rationalisation of world views and modes of social integration, democratic and authoritarian modes of government, individualism, as well as the market economy, industrialisation and capitalist modes of production. The global spread and relevance of these features are connected with the European-driven colonialist expansion of circles of political and economic activities beyond regional boundaries since the fifteenth century. It presents a history of military violence and occupation, of political, economic, cultural and religious domination and of human exploitation, including slavery. This repressive and Eurocentric process led to the fostering of a modern view of humanity and a universalistic mode of morality. The ideas of universal human rights and individual freedom, as reflected in moral and philosophical thinking of the European enlightenment (*Rousseau, Kant, Locke*), are closely linked to perception and awareness of the multitude of cultures and ways of life that was made possible by the connection of remote areas of the globe driven by European political and economic interests and legitimised by ideologies of European supremacy (see, e.g. Powell, 2014).[1]

Following Wallerstein's (1980) account of the "world system", globalisation is an effect of capitalism, since striving for capital valorisation has an impetus in itself to expand the scope of markets and investment opportunities. Thus, today's global system largely dates back to the sixteenth century when European capitalist actors started to expand their reach to the Americas and Asia. These transatlantic and Pacific explorations were enabled by significant progress in navigation technologies. The next globalisation wave in the nineteenth century was also driven by economic motives and supported by new technological developments. The intensified inter-European and transcontinental interchanges in the area of "industrialisation" were driven by new mass production technologies. New transport technologies such as railways, steam ships and later aeroplanes also improved the means, reach and speed of interchange. This wave of globalisation, which was closely linked to the struggle between the colonial ambitions of Western countries, also introduced new conflicts in social relations and politics, as was reflected in the Communist Manifesto of Karl Marx and Friedrich Engels in 1848 (Marx & Engels 1998). Their analysis is not too far from descriptions of the dynamics of globalisation which we face nowadays (Katz, 2001). The Communist Manifesto describes the liberation of economic and cultural activities from local embedding and the resulting "interdependencies". Domination and exploitation came about at the same time with opening up from local or national "seclusion" and "self-sufficiency".

The second half of the nineteenth century was a period of unprecedented economic interchange and interdependence. The First World War destroyed the level of formation of a world economy, and it took until the 1970s to reach the same level (Strikwerda, 2016). With World War I, the area of economic interchange experienced a national backlash but nevertheless and ironically provided the start for a new "world system" (Wallerstein), but with the United States rather than Europe at the centre. It is possible to speak of globalisation since World War I in terms of geopolitical thinking and attempts to establish global institutions of governance. As *Eric Hobsbawm* put it, the world, the globe, instead of nation states and national economies is the "primary functional unit" to refer to economically and politically (Hobsbawm, 1998, 30).

[1] A comparable "de-nationalisation" of world views had been observed in the late Roman empire, with the dominant philosophical-religious school of the Stoa establishing "humanity" (enclosing the whole "oikumene"—the then known inhabited world) as the reference for moral reflection.

With the end of the Soviet empire in 1991 and the end of the Cold War, the bipolarized geopolitical shape of the world dissolved and Western Liberalism with its democracy and market economy appeared to be the only alternative (which made some observers speak—prematurely—of the "end of history", Fukuyama, 1992). The apparent "victory" of the Western system together with options provided by digital technologies gave rise to the notion of a globalised world in terms of socio-political order, as well as socio-cultural closing of ranks ("the global village", McLuhan, 1962). At the same time, people became aware of global problems, such as global economic crisis and climate change. It was these developments that made the term "globalisation" a salient subject of political and scholarly debate in the 1980s and 1990s (Martell, 2017, Introduction).

Although colonialism no longer exists (in its historic manner of political expansion), and power relations have shifted significantly since the nineteenth century, economic interests and the capitalist economy still foster global interdependencies and establish new centres and peripheries in terms of economic power and benefits. Globalisation can be regarded as a project driven by economic motives and to a great part facilitated by technological progress.

This is not an exhaustive characterisation of today's global state of affairs and of the variety of political, cultural and economic aspects that have been the subject of scholarly debate on the push of globalisation since the 1980s. Those discussions are busy reflecting on the new aspects and features that discern the recent wave of expanded global interchange and interdependence from historic phases of globalisation. Whilst we cannot go into the details of these controversial debates here, it is necessary to develop some systematic understanding of what "Globalisation" means or encompasses in order to better understand the need for and the options of global technology governance and the role of TA.

3 Modern Globalisation and Reflexive Modernisation

What is "modern" about "modern globalisation"? In this section, we consider the question of what, behind all the different features related to globalisation, can be regarded as the core characteristics of our current state of global interconnectedness.

Current transnational interrelations show more expanded global outreach than historical modes of transnational interconnectedness. Changes in production and trade as well as politics or culture in one part of the world may have repercussions beyond local, national or regional spheres. This implies interdependency of national economies and politics, including in terms of the unintended side-effects of activities such as global environmental problems or global risks (see Sect. 4.3). What is also apparent is the speed and intensity of the exchange of knowledge and data. Global communication today means real-time communication, ranging from huge financial transactions to being connected live with all kinds of political or cultural events in all parts of the world, and the possibility of posting your own thoughts and beliefs about the latter to the "world" via social media. Ideas developed in one part of the globe can easily travel to any other part. The distinction between local and domestic experiences and the global arena is losing relevance, and the impacts that the local might have on the distanced and vice versa are magnified, and its effects are accelerated.

Thus, the core of modern globalisation might be caught by the term "supra territorialism" (Scholte, 2005), which means that territory no longer makes a distinctive difference, and social activities are not defined or bound by territories, due to the shrinking of time and space based on technologies of exchange. Proximate local issues and problems are caused by distant decisions or developments, and call for a non-parochial perspective to address them. The relevance of local connections remains, but people's working relations, their private social networks, their welfare and ultimately also their identities are no longer mostly defined by their local or national environments, structures and institutions, but are dependent on—and partly an effect of—global interconnectedness and interdependencies. This means that everyday life is increasingly determined by structures set up by transnational corporations and policies, and problems of global relevance (such as climate change), as well as by lifestyles whose element and forms are defined and shared globally.

Contemporary globalisation is thus accompanied by a *consciousness of globalisation* that manifests itself both in the global discourse as well as in everyday experiences, apprehension and expressions of globalisation in all layers of society. We are not only objectively globalised, but we are also becoming increasingly aware that local or national boundaries neither restrict our activities nor protect us to the extent they might have in former times. Because of the increasing interdependence and consciousness of the global whole (see, e.g. Robertson, 1992), globalisation has become a "new symbolic experience" (Martell, 2017, 53) embedded in our identities and the ways we understand the world and our future (for the good or the bad), and thus is referred to in almost every discourse on politics, culture and economy.

From a sociological perspective, all this is not in the first line based on some independent dynamics of trans-local interchange but are fundamentally features related to modernity. For *Anthony Giddens,* who provided one of the first influential sociological accounts of globalisation (Giddens, 1990), globalisation is a feature of the general process of modernisation (and vice versa), which is characterised by "dis-embedding" social relations, and reflexivity of social institutions. Social activities are increasingly dependent on remote activities, provisions and institutions—not as a result of globalisation as such—but as a result of different dimensions of the process of modernisation, i.e. rationalisation, scientification, devaluation of traditional knowledge, trans-local division of labour, capitalist market economies and monetarisation. Thus, the reorganisation of the social dimension of space and time which appear to be an effect or the essence of globalisation is basically a feature of modernity. When regarding socialisation (the forces of integrating and constituting societies) at its core as a problem of organisation of time and space, it is apparent that "… in the modern era, the level of time space distanciation is much higher than in any previous period, and the relations between local and distant social forms and events become correspondingly 'stretched'." (Giddens, 1990: 64). What the previous section described as a feature of globalisation—the "dis-embedding" of the local and its dependency on widely dispersed structures in time- and space—is for Giddens an aspect of "reflexive modernisation".

Contemporary globalisation is the latest consequence of this process. It is characterised by "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" (Giddens, 1990, 64). This implies economic dependencies, but might simultaneously bring about contradictory cultural shifts. Giddens believes that a global "stretch" of social relations might loosen the mental bounds to socio-cultural and political dimensions of the nation state and at the same time "be causally involved with the intensifying of more localised national sentiments" (ibid., 65). Modernity is not only a structural process but also affects individual and social identities which become "a reflexive project" (ibid., 124) in the sense that they are no longer pre-stabilised by local traditions and commitments, but have to be constructed individually, and become a subject of "life politics" (Giddens, 1991). This might lead to cosmopolitan attitudes as well as to a reaffirmation and demarcation of group identities, the conflictive effects of which we nowadays see in fundamentalism, nationalism and identity politics.

Giddens discerns four dimensions of globalisation: the nation state system, the world capitalist economy, the world military order and international division of labour (Giddens, 1990, 70f.). The division of labour dimension refers to industrialisation—transformation of nature, development of a created environment (ibid.: 59)—and includes a focus on production technologies and the environmentally negative consequences. In this volume and in TA, we are concerned with S&T in general and its socio-cultural meanings. Cultural globalisation is driven by communication technologies (from letterpress to modern communication technologies), which, according to Giddens, are the driving forces behind central features of modernity such as social expansion, loss of traditions and local perspectives, rationalisation and reflexivity.

At this point, we arrive at what the terms "reflexive" or "second" modernity, as applied by *Giddens*, *Ulrich Beck* and others (see Beck et al., 1994) actually mean: the confrontation of (first) modernity with its "non-intended" consequences and side-effects, as well as the process of applying reflexivity and critical scrutiny—the heritage of enlightenment—to the fundaments of modernity itself. This includes the promise of scientific rationalisation (and its material outcome: modern technology) as a guarantee for increasing social wealth and security. The success of modernisation in bringing about relative wealth for a greater part of society and increasing the reach and effectiveness of human intervention in nature unavoidably brings negative side-effects and systematically comes with risks and new uncertainties which lead to new conflicts and legitimisation problems for governments and experts. Modern forms of technology governance and problem-oriented research like TA can be regarded as an answer to these problems. The idea, mission and practice of TA can be understood as emanating from reflexive modernisation (Delvenne et al., 2011; Hennen, 1999, Grunwald, t.b.p). Although it is quite obvious that globalisation, with its achievements and problems, is part of or an enactment and consequence of modernity, it must be seen also as underlying the problems of "reflexive modernisation", which explains much of its ambivalent character. We will touch on examples of these issues in the next section.

4 Three Dimensions of Modern Globalisation: Culture, Economy and Risks

The debate on globalisation is not just a debate about its sources or about the level of interconnectedness and interdependency; it is essentially a debate about what globalisation has brought about or will bring about in the future. A positive normative connotation of globalisation as a vision of cosmopolitanism, global exchange across world views, global joint problem-solving and global democracy might be widespread, but this vision is not uncontested, and those in favour of it are also aware of the problems that globalisation brings and the challenges ahead in this cosmopolitan vision of globalisation. The debate on globalisation is not only concerned with and driven by the question of how globalisation proceeds, but always also evolves around the question of whether it is for good or for bad.

4.1 Cultural Globalisation

As well as capturing the often contradictory and diverse developments that can be regarded as features or effects of globalisation, one of the central problems is the question of "global culture".[2] Are we on the way to cultural homogeneity, to a global culture, i.e. a worldwide alignment of ways of life, world views and normative orientations? Opinions are strongly divided and range from bold statements on the increasing homogeneity of culture across the globe to a diversification or even a "clash of cultures" (Huntington, 1996). In the latter notion, globalisation is regarded as the cause of conflicts and terrorist activities of cultural fundamentalism. This clash can also be observed from a different angle when national governments perceive criticism based on Western notions of human rights and democracy as illegitimate interventions in their internal affairs and cultural traditions. It is not our intention here to give a consistent analysis of the debate on global culture; the point we want to make is that technology matters.

Since the 1960s, electronic mass media (namely TV) and the economic Western hegemony in the production of media content have enabled the diffusion of (mainly) the American way of life and norms and values around the globe, by means of movies, TV soaps and advertisements, but also political news broadcasts. This has led to the notion of the homogenisation of cultures: globally, people are watching the same TV shows and formats, play the same video games and consume the same products. This

[2] The following paragraphs owe much to Martell (2017) where a more detailed analysis of the complexity of cultural globalisation is available.

has often included the notion that Western culture is about to erode local or regional cultures and that authentic cultural identities are substituted by an "impoverished" global consumption culture. So cultural imperialism and commercialisation are often seen as the drivers of homogeneity (see, e.g. Bourdieu, 2003).

However, salient phenomena referred to as "glocalisation" can also be observed. There are means to adopt formats as well as content to local or regional traditions, needs and values. And some of the changes in global culture obviously travel the other way—i.e. cultural production of Asia and Africa (lifestyle, music, movies, as well as world views, philosophies, religion) are adopted in Western countries. These phenomena lead to the notion of a "hybridisation" (e.g. Nederveen Pieterse, 2004) of global culture. Due to the intensified and extended exchanges made possible via new media as well as by international tourism and massive migration, we arrive at a global culture which is a mix of inputs from all parts of the world. "Global cities" such as London, New York or Hong Kong are regarded as knots of globalisation, where cultures are mixed and identities are manifold (Sassen, 2001). The same process may, however, also imply a loss of ability for local communities to keep their identities or produce meaning for their members whose identity is shaped more by foreign influences than by local experiences (Bauman, 1998; Beck, 2017). The Internet allows for a diversification of the cultural content produced and dispersed. Thus, there is an abundant space to express cultural identities and political views which are opposite to dominant political cultures and interests. The migration from Asia and Africa to Western countries (often from formerly colonised territories) leads to introducing new cultural elements into Western nations that may be either acknowledged as "multi-culturalism" or opposed by xenophobic right-wing populist groups. So, it is not clear whether hybridisation of culture is leading to an increasingly shared global culture or to a (peaceful or conflictive) coexistence of hybrid cultures and ways of life.

As discussed above, communication technologies, migration and global travel currently create global interconnectedness on the symbolic level. Economic calculus and commercialisation are important drivers which shape the content and values that make up the cultural exchange. At the same time however, this interconnectedness allows for a diversity of cultural expressions to come into dialogue with one other in a way not previously possible. This involves options for creativity and enrichment of cultural experience and also presents a source of conflict about identities. The central question is to what extent our economic interdependence, as well as the ways in which we are affected by global problems, is accompanied by developing a cosmopolitan perspective, or at least a widespread feeling of global citizenship. And further, to what extent can global digital exchange contribute to a sense of global citizenship, or in contrast lead to strengthening group identities that experience themselves as exclusive and superior to others? The political implications of cultural globalisation are pivotal to this.

4.2 Economic Globalisation

History shows that specialisation and rationalisation of production, including national and later international division of labour and the search for new markets and profitable trade relations, have been central driving forces for global interchange. This process has always been facilitated by technical and social innovations opening up new options and allowing the expansion of the exchange of goods and of resources all over the globe. In the 1990s, this culminated in technical options for real-time exchange and dislocation of finance. Technical innovations, like the Internet, have facilitated salient features of globalisation such as migration (of labour and tourism), the availability of information and news from all parts of the globe to everybody, globally integrated production chains, and global markets, as well as the socio-cultural modes of globalisation. According to McKinsey (2019, 72), cross-border data flows have grown 148 times larger from 2005 to 2017 (measured by used cross-border bandwidth: from 5 terabits in 2005 to 704 terabits in 2017). Innovation is the driver of the global integration of production and trade, in terms of facilitating global transactions. Innovation also fuels the production and exchange of commodities. At the same time, economic rationalities and increasing international competition are driving the innovation system through internationalisation of technology development and knowledge exchange. The big players of the digital economy are multinational tech companies using integrated production and supply chains all over the world.

Since the 1980s, the global exchange of goods and services has been growing significantly, and the production chains have become more and more complex. In 2019, the global trade value of goods exported throughout the world amounted to approximately 19 trillion U.S. dollars at current prices, compared to around 6.45 trillion U.S. dollars in 2000 (www.statistica.com, 26-07-21). Foreign direct investments have been growing massively from 1990 (239.4 billion $) to 2007 (3.134 trillion $) (data.worldbank.org/27.07.21). The financial crisis of 2007 brought about a slowdown of economic globalisation. Foreign direct investments went down to 1.744 trillion $ in 2019. But still, world trade has been growing significantly, although not faster than industrial production (Felbermayer & Görg, 2020, 264). Most significant for globalisation is the relevance of knowledge-intensive goods and services. Although globalisation is often identified with the global exchange of labour-intensive goods, with China as the current largest producer, value chains in this sector represent only 3% of global gross output and employ only 3% of the global workforce. Value chains of knowledge-intensive goods production (automobile, computers, machinery) account for 13% of gross output and even 35% of trade (McKinsey, 2019, 2).

The interconnectedness of the world economy brings about not only an increase in international trade and production, but also new insecurities and vulnerabilities. As shown by the financial crisis of 2007/2008, the international mobility of finance—driven by the real-time exchange of money and investments made possible by the Internet—induces repercussions on the world economy from local or regional events (like the breakdown of the American real estate market). The central question that sparks fierce political and scientific debate is: who benefits from economic globalisation? This question is closely related to the effects of neoliberal politics as well as to changes in international power relations.

The push of the globalisation of economic exchange in the decades after World War II (which took over from the phase of European colonialism in the nineteenth century) was clearly dominated by the US and its Western partners, who in the 1980s shifted to neoliberal politics demanding the abandonment of market regulations and protectionist barriers (see, e.g. Crouch, 2018). The effects of this policy pushed advanced economies significantly, but also led to pressure on the Western welfare system, inducing new inequalities within Western economies. This pressure increased with the entry of China into the global market, which together with the countries of the former Soviet Union had formerly been excluded from globalisation. Low-wage production was shifted to China and other Asian countries, and Western economies had to foster economic activities in high-wage production and service activities, with problems for the low-wages sector of their home labour markets. This was connected with an increasing tendency of parts of the population to apprehend "globalisation" as a menace to their economic situation. This has contributed to strong nationalist and (in connection with global migration of workforces and refugees) xenophobic tendencies, indicating a countertendency towards cultural globalisation (see above).

With regard to international relations, Asian countries whose economies had been pushed by global economic exchange—especially China—could increase their international weight drastically, thus ending the phase of Western (US) domination. For people in emerging economies, the globalisation push of the 1990s has come with stronger participation in world trade and a higher level of welfare for a growing sector of the population, especially in China. Since 1990, a billion people outside the advanced economies have emerged from poverty, which for critics of current international politics like Crouch (2018) is a reason to dismiss any attempt to return to national protectionist policies. Compared to 1995, in 2017 developing countries' (excluding China) share in the world market as regions receiving goods and services increased from 20 to 29%, with China's share increasing from 3 to 12%. In terms of production, the share of non-Western countries in the global economy has also been increased (although mostly for developing countries in low-wage value chains). China's share in global output grew from 6% in 2000 to 33% in 2017 (McKinsey, 2019, 64). In China today, only 1.9% of the population live in poverty. However, as in other new economies, economic development is unequally distributed within the country: the inequality of the distribution of wealth in China nowadays is (according to the Gini coefficient) greater than in the US (Crouch, 2018 24).

The pressure of neoliberal politics—executed for a long period by the International Monetary Fund (IMF) and World Bank—on developing countries to open their markets for international trade often worked out negatively for emerging economies because they could not compete with stronger economies. Thus, while South-East Asia was able to benefit from globalisation, most African countries could not. And moreover, less advanced economies are more vulnerable than advanced economies to critical developments of the world economy. For example, the reduction of foreign direct investments (see above) during the recent COVID-19 pandemic years hits transition economies much harder than advanced ones (UNCTAD, 2021). The opportunities for emerging economies to actively participate in global markets (not only as a provider of raw materials or as an extended cheap work bench for advanced economies) strongly depend on access to technologies. To achieve this, support is required in assessing options to adopt new technologies in an environmentally and socially sound way to limit negative repercussions for societies—meaning that concepts like Technology Assessment would have a role to play (Ely et al., 2014).

Despite the positive effects of globalisation for many people in emerging and transition economies, it is still the case that the countries which benefit most from globalisation are the advanced OECD economies (paradoxically often those with the biggest problems with national-populist reactions among their populations). The UN World Social Report "Inequality in a changing world" (2020) states (taken from the report's summary):

- Although the income inequality between countries did improve during the last 25 years (mainly due to strong growth in China and other emerging economies), the gap between countries is still considerable. Average income of people in North America is 16 times higher than of people in Sub-Saharan Africa.
- Income inequality between countries has improved but inequality within countries has grown. Today, 71% of the world's population live in countries where inequality has grown.
- Income and wealth are increasingly concentrated at the top. In 2018, the 26 richest people held as much wealth as half of the population (the 3.8 billion poorest people), down from 43 people the year before.
- Although gender inequalities have been shrinking for some woman in certain occupations, at the same time women and girls put in 12.5 billion hours of unpaid care work each day, a contribution to the world economy 3 times the size of the global tech industry.
- If climate change continues to be unaddressed, it will increase inequality within and between countries.
- With a global trend towards urbanisation, cities will find "high levels of wealth and modern infrastructure coexist with pockets of severe deprivation often side by side".

4.3 Globalisation of Risks

The relation between science, technology and society and the question of bringing the ever-accelerating pace of technology development and use into relation with the needs and values held by different groups in society has been at the centre of political and scientific discourse for many decades. The debate about how to come to terms with often negative effects of technology on society and the environment can be said to have changed the political landscape in terms of issues that are high on political agendas, and in terms of relevant political actors and parties, at least in

Western societies. TA is a product of this development. What is absolutely necessary in order to provide a full picture of globalisation, and has a special bearing for TA and technology governance, is the fact that the science and society discourse and its main reference, i.e. the problem of managing ethical ambiguities and social and environmental risks, has become a global discourse due to the global character of the problems to be dealt with, and the global strategies required to deal with these problems.

Global warming and the fiercely discussed need for global strategies to reduce the CO_2 footprint of our economies is only the most salient example of how we are not only globalised in economic or cultural terms. We are also a global community both producing and affected by risks. The risks that we necessarily take while we are shaping our futures through our growing capacities for action and intervening in the world are of global character, as is the uncertainty of the knowledge that we necessarily produce and have to deal with when trying to manage these risks and decide on safe enough, ethically viable options to pursue, on the individual as well as the societal level. Globalisation in this respect also proves to be the most advanced state of "reflexive modernisation", of the process of undermining the hopes and rationales of modernity, and its belief in the unambiguous benefits of technical progress as well as the application of its heredity of rational criticism and scrutiny to the achievements of modernity itself (Science, Technology, Rationalisation of all kinds of human activities).

What have been discussed as features of the "risk society" on a national level since the 1990s (Beck, 1986/1992) have now become issues of the "world risk society". In the 1980s, the depletion of the ozone layer of the atmosphere caused by the world-wide use of chlorofluorocarbons was one of the first phenomena to be perceived as an effect of global production of environmental risks. The finite nature and instability of fossil fuel supply had become obvious in the 1970s, making it clear that global natural resources are limited. Nowadays, the planetary boundaries of various fundamental resources, such as arable farm land or freshwater, are acknowledged (see, e.g. Rockström et al., 2009). Air and environmental pollution could never be regarded as phenomena that end at national borders, and the pollution of the world oceans with plastics, the remainders of the essential material of modern lifestyles as well as the global reduction of biodiversity make this all too obvious.

Conflicts about the distribution of the benefits and risks of innovations (whether in terms of environmental risks or the effects of new production technologies on economies and labour markets) are now global conflicts. The question of "who will be the losers, who are the winners of modernisation?", the questions of access to resources, knowledge and markets all need to be addressed on a global scale. There is also the question of who should contribute, to what extent and how, to developing the necessary strategies of reduction of resource consumption and outputs. The prime example is the much-needed reduction of CO_2 emissions by changes to sustainable production and lifestyles, where it is important to note that the carbon emissions of the richest 1% are more than double the emissions of the poorest half of humanity (see, e.g. Oxfam, 2020).

As regards to ethics, it appears to be difficult to align the challenges of innovation such as human in vitro fertilisation (IVF) and the promises of embryo research or of genome manipulation with relevant values and religious beliefs at the level of national policymaking. Reaching a consensus on ethical barriers and effective legal regulations in biotechnology, synthetic biology or nanotechnology is a global challenge for which mutual respect and productive exchange of cultures are needed (Ladikas et al., 2015). Not least, the push of global real-time exchange of data and the related risks for privacy, and of abuse of the Internet for manipulating political debates are issues induced by the global character of digital networks that demand global political reactions. The social networks are as global as the sources of manipulation and misuse that are driven by digital warfare and criminal activities. The list of global risks seems endless and includes challenges attached to global migration, cultural globalisation and global terrorism.

Thus, we are a global community with respect to the central challenges we face in our everyday lives and in politics. *Beck* (2017) argued convincingly that we are facing a "metamorphosis of the world" that asks for a new global perspective, including social scientific analysis, since the societal structures, interdependencies and problems as well as political options that we have to take into account in our private and political lives can no longer be restricted to the perspective of the nation state. Central concepts of societal change, societal revolution and transformation that are tied to the concept of the nation state are no longer valid or useful and have to make room for what *Beck* calls "methodological cosmopolitism", that is, the systematic account of the cosmopolitan character of modern society and its problems.

The driver of this "cosmopolitan" metamorphosis is the world risk society and its "comprehensive, and profound failure" indicated by global environmental problems, world poverty, global inequality, global economic crisis and the related global conflicts (Beck, 2017, 32). But the other side of this, *Beck* holds, is the fact that a new cosmopolitan consciousness is growing alongside the problems. The global complaints and allegations regarding these problems are indications that also subjectively we are cosmopolitans—we are aware of the global character of our situation and we know that we can only deal with them by taking up a cosmopolitan perspective. Also, our risk perception and the normative horizons we apply in our search for solutions are becoming (or must become) "cosmopolitan".

5 The Need for Reflexive Global Governance

Now that we have become a global "community of fate" (Beck, 2017), it still needs to be proven whether we are able to form a global community of action, a political community. And this, first of all, is a question of global awareness of the global character of the challenges ahead and the willingness to take joint action on a global scale. Is there a potential for (democratic) world politics based on a common civic culture allowing for open global exchange about joint problems and their possible solutions?

With regard to policymaking in the field of environmental risks, technological innovations and their ethical and socio-economic implications, the question is whether it is possible on a global level to implement adequate structures and processes of deliberation and decision-making. This would require institutions and procedures that allow for "reflexivity". "Reflexivity" means to reflect on the uncertainties we face and critically assess the knowledge at hand, including different cultural views as well as the variety of needs and capacities that are given by differing environmental conditions (such as climate or access to water). Reflexivity includes taking into account the existing inequalities and asymmetries of the global economy.

Sheila Jasanoff (2007) speaks of "global civic epistemologies" that comprise the ways, procedures, institutions and rules of societies to achieve consensus about what we can hold to be certain or legitimate as arguments, what uncertainties we actually are faced with and what are realistic options for problem-solving. This involves formal as well as informal structures of exchange and deliberation. It involves institutions of representative democracy that are informed by the best science as well as by their citizens. It asks for an open public sphere, a space accessible to everybody for the exchange of information and arguments. It needs an active civil society providing for a system of articulating needs and problems and monitoring the performance of political decision-making with regard to these. It depends on a variety of sources of knowledge production that can serve as independent and trustworthy references for societal reflection and discourse. It also would include all kinds of informal political communications such as fora and meetings, as well as online and offline deliberations. All of these would be needed on a global level. Some exist already or are emerging alongside growing awareness of global risks, such as global fora of problem definitions and mutual understanding as well as more manifest negotiations about mutual commitments or agreements that come close to globally binding legal regulations. The shape and functionality of a global system of civic epistemologies are however a desideratum which has to face many challenges.

With a view to global discourses as well as social movements regarding central aspects of the world risk society (climate change, environmental pollution and sustainable use of global resources, equal access to technologies and knowledge, economic inequalities and unequal development, migration and refugees), there is reason for some humble optimism. There are indications that a cosmopolitan consciousness and a feeling of global citizenship is evolving and is able to put pressure on institutions of governance at the national as well as the global level. The growing involvement of civil society organisations in the activities of international organisations and global phenomena of public awareness—such as Fridays for Future, a youth-led and -organised global climate strike movement—indicates that a central feature of democratic problem-solving can function on a global level. This is the observation and criticism of politics by attentive publics, and the awareness and responsiveness of decision-makers to such global publics and their manifestations in their home countries. Thus, there are some indications that Beck was right when stating that "… global risks bring about globalised public spheres – these again make global risks visible and equip them with political relevance" (Beck, 2017, 168, see also the chapter on the global public sphere, this volume).

At the same time, we have seen in the section about cultural globalisation that "globalisation of minds" is an ambivalent and conflicting process. People have the means to communicate in real time across the globe and are aware of the situation and mind-sets of other regions of the world like never before. But we should not overlook that the great bulk of communication around the globe is of commercial character, and the commercialisation of culture globally appears to function as a vehicle to spread Western lifestyles and consumerism (see, e.g. Bourdieu, 2003). The means of global communication can be misused for disinformation and also bring about counter-reactions of fostering nationalism and populistic movements that regard globalisation as a menace to cultural identities. Due to disparities and asymmetries in the world economy, there are also asymmetries in the opportunity to articulate one's views. In addition, hegemonic cultural structures benefit disproportionately from means and technologies of cultural globalisation. This clearly affects the normative foundations of options for global governance of S&T. Even ideas as universalistic as global human rights can serve as vehicles for Western hegemony when connected with neoliberal concepts of economy. They can be used to hide or justify the continuing existence of discrepancies in access to markets, and thus to welfare and participation in the benefits of globalisation. How do Western accounts of individual rights relate to other more collectivist or economic ideas of rights, such as the right to food and water? Thus, despite strong indications of an emerging "cosmopolitan" perspective on the goods and bads of globalisation, there is a huge task ahead to provide for spaces and opportunities where cultures can meet and discuss differences in what they regard to be the problems of our time and world. These need to be meeting spaces where people can reflect on the values they want to apply to evaluate the societal meaning of innovations and the acceptability of risks, and on how widely accepted values such as equality, justice, welfare, the common good and individual liberty and dignity actually can be meaningfully applied to concrete problems.

Besides deliberative spaces, global civic epistemologies also need functioning global structures of governance and decision-making. Globalisation has brought about a decline of the governance powers of the nation state. And so far this is counterbalanced only by weak structures of transnational governance. The increased integration of the global economy has strengthened the ability of globally operating transnational companies to direct investments to economies with conditions that fit their purposes best in terms of the price of labour and resources, as well as low levels of social-welfare restrictions and regulations. As a consequence, the abilities of nation states to preserve the social contract based on welfare policies have become restricted. For many, this represents one reason for the growth of populist movements and policies over the last two decades. According to some, the increasing powers of non-state actors in setting the rules of international economic exchange—which is also manifest in the often neoliberal policies of international organisations such as the World Trade Organisation (WTO) or World Bank—indicate the beginning of an area of "post-democracy" (Crouch, 2004). In addition, global risks delegitimise the national state: the foremost function of the national state is to provide protection for its population. Yet a national state's capacities to do this are massively restricted by global risks whose sources and effects it cannot control. National law is only valid for the national population, but blind with regard to the effects, and those affected, beyond its national boundaries (Beck, 2017, 132 ff.). The late British historian *Eric Hobsbawm* in his account of globalisation concluded that we are facing the global problems of the twenty-first century with a set of political mechanisms that are not fit to help. Neither the counting of votes nor the measurements of consumer preferences in a global market would help to solve the problems of a globalised world (Hobsbawm, 2009, 114 f.). Indeed, the international and transnational institutions of global governance that have been built up since the Second World War—most salient are the different programmes of the UN—lack democratic legitimation by not being directly accountable to a global citizenry. With the exception of the European Union, citizenship and related political rights are restricted to national boundaries. This democratic deficit combines with the difficulties in coming to international agreements on critical matters that go beyond a minimum consensus, and the restricted powers of transnational governance institutions to enforce the international observance of any agreements reached.

At the same time, there are strong indications of transnational awareness of the need for "cosmopolitan" policymaking in the light of global challenges and problems. This is indicated by the growing number and importance of international agreements on environmental, security and health issues supported by international organisations such as the WHO, OECD, WTO and not the least by the UN. Since the Earth Summit in 1992, the UN has made sustainable development a main issue in its activities and has set up a global exchange on how to translate defined sustainable development goals into international programmes of knowledge sharing, technology transfer and national programmes of economic development and innovation (see chapter on global governance, this volume). Other activities are related to health issues, to questions of security of digital innovations or to ethical evaluation and regulation of the use of biotechnology and human genome research. Most outstanding when thinking of reflexive modes of governance is the Intergovernmental Panel on Climate Change (IPCC), through which the UN has established a body of science and policy advice whose reports are acknowledged as an independent and reliable source of information all over the globe. Many of these achievements in establishing processes and institutions of global governance are dealt with in more detail in chapters in this volume.

The legitimation of transnational institutions of policymaking and transnational agreements is a critical issue. Citizens have influence on politics in the framework of the nation state but not at the level of the United Nations or other transnational institutes. For the moment, it appears to be utopian to think of a global democracy in terms of global elections and government. The authority of international governance structures (institutions and agreements) is critical. Global governance structures cannot rely on unquestioning recognition of rules and regulations by those who are expected to comply. Its authority is not based on cultural traditions and cannot rely on coercive means. The authority of global governance structures has thus been coined to be "reflexive authority" (Zürn, 2016). The recognition of authority is not a given but is a reflexive act, constantly open to critical assessment in the light of the legitimacy of the procedures applied, the "epistemic authority" of knowledge references (such as, e.g. the IPCC), as well as the congruence between decisions taken and normative expectations.

There might currently be little prospect for more global democratic decision-making structures or institutions beyond the existing often not very powerful and conflictual ones. It is therefore more necessary to support the "reflexive authority" of existing structures. This can be done by providing for transparency and responsiveness in international decision-making and establishing strong connections with civil society. Both might best be achieved by—involving civil society organisations in global governance, as is already the case to some degree. But there is also a role for intermediate "reflexive" organisations and initiatives of policy advice in the field of science and technology. Such institutions—as among others the overview on TA activities given in this volume shows—exist around the globe and nationally are often already closely involved as an independent actor in policymaking.

The legitimacy of global politics can be supported with regard to the two central dimension of its legitimacy. First, the quality of decisions taken, which is the appropriateness and effectiveness of its output, and by this its acceptability by the addressees (output legitimacy). And second, the quality and representativeness of the data, arguments and articulated needs and demands that inform its decisions (input legitimacy). Both dimensions are supported at the national level by a broad scope of independent "knowledge brokers" (Pielke, 2007). Institutions like the IPCC do a similar job on the global level. To join forces between organisations involved in TA and policy advice for technology governance from all parts of the world would open up additional means in the field of S&T policy. The central task would be to provide problem-related normative knowledge, as well as factual knowledge based on TA studies from national TA institutions, and organise co-operative work to develop synthesis based on such studies. The central means would be to organise input from the global public and civil societies around the globe for international negotiations.

Governance is a term for a co-operative rather than a top-down mode of reaching policies and decisions in an increasingly complex policymaking environment. This complexity is even higher at the global level. Global governance is about more than just the relationship between states. It is about ways to involve a broad spectrum of actors in governance issues in order to achieve a best and best-accepted solution for problems by making use of the different sources of knowledge and the full spectrum of the potential for action. Global governance of S&T with all its implications for environment, health, the economy and social justice is, as has been stated by an expert commission of the EU, "… faced with the challenge of rapidly-advancing possibilities realized through research. Across borders the social contexts within which new knowledge is generated, distributed and regulated will vary hugely. Science nevertheless remains a non-state and transnational social institution, so that its governance is necessarily global, both internally and externally" (EU, 2016).

It is a complex task to make use of the many sources of knowledge that are provided by the social institutions of science around the globe to come to a critical assessment of both the state of research as well as of arguments in societal discourse. But this is needed in order to come to legitimate decisions on a global scale with regard to complex problems emerging from scientific and technological modernity, as there is

"… no sensorium for global risks, no direct perception and experience, no evidence achievable based on common sense alone" (Beck, 2017, 133). It is mainly through scientific evidence that global risks are testified and can be experienced. The issues of justice and equal access to the economic opportunities of globalisation as well as the challenges of aligning different cultural perspectives to problems and solutions need support from reliable knowledge arrived at in scientifically supported modes of global deliberation. This scientific mediation makes "reflexivity" and reflexive concepts like TA salient. The high level of reflexivity involved in this endeavour is exactly the level needed to face the risks and opportunities of globalisation. Reflexive modernisation, of which globalisation is maybe the most complex feature, needs reflexive global governance of S&T, where knowledge-based structures and institutions have a role to play as intermediates between science, society and policymaking.

- The sources and effects of globalisation are often of local character. Identification of problems and providing appropriate solutions is in need of "connecting the dots" through global networks of independent problem-oriented research and advice.
- A reliable knowledge base is needed as input to the search for common policy on a global level which affords reflexive and open exchange on the broad scope of effects of S&T on society in different national environments, on the different problems and perspectives in different parts of the globe as well as on different values and conflictive demands and expectations.
- Reliable input has to be elaborated to ongoing global discussions as well as policies (UN) on ways to achieve a sustainable, i.e. environmentally sound and socially equal and inclusive development of societies and economies.
- "Science in Society" as a concept and reality has to be spelled out on a global level. The existing systems and institutions of global governance lack democratic legitimisation and input from a wide range of relevant actors. TA can serve as a facilitator for inclusive formats in the mainstream zone of decision-making.

It is obvious that with these challenges ahead, TA has to think about its own role and mission. Reflexivity in this respect also applies to TA itself. Just as globalisation in the sense of cosmopolitan interchange cannot be about modelling the world according to Western standards and formats, "Global TA" cannot be about just exporting Western thinking about the central problems of the science and society complex to the rest of the world. As a means of global reflexive technology governance, TA may have to reinvent itself in the confrontation with problems, expectations and needs as defined by many and various cultures or communities. Problems of access to technologies, adopting these to local needs, and normative standards as well as economic and political power relations implied in the adaptation of new technologies then might be as much in the focus of standard TA studies as the assessment of risks and hazards, and the discussion of generalised ethical standards.

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Technology Assessment and Public Spheres in the Context of Globalization: A Blueprint for the Future

Rinie van Est and Leonhard Hennen

1 Introduction

While the private or domestic sphere is the realm of family life, friends, and personal matters, the public sphere is where the expression and discussion of ideas occur regarding common concerns and collective social interests. The term "public sphere" is often used in the singular form, but "in large-scale, differentiated late modern societies, not least in the context of nation states permeated by globalization, we have to understand the public sphere as constituting many different spaces" (Dahlgren, 2005, 148). That is why we prefer to use the plural form here—public spheres—to recognize that there are countless forms of fragmentation and contestation and both off- and online public spheres. And within the global context there is a collection of public spheres that can vary from deeply democratic to authoritarian (cf. Dukalskis, 2017).

Public spheres can arise when people express their personal experiences of particular problems and solutions in public. This may allow others to listen and recognize those experiences as a public issue, and to develop a shared understanding of the problems and solutions, together with a collective will to address them. In these public sphere processes, media of all kinds play a central role in the circulation of information and the interactions and communication between people. This chapter reflects on the relationship between public spheres and technology assessment (TA), which addresses the relationship between technological and social change. In particular, we

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consider the connection between TA and public spheres from a global perspective, that is, from the context of globalization. The globalization of science and technology, among other things, impacts the theory and practice of TA, but there has been little reflection on the significance of this.

We begin that reflection by stating that TA wants to make the social significance of technological change publicly visible and open to discussion. TA assumes that groups of people can be affected both positively and negatively by scientific and technological developments. These (positive and negative) consequences can lead to certain groups in society becoming politicized and thus becoming a public that creates a public sphere. According to Dewey (2016, 69), "The public consists of all those who are affected by the indirect consequences of transactions to such an extent that it is deemed necessary to have those consequences systematically cared for."[1] This is where the "all-affected" principle—also known as the "congruence," "symmetry," or even "democratic" principle—comes into play, which generally says that "all who are affected by a decision should have a right to participate into making it" (Dahl, 1970, 64; quoted in Lagerspetz, 2015, 6).

Based on this thought, TA should critically relate to the public sphere. For example, which people, interests, visions and issues do or do not receive attention? In particular, TA's role is to make publics which are emerging from the influence of science and technology visible in the public debate and give them a voice. When TA takes globalization seriously, the global perspective provides an additional critical perspective on the public sphere, especially the national public sphere. The Global TA network, almost by definition, wants to take globalization seriously and therefore starts from the awareness that it is important to take into account an international context when performing a TA activity. In view of the all-affected principle and the fact that science and technology and their social consequences are global phenomena, TA should therefore, in principle, take into account the groups of people that are affected worldwide, rather than only in the country where the TA is exercised or the countries where TA is institutionalized.

The above first reflection already indicates the relevance of the global perspective on public spheres and TA. This will be further elaborated in this chapter. We do this by first examining the relationship from a national context, because both TA and academic thinking about public spheres are mainly approached from the point of view of national political decision-making. Given our interest in the connections between public spheres and TA, we focus on those public spheres that deal with the societal significance of technology, or the nexus between science, technology and society (STS), which we call "STS-like" public spheres. We then reflect on public spheres in a context of globalization and describe how TA institutes, networks, and activities are organized beyond national borders. Informed by that, we look at the link between public spheres and TA in a global context and finish by sketching a blueprint for the future of global TA. But first we start by characterizing the public sphere concept by means of six dimensions. This characterization is needed in order

[1] According to Rogers (2016) Dewey's language of 'indirect consequences' is "deceptive because he appears to also mean harmful or unwanted consequences, indirect or not" (Rogers 2016, 35).

to interpret the academic discussion about the public spheres and their relationship with TA in both the national and global contexts.

2 Six Characteristics of Public Spheres

The term public sphere is a contested (Tully, 2012), fuzzy concept. To make it more precise, we will characterize public spheres by means of six characteristics: four information and communication processes, the central role of media, and the public sphere as a space between the private sphere and other societal domains such as science and technology, economics, and politics.

Habermas (1989) used the German term "Öffentlichkeit," which was translated in English as "public sphere." "Öffentlichkeit" refers to "publicity" in the sense that what happens in the public sphere is to a certain extent visible, legible, accessible, negotiable, shareable, debatable, and actionable to and by people. The term "public sphere" refers to the fact that publics, i.e., groups of people, create that sphere. The public sphere represents a multiplicity of publics, bringing different experiences, opinions, types of knowledge, value orientations, and capabilities to identify and articulate public problems and propose solutions, and to take action. This phenomenon, in which the human experience of what is happening in the world is collectively interpreted, can be made more tangible by distinguishing four processes in which the formation of publics can take place around collective issues, shared public understanding, public will, and action. It is these activities that constitute the public sphere.

Public expression and publishing of personal experiences

As Dewey (2016) clarified, problems, for example related to technologies or policies, first have to be experienced or perceived by people who suffer from it now, or see people around them suffering, or fear suffering in the future. Something similar applies to solutions to problems, where their feasibility and desirability must first be tested and experienced on a small scale. Such private experiences are not yet public issues. For that to happen, personal experiences must be expressed—words and images must be given to it—and made public so that they become visible for others.

Public listening and recognition

Publicly voicing problems and solutions gives fellow human beings the opportunity to listen to those outpourings. Informed in this way, other people may be able to recognize the particular problems and solutions, by putting themselves in the shoes of others and seeing the consequences of a certain development from their perspective. Human empathy has the potential to connect with similar people and people close to us, but also with citizens, non-citizens (like migrants), and non-humans (like animals and trees) who are far removed from us in terms of physical distance, time, and social context (Krznaric, 2010). If others recognize the problems and solutions in question, a public—a community of listening (Han, 2018)—may be formed around the relevant issues by means of the exchange of information and ideas, and through deliberation.

Shared public understanding

This is the start of a phase in which public opinion formation may take place. If a group of people can find one another and become attuned with regard to the perception of problems and solutions, a shared recognition of problems that should be resolved in a particular way can arise (Raile et al., 2018). According to Rosanvallon (2008, 307), this also "involves the production of a language adequate to our social experience, a language capable of describing social life and therefore of influencing it."

Public will-formation and civic public action

Such an alignment of the understanding of problems and solutions can lead to a collective commitment to address the situation in question. The term "public will-formation" is often used to describe this process. According to Raile et al., (2014, 105), public will becomes meaningful when "a social system has a shared recognition of a particular problem and resolves to address the situation in a particular way through sustained collective action." When we talk about collective action, it usually refers to activities of the state in the public interest. In this case, however, it specifically concerns activities of ordinary citizens to address certain concerns about their collective lives. Public action thus also has a civic aspect to it (cf. Spink, 2019). For example, Drèze and Sen (1991, vii) used public action to mean: "not merely the activities of the state, but also social actions taken by members of the public—both 'collaborative' (through civic cooperation) and 'adversarial' (through social criticism and political opposition)."

Civic public action is any form of organized action carried out by a group of people in order to address their needs and/or improve a certain problematic situation and achieve a common objective. These actions can be social, technical, economic, or political. Peaceful protests, awareness-raising, and grassroots campaigns are all forms of political action. Other forms of collective public action are, for example, a community of farmers agreeing upon how to best ration water from a common source, or forms of citizen science, like citizens measuring the severity of air pollution from industry or car traffic in their neighborhood. A social movement is a loosely organized but sustained "form of collective action that articulates a social conflict and ultimately aims at transforming a social order" (Thörn, 2007, 900). To be successful, social movements must be skilled in information politics, i.e., "the ability to quickly and credibly generate politically usable information and move it to where it has the most impact" (Keck & Sikkink, 1998: 16).

Central role of the media

Both traditional and social media play a central role in all of the above-described information and communication processes. This dynamic is shaped by the political economy of media and enabled and constrained by information and communication technologies (ICTs), and the control of and access to them. The technological infrastructure of the public sphere plays an important role, because it strongly influences how people perceive and experience the world. While at the beginning of the nineteenth century people's experiences were largely limited to what was happening locally, and news from other parts of the world often did not arrive until weeks later, nowadays people can often follow what is happening in almost every other place in the world in real time via satellite and Internet connections. Due to this intertwining of our private lives and the mix of traditional and social media, our personal life worlds have increasingly become sites of globalization (Volkmer, 2014).

The public sphere as an in-between space

The public sphere is positioned as a part of our society that fulfills a linking function, an intermediary structure or role between the life world of people and more institutionalized societal domains, such as the private sector or economic sphere, the scientific and technological domain, and politics. This last characteristic is referred to as the "inbetween-ness" of the public sphere, or the public sphere as an in-between space, a nexus between the unorganized private world of people and the organized world of public and private institutions.

Starting with Habermas, scientific discussion of the public sphere has traditionally focused on the role the public sphere plays between people's private lives and the national political system in democracies. This therefore involves an inbetweenness between "the nation state" and "the people," in the capacity of citizens of the respective nation. This concerns citizens indicating what their social wishes are and expressing their confidence about a particular political course. However, it also involves citizens critically monitoring and questioning existing policies, including organizing social counter forces to prevent the implementation of particular political decisions.

From the perspective of globalization, this dominant view of the public sphere as the nexus between the people who are governed and the people who—or maybe better the institutions that—govern, immediately raises a number of essential questions (cf. Volkmer, 2014). For example, how can such a global public sphere arise and function in a situation where in the legal sense there is no such thing as a world citizen, and in the political sense there is no such thing as a world parliament (representing the entire world population with powers to frame international laws for the entire world), or world government (as a common political authority for all of humanity)?

Before dealing with such thorny questions, let us first consider the dominant model of the national public sphere as the space between the life world of citizens and the national democratic political system. We also look at the relationship between TA and the public sphere, as the political and public role of TA is often discussed at national level, in the way we have characterized the public sphere in this section. And given our interest in the connection between public spheres and TA, we focus on those public spheres that address the societal significance of technology, or the nexus between science, technology and society (STS); so-called STS-like public spheres.

3 STS-Like Public Spheres and TA in a National Political Context

Above, we distinguished between collective action by ordinary citizens and public authorities. In the academic literature, by far the most attention is paid to the way in which public recognition of certain issues, and subsequent public opinion-forming and will-formation can eventually lead to political action by governmental organizations. In order to achieve this, it is important that a sufficient set of decision-makers become "committed to supporting a commonly perceived, potentially effective policy solution" (Post et al., 2010, 659).

The basic premise of any political system—whether democratic or authoritarian (cf. Dukalskis, 2017)—is that the people who govern must somehow find their legitimacy with the people they govern. Rosanvallon (2008, 328) speaks of the continuous "crisis of political representation," since there is a perpetual gap between the governors and the governed. This requires constant interaction and communication between the state and the people in order to reconcile societal needs and public policy. To examine the functioning of democratic political practice, Habermas used the concept of the public sphere to describe and reflect upon how this interaction between the "people" (i.e., "society") and the "state" takes place and should take place. In essence, this is about enabling collective understanding of problems and solutions, collective will-formation, and transforming the public will into political will.

Habermas (1989) became famous with an historical study which situated the emergence in the eighteenth century of the bourgeois public sphere in Germany, Great Britain, and France. Informed by newspapers, citizens gathered mostly in pubs, coffeehouses, and literary salons to discuss politics and society. According to Kellner (2000, 3) "for the first time in history, individuals and groups could shape public opinion, giving direct expression to their needs and interests while influencing political practice." In this way, which is at the crux of a democratic public sphere, precisely by forming a public sphere, citizens changed from those who are governed by the authorities to citizens who demanded a say in the issues and the way they were governed. This shows that people can also affect the form, role and function of the public sphere, and its link with the political system. In relation to this, a distinction can be made between engagement *in* and *with* public spheres, where the stake of the latter is the democratic transformation of the public sphere itself (Tully, 2012, 171).

An influential normative framework regarding the public sphere in democracies is the Habermasian principle of an ideal speech situation. Habermas argues that to arrive at an adequate picture of the realities of society, opinion- and will-formation within the public sphere should be based on the free exchange of arguments and rational-critical discourse. He named six conditions for such a "power-free" ideal speech situation (Habermas, 2001). First, every citizen should have equal opportunities to participate in the public debate on a subject relevant to that citizen. Secondly, participants in the audience sphere must be truthful and say what they mean. The third requirement relates to the autonomy of citizens and suggests that communication must be free of external and internal coercion. The fourth relates to the public character of the deliberations that take place in the public sphere. The fifth condition concerns the rejection of hierarchy between participants and demands equal communicative rights for all, so that each can participate on an equal footing. The final condition requires participants to have an intention to reach agreement, to be oriented toward consent, and requires that "participants reciprocally impute an orientation to communicative agreement on one another, this … acceptance can only occur jointly or collectively" (Habermas, 2001, 44).

3.1 Three Factors Influencing the Autonomy of the Public Sphere

The above normative ideal of the public sphere has never been fully achieved in practice. We can look at the first condition concerning equal access to the public sphere. Habermas' (1989) historical study situated the emergence in the eighteenth century of the bourgeois public sphere in Germany, Great Britain, and France. Informed by newspapers, citizens gathered mostly in pubs, coffeehouses, and literary salons to discuss politics and society. However, that bourgeois public sphere was accessible mainly to educated, propertied men, who conducted a discourse prejudicial to the interests of those excluded, like workers and women (Calhoun, 1992, 3). Here, we focus on the third criterion regarding the autonomy of the public sphere, and specifically how its functioning is influenced by political rulers, science and technology, and the media.

Political rulers—the problem of agenda-setting

It is often implicitly assumed that public issues are put on the political agenda via the public sphere. The excluded groups mentioned above, for example, created their own publics—or better counter-publics—and alternative public spheres in order to politically claim their democratic voting rights and other rights. As a result, many important social issues, like women's rights and environmental protection, which previously only played a role in alternative public spheres on the margins of civil society, have been placed on the political agenda (Habermas, 1996). However, issues are also put on the agenda via other routes.

Many political issues do not originate in the public sphere, but in politics. Governments can choose to submit these issues to the critical public sphere in order to arrive at more adequate and legitimate problem perceptions and solutions. In some cases, the interaction between the public and public authorities is regulated by law. For example, since 1998 the United Nations Aarhus Convention grants the public rights regarding access to information, public participation, and access to justice in governmental decision-making processes on matters concerning the local, national, and transboundary environment. However, citizens are not always involved in a transparent and fair manner. Snider (2010) sees fake public participation as a widespread global phenomenon.

The manipulative orchestration of public opinion by political movements and leaders may undermine the role of the public sphere in producing a legible world for citizens, and articulating the real needs of society. Archetypical anti-democratic populist leaders, like Perón in Argentina and Chávez in Venezuela, even aimed to manufacture the will of the people (Bartley, 2017). And once in power they broke down independent forms of civic organization, ranging from parliaments, governmental agencies, and trades unions, to political parties. In this way, flawed democracies can turn into authoritarian regimes (cf. The Economist Intelligence Unit, 2015). The "authoritarian public sphere is characterized by the state's efforts to establish its foundations, delineate its boundaries, and monitor its content" (Dukalskis, 2017, 4). The authoritarian state manipulates the public sphere by positive legitimation (i.e., crafting and disseminating messages legitimating the regime) and negative repression, including blocking, censoring, or undermining viewpoints that might threaten the state's narrative (ibid.). The fact that the information environment is imbued with aspects of reality prioritized by the state makes it difficult for citizens to (individually and collectively) form an accurate picture of social reality. Dukalskis (2017, 4) shows that despite this challenge, sometimes ordinary citizens do manage to maneuver within the tightly controlled public discourse by taking advantage of autonomous spaces or networks to articulate and discuss their ideas and even find ways to seriously oppose the authoritarian political regime.

In the Internet age, countries may also have and use capabilities to influence the information that reaches the populations of other countries. For example, the Russian government "actively undermines the rule of law and free democracy both in the domestic political processes and the political processes of other states" (Hamer et al., 2019, 53). Russia uses espionage and disinformation to undermine the democratic process and to destabilize a foreign society. The country is suspected of actively spreading disinformation on various occasions, from undermining the American presidential elections in 2016, to influencing the American mid-term elections in 2018, and targeting the Yellow Vests movement in France.

Media—the (technical) mediation of the public sphere

Above, we mentioned the central role that traditional and social media play in the public sphere. Habermas considered the press to be the most important catalyst of the bourgeois public sphere of the eighteenth century (cf. Peters, 1993). In the twentieth century, besides newspapers, radio and television became influential means to broadcast information. Habermas was highly critical of the role of such mass media. In the early 1960s, he stated that in modern European nations mass media had become "the gate through which privileged private interests invaded the public sphere" (Habermas, 1989, 185). He argued that the acquisition of the control of mass media—such as newspapers, radio, and TV—by private owners and their relationship with the political class had made "manipulative publicity" common and had led to the so-called refeudalization of the public sphere. Commercialization of the news media also led to people being approached as consumers, and little attention was paid to critical discourse and raising political awareness among citizens. As a result, Calhoun argues that, "With the loss of a notion of a general interest and the rise of a consumption orientation, the members of the public lost their common ground" (Calhoun, 1992: 25).

We now live in the Internet age. In the early days of the Internet, the popular utopian vision was that the Internet could serve as a global public sphere with the potential to reshape democracy. It was thought that in contrast to the passive consumption of mass media, the Internet would provide a new well-informed public sphere, where citizens could form active Internet communities, with room for criticism, arguments, and unmanipulated power-free discussion among all kinds of people and views. In the meantime, various scholars worry that phenomena such as filter bubbles and digital echo-chambers cause isolated self-referential public spheres that increase ideological segregation. Flaxman et al. (2016) found that social networks and search engines both increase the mean ideological distance between individuals as well as increase an individual's exposure to material from their less-preferred side of the political spectrum. Also, much attention has been paid to the ways in which the use of the Internet and social media in combination with big tech dominance can put pressure on democracy. This discussion is fueled by the fact that the public debate has turned into a revenue model by large social media companies, like Facebook, Twitter, and Google. Moreover, the Internet has been flooded with "fake news," or more specifically: mis-information (incorrect information), mal-information (information based on reality, used to harm a person, organization or country), and disinformation (dissemination of misleading information with the aim of harming public debate and democratic processes) (cf. Wardle & Derakhshan, 2017). For example, Myanmar military officials misused Facebook to set up a systematic hate-speech campaign to target a Muslim Rohingya minority, which has led to murder, rape, and forced migration (cf. Stevenson, 2018).

Science and technology—knowledge as a resource and problem of modern public spheres

In our technological culture, identifying and addressing public issues is often highly dependent on scientific knowledge and technological expertise, capabilities, and instruments. Science and technology play at least three roles (cf. Beck, 1992, 163). First, the industrial use of science and technologies creates social benefits and risks. Second, science and technology provide means to recognize and measure physical risks, but also indicate and articulate social and ethical issues related to technologies. And finally, science and technology can be used to deal with risks in the best possible way. With his book *The public and its problems* (1927), Dewey (2016) was one of the first to draw attention to the role of scientific and technological expertise in decision-making and the citizen's dependence on the knowledge of experts. Dewey identified science and technology as a main source of public problems in modern societies and thus as drivers of public debates and the emergence of new publics. As stated above, citizens depend on the state to address their needs effectively. Often, however, existing state institutions are incapable of addressing these new public needs and are hostile to those needs because they have been organized to serve the sometimes-conflicting interests of other publics. As Dewey (2016, 80–81) puts it, “The new public which is generated remains long inchoate, unorganized, because it cannot use inherited political agencies. The latter, if elaborate and well institutionalized, obstruct the organization of the new public. … To form itself, the public has to break existing political forms.” Therefore, according to Dewey, publics must first develop outside the incumbent institutions of the state, until they are powerful enough to function as a counterweight to publics that are entrenched via the state and change the institutions of that state. “This, for Dewey, is the essence of democracy’s radical character.” (Rogers, 2016, 42).

At the same time, science and technology development is a challenge for publics due to the complexity of the issues at stake. The difficulties in capturing the complexity of problems and identifying possible options for action can stymie the effective articulation of problems and thus the emergence of active public debates: “The ramification of the issues before the public is so wide and intricate, the technical matters involved so specialized, the details are so many and so shifting, that the public cannot for any length of time identify and hold itself” (Dewey, 2016: 166). With the new emerging roles of experts and laypeople, it becomes decisive for citizens to fulfill their democratic role to be provided with reliable knowledge in order to be able “to judge of the bearing of the knowledge supplied by others upon common concerns” (Dewey, 2016, 225). It is at this intersection of expertise, public opinion-forming, and policymaking where institutions such as (parliamentary) TA organizations are situated, and through which they define their roles (see below and Hennen, 2021).

3.2 STS-Like Public Spheres and TA

Since TA deals with the relationship between technological change and social problems, it has a strong public and political dimension (van Est & Brom, 2012). The practice of TA thus recognizes the important role that science and technology play in society and in political decision-making. Ganzevles et al. (2014) model (parliamentary) TA as an activity at the interplay between society (including citizens and civil society organizations), politics (including parliament and government), and science and technology. TA thus functions as a mediator among the actors and their knowledge claims in these spheres. So, interestingly, STS-like public spheres and TA practices populate the same in-between spaces.

Related to this, it is important to recall that TA owes its existence to the emergence in the 1960s and 1970s of a public sphere that was critical of science and technology and the way politics dealt with it. Important new public issues included environmental pollution, car safety, nuclear energy, and the impact of information technology on employment. Societal criticism was that politics and policy failed to deal with the negative effects of technological change in a timely and adequate manner. And there was a social call for the democratization of science and technology and related political decision-making. One of the political responses in various Western countries was the establishment of parliamentary TA organizations. Parliamentary TA was first institutionalized in the United States in 1972 with the founding of the Office of Technology Assessment (OTA) as part of the American Congress. Inspired by this event, in the 1980s, parliamentary TA took root in various European countries, starting with OPECTS in France, which was established in 1983 by law "to inform Parliament of the consequences of the choice of scientific and technological options, in particular, so as to enable it to make enlightened decisions."[2]

TA is often defined as "a scientific, interactive, and communicative process that aims to contribute to the formation of public and political opinion on societal aspects of science and technology" (Bütschi et al., 2004, 14). Given the intermediary role of TA in the triangle between society, politics, and science and society, TA can thus focus on *studying* these domains and their interactions, *informing* the players in those domains and stimulating their *engagement* in the debate about the social significance of science and technology. As a result, we can describe the relationship between TA and STS-like public spheres (and also with politics and science and technology) along three dimensions, namely from the perspective of studying, informing, and engaging (cf. Hennen, 2021).

First, STS-like public spheres are objects of study for TA. This makes much sense, since public controversies surrounding science and technology can be seen as informal forms of TA that in many cases "provide partly conflicting assessments of new technologies or of the impacts of actual or proposed projects, that are further articulated and consolidated in the course of a controversy. Thus, informal technology assessment occurs." (Rip, 1986, 350). So, by studying the positions and discussions in the public sphere, TA tries to gain insight into the way in which citizens, stakeholders, and experts perceive the social significance of science and technology.

The classic role of parliamentary TA is to inform parliaments (representatives of the people) about the state of public debate. But parliamentary TA may also be tasked with informing the general public. In such a case, the public sphere is regarded as the addressee of TA, based on the idea that insights from TA studies can contribute to the quality of the public debate about science, technology, and society.

In line with this lies the third dimension, in which engaging society and thus stimulating the public sphere is seen as an explicit task for a TA organization. This is the realm of participatory TA, which deals with the interface between the (political) decision-making arena and society (van Est & Brom, 2012). Participatory TA intellectually connects to the Habermasian model of discourse ethics (Dalton-Brown, 2015, 109), and in general to a deliberative model of democracy, in which it is considered important to confront actors with the political views of other actors. The aim of participatory TA is to broaden, and thus enrich, the political and public debate around the social aspects of science and technology. This mode of TA organizes the involvement of experts, stakeholders, and citizens to identify and evaluate the

[2] See https://www2.assemblee-nationale.fr/15/les-delegations-comite-et-office-parlementaire/office-parlementaire-d-evaluation-des-choix-scientifiques-et-technologiques/articles-caches/about-opecst.

societal impact of technological change. A large toolbox of participatory methods has been developed for this purpose, including citizens' panels, scenario workshops, and consensus conferences (Joss & Bellucci, 2002; Slocum-Bradley, 2003).

A question that arose in the context of public controversies surrounding biotechnology in the 1990s is when should citizens and societal actors be involved in the development of science and technology? In the field of nanotechnology, it was feared that this development could also lead to a great deal of public controversy. This gave rise to the idea that civil society organizations and the general public should be involved in the development of nanotechnology at an early stage. In this way, the notion of "upstream public engagement" entered the existing discourse on public participation (cf. Wilsdon & Willis, 2004). This created a window of opportunity in the United States and Europe to organize social participation not only around technology that was already on the market, but also in science, and decisions about the R&D agenda. Public engagement is thus not placed here between the public sphere and politics, but between the public sphere, and science and technology.

4 Public Spheres in a Context of Globalization

In the previous section, we discussed public spheres and their relationship with TA in the context of the political sphere of the nation state. However, the nation state and its politics are part of a bigger world. Since each country depends on other countries—politically, economically, environmentally, socio-culturally, and also with regard to science and technology—interdependence defines the state of the world (see Hennen and van Est, this volume). From that perspective, globalization refers to "a trend of increasing transnational flows and increasing thick networks of interdependence." (Keohane, 2002, 15). This raises the question of how we can interpret the relationship between the public spheres and TA in a context of globalization.

First, we will look at the public sphere in the context of globalization. We show that the globalized media landscape provides tools for people around the globe to make local issues visible at a global level. Then, we argue, on the basis of the political European Community, that there is not yet a real transnational European political space or public sphere, let alone a global one. At the same time, there is a so-called internal globalization or cosmopolitanization of the identity and perception of (in particular young) people all over the world. This condition implies that for successful action, people and states must always take into account and make use of the opportunities that so-called cosmopolitanized action spaces offer. We then describe two examples of cosmopolitanized public spheres for collective action.

Visualized global media landscape

Originally, Habermas discussed public spheres mainly in the context of modern democratic European nation states, territorially bounded political community, national economy, national media, and linguistic and cultural homogeneity (Fraser, 2007). A quick reflection on these elements shows that globalization has radically changed the context in which public opinion may form and lead to action. We now live in a highly networked global-knowledge economy, in a multicultural society (partly as a result of centuries of enslavement and decades of colonial, labor and asylum migration). At the start of 2021, there were almost 4.7 billion active Internet users worldwide, some 60% of the global population[3] with a similar number of TV viewers. The widespread use of television and Internet has created a visualized global media landscape, where local or personal issues can become national or even global concerns.

Increased means for global exposure

We can safely say that this media landscape has greatly increased the possibilities for many people to publicize their personal experiences with particular problems and solutions worldwide, accompanied by transparency about what is happening in the world (the first requirement for creating public spheres). Think of Wikileaks, and famous whistleblowers in the field of IT, like Edward Snowden, who in 2013 revealed numerous American global surveillance programs, or Christopher Wylie, whose revelations in 2018 prompted the Facebook–Cambridge Analytica data scandal. Another interesting example is the online campaign called *Ushahidi* ("testimony" in Swahili), which was launched by a group of concerned Kenyans (in and outside of Kenya) to raise awareness about the violence that was spreading the country after fraudulent elections took place at the end of 2007. This crisis-mapping tool was incorporated into Google Maps and enabled the crowdsourcing of testimonies of ordinary people, who could share what they saw and perceived almost in real time through SMS, tweets, Facebook messages, mobile camera photos, Skype chat logs, and voice recordings. The originator of the idea for such a platform, Ory Okolloh, a Kenyan female lawyer in South Africa, stated: "the idea behind crowdsourcing is that with enough volume, a 'truth' emerges that diminishes any false reports" (Okolloh, 2009, p). At the time, this reporting of violence was a new form of public engagement of citizens in Kenya and the Kenyan transnational diaspora (Goldstein & Rotich, 2008).

No generic pan-European or global public sphere

Citizens can thus obtain information about what is happening around the world and make it visible via traditional and social media. But in what way does this transparency also lead to collective understanding, collective public action, and perhaps also political action? Let us first look at the European Union, because a transnational European public sphere still seems to fit well with the Habermasian model (for an overview of the discussion on the problems of a European public sphere see Hennen, 2020). While there are European citizens who have freedom of expression, the right to vote, and the possibility to start a European citizens' initiative, there is also a European political sovereign, embodied by the European Parliament, the European Commission, and the European Council which includes the heads of government of the member countries. The opinion of EU law professor Alberto Alemanno is quite

[3] See: https://www.statista.com/statistics/617136/digital-population-worldwide/, website accessed on August 12, 2021.

sobering: "We don't yet have a European politics – there's no real pan-European public opinion, no transnational political debate or dialogue on the issues that affect our common interests as Europeans – unemployment, the environment, migration, data protection. But as the need increases, it's starting to come." (quoted in Henley, 2019). Mak, a historian (2019, 152), agrees with this analysis and states (subtly referring to Habermas) that "the dreamed European coffee house, where a permanent public street debate takes place, only slowly got off the ground."

All transnational political bodies, including the European Union, face the problem of institutionally restricted options to directly refer and relate to a specific constituency. This causes problems in legitimizing its policies, as well as hampering the emergence of a transnational public sphere to which it can relate. In order to improve this situation, a democratization of transnational political institutions is required, alongside the development of an active transnational civil society and a felt transnational citizenship. As regards the latter, there are indications that together with the globalization of political problems and issues, a cosmopolitan perspective and identity of publics is emerging, which the technical options provided by the Internet support (see Hennen and van Est, this volume).

Internal globalization of the public sphere

One signal that this process of Europeanization of the political and public sphere is underway is the recent emergence of truly transnational, pan-European political parties, such as Volt. In addition, many young people, fueled by global issues such as migration, climate change, and security, and socialized in the sphere of the network society, are forming a cosmopolitan identity (Volkmer, 2014). A study among 14- to 17-year-olds in mid-sized cities in nine countries (Australia, Germany, Japan, Kenya, Malaysia, Mexico, New Zealand, South Africa, and Trinidad & Tobago) shows that this group "collectively share the engagement in social media (Facebook), participates through a transnational angle in transnational events, and engages collectively in concerns of a globalized nature, human rights, the environment, … military conflicts and war" (ibid., 183–184). About half of these youngsters perceive themselves as citizens of the world, and half as citizens of their country, while a majority is interested in information about the world (ibid., 185). As a result, Volkmer (2014, 184) positions this new generation "between the lifeworld 'locality' and the globalized public."

So we see that globalization leads to a reflexive process where (young) people start to think and act, taking into account the position of themselves and their country within a transnational and/or global context. Beck (2005, 143) speaks of "the '*internal* globalization' or 'cosmopolitanization' of nation state societies from within," and of cosmopolitan realism, which in order to be successful forces people and countries to make strategic use of "cosmopolitanized spaces for action" (Beck, 2016). Below we briefly discuss two examples of cosmopolitanized public spheres for collective action: a pre-Internet and a post-Internet example. One example concerns the historical struggle against apartheid in South Africa, where activists purposefully built incrementally a public sphere with global scope in order to increase foreign pressure for change on the national political regime. The second example concerns the contemporary formation of a global public sphere that includes, among other things, a diverse global assemblage of climate activists who exert political pressure at both the national and global political levels.

Anti-apartheid movement—building a global counter-public[4]

The anti-apartheid movement was increasingly globally active from around 1960 (the Sharpeville massacre occurred on March 21, 1961) to 1994, when apartheid was formally abolished in South Africa (Thörn, 2007). The movement intentionally contributed to that political regime shift by prompting disinvestments by global corporations and stimulating nation states and supranational organizations, such as the United Nations, European Economic Community (EEC), and Organisation of African Unity (OAU), to boycott South Africa. Besides South Africa, the movement took organizational shape in, among others, the United Kingdom. Its long history shows that it took decades to build a global anti-apartheid counter-public and that informal contacts and networks between anti-apartheid activists within South Africa and in exile, and activists in other countries played a central role. The national, international, and transnational dimensions of this social movement dominated its global aspect (ibid., 911).

The anti-apartheid movement employed two interrelated information and communication strategies, before the Internet age: (1) influencing and achieving visibility in the established media to communicate their message to the public and (2) developing alternative media and information networks with a global reach in order to create an independent, "alternative public sphere that would make it possible to address publics directly, thus freeing the movement from any dependence on global media industries" (ibid., 906). For the second approach, archives of well-researched information material and photographs were built up, and news bulletins, magazines, films, and videos about the apartheid regime and resistance to it were produced and distributed to members and sold publicly. These products created an important base for attracting established media. The International Defence and Aid Fund (IDAF) played a central role in collecting and producing information material and made it easily accessible for other anti-apartheid organizations, as well as to journalists and a global public. Connected to the global media revolution, cultural events became crucial means to attract global media attention to the movement during the 1980s. Most important were the Nelson Mandela Tribute concerts in 1988 and 1990 that filled the Wembley stadium in London and were broadcast globally by the BBC.

Influencing national and global decision-making on climate change

At the international and global level, there is not always a decision-making body through and upon which the public sphere can exert political influence. However, such a visible decision-making platform does exist in the field of climate policy. The Conference of Parties (COP) is the highest decision-making body of the United Nations Climate Change Framework Convention (UNFCCC), consisting of world leaders from 189 nations. In 1997, the Kyoto Protocol—which operationalizes the

[4] This section is based on Thörn (2007).

UNFCCC by committing countries to limit and reduce greenhouse gases emissions in accordance with agreed individual targets—was adopted during COP3 and entered into force in 2005. Since 2005, civil society organizations have collaborated worldwide to influence decisions regarding the implementation of the Kyoto Protocol. Actions have taken place at country level all over the globe, as well as wherever a COP-meeting took place.

The First Meeting of Parties (MOP1) to the Kyoto Protocol was held in conjunction with COP11 in 2005, in Montreal, Canada. This was the reason for environmental organizations to begin organizing a Global Day of Climate Action; peaceful demonstrations in many countries around the world, to influence the delegates to honor the commitments made in the Kyoto Protocol.[5] In 2015, these protests were given new impetus by the contribution of young climate activists. On the first day of the Paris climate summit (COP21), a worldwide Climate Strike was organized by students in over 100 countries, in which over 50,000 people participated. In 2018, this global youth movement was given impetus by the political actions of 15-year-old Greta Thunberg, who, in the run-up to the Swedish general elections on 9 September, started protesting every day during school hours for better climate policy in front of the Swedish parliament. Her slogan "Fridays For Future" gained worldwide attention and inspired school students across the globe, leading to various Global Climate Strikes. For example, in relation to the UN Climate Action Summit held in New York on 23 September 2019, several million students participated in climate strikes across 150 countries.[6]

A kaleidoscopic image

We might say that many countries have a generic national public sphere that is the result of many decades, if not centuries, of institution-formation, in the sense of, among other things, the national education system, political system, and media landscape. There is no such thing as a generic public sphere on a European scale, let alone on a global scale, although this may be developing very slowly. Diverse formative elements that have developed in recent decades include a global economy, a global (youth) culture, and a global visualized media landscape. The latter offers numerous possibilities for making local issues visible on a global scale, and for making global issues visible locally, as well as to comment on and discuss these. As a result, young people (in particular) increasingly see themselves as national and global citizens, although from a political-legal perspective there is as yet no such thing as a global citizen. Globalization is thus internalized in their thinking and also in the national public sphere. There is still a large gap between awareness-building and common understanding of certain global issues, and collective action to influence political decision-making at national and international levels. But we have showed two examples where this has succeeded.

[5] See: https://en.wikipedia.org/wiki/Global_Day_of_Action, website accessed on August 12, 2021.

[6] See: https://en.wikipedia.org/wiki/School_strike_for_climate, website accessed on August 12, 2021.

Archiving of events, evidence, and statements and connecting to the global cultural public sphere via, e.g., pop concerts played an important role in the success of the anti-apartheid movement. And in recent years, teens have played an important role in the global climate movement. Both examples show a complex interaction between local, national, international, transnational, and global dimensions of the public sphere. In relation to this and in order to influence political decision-making, the public sphere relates in many ways to different levels of government, again from the local and national to the international and global level, whereby the messages are also aimed at multinationals. The dimensions of the multi-level public sphere surrounding a particular issue thus mirror the multi-level governance of the issue in question. The political success of such complex-layered globalized public spheres is still largely based on personal connections within and across countries. Although the youth-organized global climate strike movement shows that conveying a global message nowadays is relatively easier than in the days of the anti-apartheid movement, achieving political and social change still takes a lot of time and energy, and the slow, tiresome building of institutions (Olesen, 2005).

5 TA Beyond National Borders

Above, we reflected on public spheres in a globalized context. In this section, we look at the organization of TA and its activities beyond national borders. In the final section, we reflect on the relationship between S&T-like public spheres and TA in a context of globalization. When thinking about TA in America's twenty-first century, Sclove (2010, 37f) identified two organizational routes. The first "Congressional option" is where a TA organization is directly linked to Congress, or in general a particular political decision-making body, which we will call the "Decision-Making Body option." According to Sclove (2010), a second option would be to establish an "expert-and-participatory TA capability by connecting an appropriate set of independent, non-partisan, and non-profit organizations into a nation-wide network" (ibid. 38), the so-called Institutional Network option. Both routes are used to organize both expert-based and participatory TA capabilities at an international level (Table 1). We will look at Europe first, before discussing the TA situation at a global level.

5.1 European Level

The classic role for (parliamentary) TA of informing political decision-making bodies is also organized at the EU level. STOA, the TA office of the European Parliament, is an example at central European political and administrative level. In addition to this Decision-Making Body option, the Institutional Network option is also used. Since 1990, international cooperation has taken place within European Parliamentary Technology Assessment (EPTA), a network of national TA institutions specialized

Table 1 Some examples of how expert-based and participatory TA are organized at European and global political level

Organizational options	Type of TA	European level	Global level
Decision-making body	Expert-based	STOA of the European Parliament (est. 1987)	IPCC of the United Nations (est. 1988)
	Participatory	–	–
Institutional Network	Expert-based	EPTA network (est. 1990) & EPTA reports	Global TA network (est. 2018)
	Participatory	Meeting of minds (2005–2007)	World wide views on global warming (2008–2009)

in advising parliamentary bodies both in, and partially outside, Europe. The EPTA network has a light organizational structure, and each year its members produce jointly an EPTA report which provides an up-to-date international overview of policies linked to a current TA topic.

This Institutional Network option has been used several times to organize participatory TA at European and global level. The first transnational participatory TA project was Meeting of Minds, the European Citizens' Deliberation on Brain Science, which aimed to rectify the lack of public debate on brain research in Europe (Rauws, 2010). The two-year pilot project was led by a panel of 126 randomly selected citizens from nine countries. A partner consortium of TA bodies, science museums, academic institutions, and public foundations launched this initiative in 2005 with the financial support of the European Commission and the King Baudouin Foundation. The participating citizens discussed matters in their own national panels, but also gathered together in two meetings in Brussels. At the end of the second international meeting in January 2006, the citizens' report was presented to the European Parliament. The panel's results have also been presented and disseminated at individual country levels.

5.2 Transnational and Global Level

TA is also organized at a global level on the basis of the Decision-Making Body option (Ladikas and Stamm, this volume). Part of the work of the IPCC also fits this option. The IPCC serves as the core scientific advisory board delivering evidence-based climate policy recommendations based on global scientific data to international climate negotiations. A key element of the advice from the IPCC is to assess the potential societal impacts of mitigation technologies, which is at the heart of TA (Ashworth and Clarke, this volume). The work of the IPCC also greatly influences the public debate in many countries around the world.

Considering the Institutional Network option, there has been a Global TA network since 2018. This network now consists of 28 non-profit institutions from around the world, working together in the area of science and technology, to promote responsible and sustainable research and innovation to tackle global grand challenges. The development of this book is the first joint TA-related activity, which aims to better understand the idea of global TA, contemporary practices, and its desired future. The big challenge for the Global TA network is to find organizations in developing countries with experience in the field of TA, as TA is much less common in non-OECD countries, while the need for TA is certainly no less.

The Institutional Network option has also been deployed to organize participatory TA on a global scale. The World Wide Views on Global Warming (WWViews) project represents a globe-encompassing participatory TA exercise (Bedsted & Klüver, 2009). WWViews enabled citizens from all over the world to define and communicate their positions on issues central to the UN Climate Change negotiations (COP15), in Copenhagen, Denmark, in December 2009. The project was coordinated by the Danish Board of Technology (DBT) and implemented by a global alliance of individuals and institutions, including governmental and non-governmental organizations, parliamentary TA organizations, and universities. On 26 September 2009, the various partners hosted one-day face-to-face deliberations in 38 nations, including Bangladesh, Brazil, China, India, Russia, the United States, and various European and African nations. Each deliberation included about 90 people, so that about 4000 people worldwide were involved.

In the field of participatory TA, it is not easy to find suitable partners in developing countries. However, there are some examples of participatory TA events. For example, in 2010, the Ministry of Environment and Forests undertook a large-scale public consultation for the first time ever in India, concerning the commercial release of the first GM food crop in that country. Ely et al. (2014) list some examples of participatory TA activities, such as citizen's juries, that have taken place in particular in the field of agricultural biotechnology in Brazil, Mali, and Zimbabwe, and reflect on three international participatory TA projects:

- The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) cost some $15 million and was funded by the World Bank, UNDP, FAO, and other institutions. Its aim was to provide a global consensus for investing in agricultural science and technology, setting priorities for both national and global organizations. The four-year TA project started in 2003 was global in scope and resulted in five regional reports and one global report. It involved some 900 stakeholders across 110 countries from multiple institutions in public, civil, and private sectors.
- The second TA project was sponsored by the British Royal Society and organized by the British think-tank DEMOS and Lancaster University, to explore the role of new nanotechnologies in clean water provision, through stakeholder events in Nepal, Peru, and Zimbabwe. The Royal Society wanted to look beyond the perspective of Western societies and take account of how people in developing societies might respond to nanotech-developments and their impacts.
- Finally, in 2008 the UK Research Council sponsored a TA project to identify maize-based farming strategies in Kenya as a means to respond to climate change.

This participatory TA project included discussions with farmers, plant breeders, policy-makers, extension workers, and executives in commercial seed companies.

6 STS-Like Public Spheres and TA in a Context of Globalization

In Sect. 3, we saw that globalization affects local and national levels and even impacts personal identity and opinion-formation. The public sphere is becoming globalized, especially through the globalization of the national public sphere. This means that the international expansion of public spheres and the internal globalization of national public spheres are taking place simultaneously. However, the latter process seems to be developing more quickly as it is embedded in existing national public, media, and political institutions. This is often not the case internationally, as illustrated in the field of TA in Sect. 4, where we described the weakness of the institutionalization of TA in developing countries and at the international level. This final section looks at the relationship between STS-like public spheres and TA, in a context of globalization.

In Sect. 1, we introduced the all-affected principle, which in the TA context means that all who are affected by science and technology should have a right to participate in decision-making about it. Based on the all-affected principle, globalization sets additional demands on the theory and practice of TA, both at the national level and beyond. Since science and technology and their social consequences are global phenomena, TA should, according to the all-affected principle, take into account the groups of people that are affected worldwide, and not only in the country where TA is organized. Below, we reflect on how globalization, including science and technology and the public sphere, challenges TA and its connection to the public sphere on both a national and international level. Analogous to Sect. 2, we use the tripartite division between TA activities that study the public sphere, inform the public sphere, and stimulate and involve the public sphere (cf. Hennen, 2021).

6.1 National TA as a Site of Globalization

TA is institutionalized in many OECD countries, but not in many developing countries. So there is literally still a world to win. Here, we focus on countries with TA capacity. Like the nation state and national public spheres, national TA has become a site of globalization. Based on the all-affected principle, globalization forces national TA, which also values inclusivity, to broaden its field of view with regard to public spheres (cf. Ely et al., 2014).

Central questions for TA activities are which scientific and technological developments to address and which groups affected by those developments will be included in a TA study. The globalization perspective calls for special attention for groups that are often not included, such as cultural minorities or new immigrant citizens, young people with an internalized global perspective, and groups in other countries, especially developing countries, who experience the consequences of new scientific and technological developments. Minorities can be much affected by developments such as ethnic profiling and AI, and the robotization of warehouses, but may lack the time, language skills, and organizational capacity to organize themselves into an active public and make themselves heard in the public debate. It is perhaps even more difficult to make visible and audible those groups from other countries who are affected by, for example, the testing of medicines, the dumping of electronic waste, or IVF through international surrogacy. A category that is easily left out are those migrants who do not have civilian status in any country. This means that the globalization perspective should also be taken into account when selecting topics for TA studies—such as the role of technology in migration policy (Dijstelbloem & Meijer, 2009).

Paying attention to the groups identified above also has consequences for informing the public sphere and the various audiences within it. Informing them may require translation of results into specific languages, and the use of interpreters during debates. Translations into English in particular ensure that the results can be disseminated worldwide.

With regard to the stimulation of S&T-like public spheres through participatory TA activities, the choice of topics and participating groups also plays a role. Above, we saw that the Royal Society choose a global perspective on nanotechnology and organized stakeholder discussions in Nepal, Peru, and Zimbabwe. Reflecting on the transnationalization of the public sphere, Couldry wonders how Polish minorities can be given a more prominent place in the British public debate and states: "Don't the voices of migrant workers in Britain, and indeed their families abroad that depend on their remitted income, need to be heard more in British media than at present?" (Couldry, 2014, 55). Modern media makes it possible to give people from all over the world a voice in a national debate. When involving the viewpoints of people internationally, cooperation with TA practitioners in other countries can be sought. In this way, the TA capacity in such countries can also be strengthened. This brings us to the topic of TA and public spheres beyond national borders.

6.2 TA and Public Spheres Beyond National Borders

A reflection on TA and public spheres beyond national borders should start with two observations. First, there is as yet no such thing as a European, let alone global, political, and public sphere. From a global perspective, there is a patchwork from democratic to authoritarian public spheres. At the same time, we have shown two examples—the anti-apartheid and climate change movements—in which civil society actors succeeded through sustained effort in building public spheres of global scope that have had cultural and political influence at national and global levels. Both movements simultaneously constructed national counter-publics and a global counter-public, which both interacted and also acted autonomously (cf. Thörn, 2007, 912). Moreover, these movements democratically transformed public spheres.

The second remark concerns the global state of TA. Overall, the institutionalization and financing of TA in many developing countries and at an international level are still relatively weak. At the same time, we outlined a wide range of expert-based and participatory TA activities carried out by TA organizations and networks at both European and global level. Table 1 therefore shows what is possible in principle in the field of international TA and thus outlines a kind of blueprint for the future of global TA. That blueprint consists of a mix of Decision-Making Body and Institutional Network options to organize expert-based and participatory TA at an international level. Unfortunately, the Decision-Making body route is currently not used to organize participatory TA activities.

So what are the possibilities for TA at an international level to research, inform, and stimulate S&T-like public spheres? The need and potential for TA to do such things beyond national borders are strong, but are used far too little, because the lack of political vision and capacity means that both institutionalization and funding lag behind. As the history of the anti-apartheid and climate change movements shows, building a public sphere with global reach can take decades. The same goes for European and global TA. The first forms of expert-based TA according to the Decision-Making Body option at European level (see STOA) and global level, including both democratic and authoritarian states (see IPCC), arose in the second half of the 1980s. Expert-based TA according to the Institutional Network route was set up in Europe in 1990 (EPTA) and was recently established on a worldwide scale in 2018 (Global TA network). Participatory TA was organized at the European level between 2005 and 2007 (Meeting of Minds) and at the global level between 2008 and 2009 (World Wide Views on Global Warming). All such international TA activities can in principle be expanded and should be expanded from the perspective of globalization of science and technology and its consequences. According to the blueprint of Table 1, we can think of expanding the Global TA network and its funding so that the network can carry out international expert-based and participatory TA activities. Or, by analogy with the IPCC, we can think of setting up an Intergovernmental Panel on Artificial Intelligence or Synthetic Biology. So although much is desirable and possible, a lack of political vision will often stand between dream and action.

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Technology Assessment in Developing Countries: The Case of India—Examples of Governmental and Informal TA

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1 Introduction

Technology assessment (TA) has a rich history of more than fifty years. Especially, in many developed countries, TA is part of the institutional framework surrounding science, technology, and innovation (STI), or part of the policy advice system that enables parliaments to understand, debate, and decide on STI issues. TA is a generic term and there is a broad variety of different types and practices of TA (cf. van Est & Brom, 2012). TA can be considered as a stand-alone exercise or policy tool, or may be used with other policy tools, including analysis of ethical, legal, and social issues (regularly abbreviated as ELSI). According to Grunwald, TA should "enrich technology governance by integrating any available knowledge on possible side effects at the early stage of decision-making processes, by supporting the evaluation of technologies against a broad set of societal values and ethical principles, by elaborating strategies to deal with the inevitable uncertainties, and by contributing to the constructive handling of societal conflicts" (Grunwald, 2019, 702). He also suggests anticipation, inclusion, and complexity as three conceptual dimensions of TA (Grunwald, 2019, 704).

In most developing countries, TA is weakly institutionalized, or not at all. This has little to do with the fact that TA is not relevant for developing countries. For example, in the context of the UN Millennium Development Goals (MDG), Ely et al. (2011) underscored the need for TA for developing countries. Moreover, UNCTAD,

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which is the part of the United Nations Secretariat dealing with trade, investment, and development issues, currently sees a growing interest in TA and points out its relevance for sustainable development. In 2021, UNCTAD (2021, 82) launched the project, "Technology assessment in the energy and agricultural sectors in Africa to accelerate progress on Science, Technology and Innovation," which aims to build capacity in three African countries to carry out technology assessments in the energy and agricultural sectors, and to utilize technologies as catalysts for sustainable development. If TA is to contribute to sustainable development, particularly in meeting the UN Sustainable Development Goals (SDGs), what needs to be done? If we see TA as an important practice for developing countries, then how can that practice be institutionalized? And if developing countries do not have robust STI policies, and have weak institutions for doing TA, will the typical TA approach work, or is a modified form of TA needed?

This chapter examines TA in India, as an example of a developing country, and describes various types of TA being undertaken by different actors. It is argued that in developing countries like India, where the state plays a major role in stimulating and regulating STI, civil society may provide an important alternative perspective on STI, which may lead to STI becoming a contested terrain. Societal engagement may also support alternative forms of innovation that are not initially recognized by the formal innovation system. In this way, civil society may pave the way for more participation in STI and/or may lead to a further institutionalization of TA practices—similarly to what happened historically in European countries such as Denmark and the Netherlands.

As Rip (1986) and Cambrosio and Limoges (1991) have argued, both societal deliberations on and controversies surrounding STI can be considered as informal processes of TA. Such informal TA activities may open up spaces for citizens and societal stakeholders to intervene in the development and decision-making processes around STI. Moreover, formal TA can be considered either as a social process working largely in a space created by societal controversies, or as the wish to prevent such controversies. The role of public controversies around STI is relevant in each country, but likely even more so in developing countries, where formal TA is weakly institutionalized. We will argue, therefore, that both formal and informal TA are needed and can complement each other. So any study on TA in developing countries should go beyond the traditional view of TA. This is exactly what we want to do in this chapter.

For this, we can use the institutional perspective provided by Ganzevles et al. (2014) on the TA landscape. These authors model TA as an activity at the interplay between four spheres: parliament, government, science and technology, and society. TA can act as a mediator of knowledge and actors between these spheres. In the literature, there is relatively more attention for TA directed towards members of parliament, known as Parliamentary TA (PTA), that is: "technology assessment specially aimed at informing and contributing to opinion formation of the members of parliament as main clients of the TA activity" (Enzing et al., 2011, i) But actors from the three other spheres can also act as clients of TA. In cases, where scientists and engineers are the main addressees, TA can be used as a means to guide research and technology development from a societal perspective. The term constructive technology assessment is regularly used to pinpoint TA that is aimed at influencing technological choice and design processes (Schot & Rip, 1997). Policy-makers are also potential clients of TA. The task of TA is then to inform them about the societal aspects of science and technology. TA activities can also be aimed at the general public in order to stimulate the public debate on science and technology in society.

India has no parliamentary TA organization. Most TA-like activities and practices are organized by and for governmental agencies. Such policy advising TA has been somewhat en vogue, although the term TA is not usually explicitly mentioned. Section 3 describes three examples of governmental TA in India. First, the central role played by the Technology Information, Forecasting and Assessment Council (TIFAC) under the Department of Science & Technology (DST) (Ministry of Science & Technology) is described. In addition, the role of health technology assessment and TA for pollution control and prevention is described. Section 4 provides an example of constructive TA, whereby TA plays a role in the social shaping of technology. This type of TA has been used to evaluate and adopt crop varieties. Section 5 provides various examples of formal and informal TA activities that are directed towards the public domain. In Sect. 6, we draw some conclusions. But first, we reflect on the role and relevance of TA for developing countries in general.

2 Some Reflections on TA for Developing Countries

Over the past two centuries, economies and societies have been reshaped by successive waves of technological change. Global technological change clearly has two faces, in particular for developing countries. On the one hand, STI is seen as a driver of economic and social inequalities between and within countries. On the other hand, STI has helped to reduce poverty in low-income countries, like China and India, but also including countries in Africa, as shown for example by the impact of smartphones. Regardless of whether more attention is paid to the opportunities or risks of STI, it is widely acknowledged that STI has key roles to play in achieving the MDGs and thus are of great importance for developing countries. It is, therefore, crucial that developing countries have the capacities to avoid or mitigate the risks of STI and to seize its opportunities, especially from the perspective of the many challenges that exist in the field of poverty reduction, the need for sufficient healthy food, social justice, and sustainability (cf. Pansera et al., 2020). According to UNCTAD (2021, 102), foresight and TA initiatives may help "to better understand the socio-economic and environmental implications of new and innovative technologies," and "to identify the risks and benefits of technologies and the policy options for steering innovation so as to leave no one behind."

2.1 Technology Transfer and Needs Assessment

Since there remains a large technological gap between developed and developing countries, one important way to interpret the importance of TA for developing countries is to place it in the context of technology transfer. Kebede and Mulder (2008, 91) state that "The dominant mode of thinking in most developing nations is that one should try to obtain the sophisticated technologies from industrialized countries, with very often a lack of understanding for the preconditions for these technologies to be successfully applied." The authors state that needs assessment and TA could greatly increase the chances of success of technology transfer. However according to Kebede and Mulder (2008, 91) "… both formal and informal TA are almost absent in most developing nations. … So in general, not even an informal TA takes place." Given this current situation, they have developed an accessible TA framework for developing countries in order to link technology transfer with TA and needs assessment (Table 1). This framework identifies four types of relevant factors—technical, economic, institutional, and ecological—that should be addressed before a specific technology is transferred to the respective country and social practices.

A major advantage of this framework is its simplicity and the identification of practical aspects that are important for a TA in the context of technology transfer. As many developing countries are also major importers of technology, this framework can be used to perform TA in a rudimentary manner. The framework, however, pays little attention to legal issues (except for patents and licences), and basically ignores ethical issues, and issues related to access, equity and inclusion, which are crucial for developing countries.

Table 1 Technology assessment factors (*source* Kebede & Mulder, 2008)

Technical factors	• Physical facilities (infrastructures and support technologies) • Services and systems (operation and maintenance)
Economic factors	• Human resources (both technical and non-technical expertise) • Capital, land, and raw materials • Macro-economic conditions • Market and property right (patents and licenses)
Institutional factors	• Organizational factors (structure, flexibility for change, and decision-making) • Social factors (religion, taboos, language, concepts of time and honour, respect, and work ethics) • Cultural factors (taste and habit) • Political factors (political instability and corruption)
Environmental factors	• Geographical and climatic conditions • Ecological systems imbalance, and human health effects • Effects of pollution • Resource depletion and environmental destruction

2.2 TA for Access, Equity, and Inclusion

Recently Cozzens (2021) cautioned that STI policies tend to enhance inequality, unless they are particularly designed to be otherwise, and this should be analysed by practitioners of STI policy. She has pointed out that alternative designs are possible to address this. Seen in this light there can be a role for TA in assessing whether innovation can be designed to be inclusive or reduce inequality caused by STI policies. TA combined with what is known as equity assessment may offer a solution here. For example, in the field of health TA (HTA), Benkhalti et al. (2021) developed a check list for equity considerations. Moreover, we may be inspired by forms of inclusive innovation (UNESCAP, 2021), grassroots innovation (Smith et al., 2016), and frugal innovation (Hindocha et al., 2021) that are specifically aimed at promoting equity and broad access to the benefits of technology, an objective often not met by the traditional forms of innovation.

Finally, we want to draw attention to the access, equity, and inclusion (AEI) framework, which is under development at the Research and Information System for developing countries (RIS) in India (Chaturvedi et al., 2015). The basic idea is that the assessment of the societal benefits of STI needs to be based on a set of broadly accepted public values and norms. Since from a societal perspective, access, equality and inclusion are particularly relevant for developing countries, the framework uses AEI indicators to assess the impact of STI in these areas. This is under development and more work is required, particularly regarding indicators. Linking this with STI policy has been proposed, and some of the suggestions have been identified as useful for developing further (Srinivas, 2020). This framework can contribute to the existing theorization and literature on equity, inequality, and inclusion in STI, and design of policies that antidote trends that result in inequitable distribution of outcomes and benefits (c.f. Cozzens, 2021; Mirza et al., 2019; Bozeman et al., 2011).

2.3 Participatory TA

Ely et al., (2011, 7) hold that conventional TA studies are often not sufficient, since "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." They claim that more participatory models of technology assessment that combine citizen and decision-maker participation with technical expertise are required, which "position technologies within dynamic pathways of change at the system level, recognize alternative understandings of these systems by different groups within society and attempt to build resilience in the face of pervasive uncertainty" (ibid.). As such, these participatory TA activities "can contribute to more democratic governance—not only of science, technology, and innovation, but also more widely." (Ely et al., 2011, 10).

We are sympathetic to this appeal for the use of participatory methods of TA in developing countries. However, it is important to ask, in which political and institutional situations will and can such methods actually be used? A first crucial issue is whether there is a political will to engage with participatory TA. In cases, where a technocratic model of development is dominant there may be no support for public and multi-stakeholder engagement. Besides the will to use participatory TA, such methods also presuppose the organizational TA capacity and, maybe more importantly, the presence of organizations that can represent various stakeholders. So the use of participative TA methods is particularly desirable in socially controversial technology. But if that option is not politically feasible or practically impossible to realize, due to a lack of organizational TA capacity or the lack of organizations that can bring relevant societal perspectives, then conventional TA may be a feasible fall-back option. Analysing TA in theory and practice in India can give some ideas and insights into the adoption and adaptation of TA in developing countries.

3 Governmental TA in India: For S&T, Health, and Pollution Policy

In India, the state is the dominant player in STI, playing multiple roles including regulator, policymaker, promotor, and agenda-setter. The same counts for TA, a field where private organizations are absent. Thus, given its prominent role, describing governmental TA is essential for understanding the state of TA in India and exploring potential future pathways. This section provides three examples of governmental TA. We will first describe the S&T policy advice role played by the Technology Information, Forecasting and Assessment Council (TIFAC), which is the primary agency for TA in India. Secondly, the emerging role of health technology assessment, which is strongly promoted by the government, is described. Finally, we will cover the application of TA for pollution control and prevention.

3.1 The S&T Policy Advice Role of TIFAC

S&T ecosystem and policy

For a long time in India, the private sector invested little in S&T, which made the state the prime mover, in terms of funding S&T development. The state has funded both basic and applied research through different ministries and research councils (see Box 1). In 1991, India embarked upon a series of reforms that reduced governmental control over technology imports and opened up the economy for greater investment and capital flows from abroad. Technology liberalization, removal of restrictions on royalty payments, reduction in tariffs of capital goods imports coupled with the implementation of WTO Agreements, gave much scope for the private sector in technology acquisition and transfer. Since then, the S&T ecosystem in India has grown and diversified. And the focus of S&T policy has shifted to incentivizing innovation in both public and private sectors, and leveraging start-ups and venture capital as new sources for innovation. Over recent years the share of the private sector is steadily increasing. India has emerged as a major destination for R&D centres set up by multi-national companies (MNCs). Bi-lateral and multi-lateral co-operation in S&T has been expanding and is also diversifying. India is also a member of, or associated with, various mega-science-projects, such as CERN, the European Organization for Nuclear Research in Geneva.

Box 1. Key Departments/Agencies Dealing with STI (Source: Srinivas et al., 2018)

- Council of Scientific and Industrial Research (CSIR) under the Ministry of S&T
- Department of Science & Technology (DST) under the Ministry of S&T
- Defense Research and Development Organization (DRDO) under the Ministry of Defense
- Department of Atomic Energy (DAE) under the Prime Minister
- Department of Space (DoS) under the Prime Minister
- Department of Biotechnology (DBT) under the Ministry of S&T
- Indian Council of Agricultural Research (ICAR) under Department of Agricultural Research
- Indian Council of Medical Research (ICMR) under the Department of Health Research.

S&T policy in India is strongly guided by the techno-positivist idea that S&T is a non-controversial tool for modernizing and developing the country. India is quite committed to centralize planning in S&T and uses five year plans for targeted development in different sectors. So-called “Missions” are presented in specific medium- to long-term programmes to build capacity, develop self-reliance in specific sectors, and harness technologies to meet national objectives. There have been many missions, ranging from the peaceful use of atomic energy, to exploring Mars. Since 1988, the activities of the Technology Information, Forecasting and Assessment Council (TIFAC), under the Department of S&T, have played a central role in developing these plans.

S&T policy advice: TIFAC

The Advisory Committee for Coordination of Scientific Research (ACCSR) was active from 1948 to 1955. Since its establishment, there have been many committees and institutional mechanisms to provide S&T policy advice. Until 2014, the Planning Commission which prepared the five year plans and evaluated their performance had a division on S&T. Its successor, NITI Aayong, also has a division on S&T, while in 2018, the Office of the Principal Scientific Advisor was created.

There are internal ministerial mechanisms in place to evaluate and assess various S&T programmes, study the impacts and examine the outcomes vis-a-vis the costs and estimated benefits. External evaluations by agencies like the Comptroller and Auditor General of India is limited to the functioning of regulatory frameworks and administrative activities (e.g. CAG, 2016).

The Technology Policy Statement of 1983 signalled a need to undertake systematic technology forecasting and assessment on a continuous basis and make it compulsory for ministries and departments involved in large investments or large volumes of production. Three years later, the Cabinet approved the formation of the Technology Information, Forecasting and Assessment Council (TIFAC) under the Department of S&T. And in 1988, TIFAC was set up as an autonomous organization. Its broad mandate emphasizes conducting studies and giving policy advice.[1] TIFAC was to work with stakeholders including industry, and conduct studies in forecasting and assessment. It has undertaken technology missions besides conducting feasibility studies. As an autonomous organization its mandate and operational freedom are broad, and there is no other institution in India that plays a role similar to TIFAC.

The then Secretary of the Department of S&T (DST), Vasant Gowariker, hoped that with the creation of TIFAC and the TIFA network "… the national capabilities in the area of technological planning and assessment will be strengthened. This will contribute to the much needed inputs and advice for improved socio-economic and industrial planning" (Gowariker, 1988). At the time, it was envisaged that there would be TIFAC Groups at various ministries and industry levels.

TIFAC's approach

The founding of TIFAC was based on a strong belief in technology and centralized, top-down expert-driven policy advice, planning, and implementation in the field of S&T. As a result, TIFAC's approach is expert-driven and technology-oriented. At the same time, TIFAC's approach has been holistic, covering the entire innovation chain, including commercialization and upgrading, economic benefits, and meeting societal needs. A five step process is employed: (1) brainstorming, (2) defining the scope of assessment, (3) defining the time horizon to be covered, (4) assessing the effects of technology, and (5) analysing policy options. Given its broad mandate, TIFAC uses forecasting and integrated that with TA. This integration was done "with practical goals in mind, namely to create alternative technology trajectories for various important sectors with broad acceptance from stakeholders, ranging from scientists to industrial and technical personnel, to business leaders and government" (Bhatnagar & Jancy, 2003, 24). As such, TIFAC needed to look at available technologies, and alternatives, and situate TA in the larger context of using S&T for national development.

According to Bhatnagar and Jancy (2003), TIFAC focussed on capacity-building and global competitiveness, evaluated emerging technologies, and assessed technologies for promoting sustainable development. TIFAC worked across sectors and managed technology missions concerning the utilization of bamboo, fly ash,

[1] See: https://www.tifac.org.in/index.php/about-us/mandate.

construction waste, and nicotine waste, and the commercial extraction of potash from sea water. TIFAC has been doing TA with the motto of "make technologies work for people" in different sectors of the economy. For this, the council assessed technology readiness levels, societal needs, and the socio-economic and technology import or development needed to provide for those needs. Given the importance of developing alternative technologies and substituting imported technologies with indigenous ones, TIFAC played a key role in technology assessment and absorption. In 2012, TIFAC claimed that it had completed more than 500 technology assessment, demonstration and development projects, involving more than 1500 experts. Although TIFAC's TA is done to assess utility and relevance for the users, it seems to be driven more by the institution than by users or society. There is hardly any reference to participatory TA or constructive TA in its work.

Although TA was one of the key initial mandates of TIFAC, TIFAC is now more focussed on technology forecasting exercises. TIFAC developed a Technology Vision 2035 and follow-ups to that and is involved in scaling up of technologies. However, its work on emerging technologies does not seem to have a TA dimension. With focus on forecasting and foresight studies, and on ideation and scaling up, TIFAC is active on many fronts. According to Goswami and Selvan of TIFAC, TIFAC has employed TA in a particular mode.[2] In the Technology Vision 2035 program, technologies were assessed based on their technology readiness levels and to what extent they were able to address the needs of citizens of India.[3] Similarly, for preparing their Technology roadmaps, TIFAC has identified many technologies after carrying out TA-like processes. Recently, TIFAC did a comprehensive TA exercise and identified technologies in 10 key sectors for the governmental climate change mitigation and adaptation agenda. Currently, TIFAC prepares a database of Global Technologies and assesses India's needs by means of a quantitative multi-criteria decision analysis (MCDA). Moreover, an assessment of technologies developed in Indian R&D institutions is underway, which analyses the scale of their adoption, economic feasibility, and commercial potential.

3.2 Health Technology Assessment

The government supports health technology assessment (HTA) in India, which is emerging as an important component in decision-making on medical technologies and treatments. In 2017, the Government of India proposed setting up a Medical Technology Assessment Board (MTAB).[4] But later this idea was replaced with the health technology assessment in India network (HTAIn).[5] HTAIn comprises of three

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[2] Based on e-mail communication with Janice Selvan and Gautam Goswami, 13 December 2021.

[3] See: https://www.tifac.org.in/index.php/programmes/activities/technology-vision-2035.

[4] See: https://nhm.gov.in/New_Updates_2018/Innovation_summit/6th/Health_Technology_Assessment_in_India_Deptt_of_Health_Research.pptx.

[5] See: https://pib.nic.in/newsite/mbErel.aspx?relid=157976.

organizations, including HTAIn Secretariat, HTAIn Technical Appraisal Committee (TAC), and HTAIn Board. The HTAIn Secretariat collaborates with identified technical partners (TPs) and regional resource hubs (RRHs). Requests to conduct a HTA study can emanate from health departments in central and state governments. The HTA study goes far beyond cost–benefit analysis and has to be rather comprehensive; it should also include systematic literature reviews, economic evaluations, measuring and valuing the health outcomes, and analyses on equity and access issues. An HTA also has provisions for stakeholder consultations. For example, the "HTA of intraocular lenses for treatment of age-related cataracts in India" published in 2018 addresses equity issues through literature survey, compares different technological options and makes recommendations.[6] Finally, the HTA report, together with a policy brief, is sent to the department that requested it (Jain et al., 2018).

3.3 Governmental TA for Prevention, Control, and Abatement of Pollution

In the National Clean Air Program (NCAP 2019), the Ministry of Environment, Forest and Climate Change (MoEFCC) announced that a Technology Assessment Cell will be established. According to NCAP (2019, 60f.) the Technology Assessment Cell is envisaged to:

- evaluate significant technologies with reference to prevention, control, and abatement of pollution;
- to focus on both indigenous and international monitoring and abatement technologies, ranging from engineering and chemical to biological technologies, including extensive development of plantations
- contribute towards evaluating the technology and devising the mechanism of technology transfer under various bilateral and multi-lateral agreements.

This is a welcome development given the need to curb pollution and address issues related to climate change. The Technology Assessment Cell will use the existing mechanisms and programmes of the Department of Science & Technology and the India Innovation Hub (NCAP 2019, 61). Moreover, it will involve the Indian Institutes of Technology (IITs), Indian Institutes of Management (IIMs), major universities and industries. However, the involvement of other stakeholders is not mentioned, nor does a consultative mechanism seem to be envisaged. Thus, it seems that a technocratic exercise is envisioned, involving experts, academic institutions, and industry.

From the above, it is clear that TA is growing in India, in terms of themes and as a relevant input for policymaking, particularly in the field of health. Some of the activities on TA are linked with other objectives such as transfer of technology (ToT) and diffusion of technology.

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[6] See: https://dhr.gov.in/sites/default/files/htaincataract_0.pdf.

4 Constructive TA: Evaluating and Adopting Technologies in Agriculture—ICAR

4.1 Extension and Technology Assessment and Refinement

In India, there are many agricultural research organizations and activities, such as agricultural universities, private sector entities, farmers doing research, and civil society-supported initiatives. The Indian Council of Agricultural Research (ICAR) is the premier research agency in agriculture in India. ICAR engages in technology development and assessment through research laboratories and extension centres. Extension is a service or system which assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their standard of living and lifting social and educational standards. The agricultural extension system was developed in the 1960s and was expanded on account of the Green Revolution. At that time, the focus was on adopting technology, and not on TA.

In 1995, ICAR institutionalized technology assessment and refinement (TAR) as part of the extension services, through the Institute Village Linkage Programme (IVLP), in 42 centres linking with 42,000 families (ICAR 1995, 6). TAR is meant to assess technologies at the field level and refine them in such a way that they will fit the ecological, social, and technological context of farmers. Important questions within the TAR, therefore, are (ICAR 1995, 10): What are the constraints in the farming system? Which indicators do farmers use to assess the various technologies for their worth, or relevance, and could there be rationality in adopting, rejecting, or modifying a technology? Are there differences among the indicators chosen for technology assessment by big, small, and marginal farmers? (ibid). The objective of the TAR is thus to produce and transfer technologies that are suitable, based on the needs and aspirations of the farmers.

4.2 Krishi Vigyan Kendras (KVKs) as Extension Centres

The Krishi Vigyan Kendras (KVKs) act as extension centres and disseminate technologies. As part of their work, they do technology assessment, technology evaluation, and refinement. KVKs are the key component of TA in agriculture in India although their work goes beyond TA. For ICAR, TA is part of its mandate to help farmers and society through the development, dissemination, and adoption of technologies. As a public sector research institution, ICAR is funded mostly by the Government of India and also collaborates with stakeholders, in particular farmers, in TA-related activities.

Spread across different states and climatic zones of India, there are 722 KVKs that play a part in the testing of crop varieties and other technologies in farmers' fields (ICAR, 2020). In 2019–2020, more than five thousand technologies were assessed in some thirteen thousand locations through more than twenty-five thousand trials. For different assessments, different criteria, like drudgery reduction, and purposes, like resource conservation, value addition and production of planting materials, are included. Regarding livestock, 1034 "technological interventions" were made in 3338 locations, with 5156 trials related to different themes, such as disease management, breed evaluation and production management. KVKs are involved in demonstrating the potential of new plant varieties and technologies developed by ICAR (ICAR, 2020, 143). Besides analysing samples for farmers, KVKs produce seeds and planting materials. Thus, in ICAR, TA is integrated in many developing technological activities. This type of TA is known as constructive TA, which implies that ICAR is both the developer and assessor of technology. Similarly, both assessment and adaptation are done by ICAR, or under its aegis through the KVKs.

ICAR also does participatory technology assessment (pTA) in a limited way. But the issue is complicated by the fact that TA activities are linked with adaptation, since "Technology assessment is one of the main activities of KVKs to identify the location specificity of agricultural technologies developed by the National Agricultural Research System (NARS) under various farming systems." (ICAR, 2020, 6). Refinement, therefore, is linked with TA, and TA results in refinement. For example, according to ICAR, demonstration in a participatory mode resulted in adoption of pineapple as an intercrop as it scored 86.6 in the Sustainable Livelihood Index (ibid., 138). However, it is not clear how this Index was developed or whether the same index is used for different agro-climatic zones with the same methodology and data set. Other projects have made use of the Sustainable Livelihood Security Index, developed by the Department of International Development (DFID) for different agro-climatic zones, to assess the livelihood of cassava and rice paddy-growing farmers in Tamil Nadu, and used this assessment to suggest which crops and farming methods are preferable.

4.3 Gender Assessment of Technologies

ICAR's Central Institute for Women in Agriculture is the leading institute in gender assessment of technologies. ICAR links TA with gender empowerment by assessing how technologies could help women to reduce their drudgery and enhance livelihoods. According to the Annual Report "Farm women related 280 technologies were assessed through 2,797 trials at 699 locations. Major themes under this category were drudgery reduction (technologies 92, trials 880, locations 126), and health and nutrition (technologies 59, trials 492, locations 74)." (ICAR, 2020, 153). In this, ICAR evaluates the available technologies, "Drudgery experienced by women was assessed on a 5 point scale, with the highest score given to drudgery experience during marketing of fish (28.01). Two model prototypes of disc ridger—a primary soil tillage machine—were tested and developed based on the anthropometry and strength of farm women. As a part of livelihood improvement of tribal farm women through secondary agriculture, technological interventions in the processing of ragi, mango, tomato, and cashew nut were given to tribal women of Ganjam district and a schematic model for establishing small scale enterprise was developed." How exactly the notion of gender is integrated in TA is not clearly known. Moreover, there has not yet been an external or independent evaluation of ICAR's role, and that of the KVKs, in TA and how successful its TA activities have been.

In summary, ICAR has institutionalized TA in agriculture and has been sensitive to women's issues and concerns. This shows that formal systems for TA are widely used in India. The TA methodology is oriented towards adapting a technology which is developed elsewhere, to suit local conditions. Such a locally constructive TA approach is valuable, but not sufficient for controversial technologies, such as GM crops, which need a more comprehensive socio-economic impact analysis, which include the perceptions of all relevant stakeholders. A locally constructive TA should be able to weigh technological options and alternatives. ICAR's TA is oriented towards adapting the technology in question. For controversial technologies, a different type of constructive TA is needed that pays attention to the usefulness and necessity discussion surrounding such technologies.

In such cases, firstly, there is a more generic usefulness and necessity discussion needed, in which conflicting visions can play a role, and secondly, there are various social issues that go far beyond the local application level, such as dependence on large biotech companies, and the future role of organic farming in India.

5 Formal and Informal Participatory TA in the Public Domain

India has a rich history of civil society engagement with S&T. In this section, we discuss the case study of Bt brinjal in which the government experimented with participatory TA. Next, we describe some examples of the engagement of civil society with STI. These examples could be described as informal participatory TA-like activities (cf. Rip, 1986). In order to contextualize these examples, it is important to first outline three relevant Indian political-cultural visions of the social role of science and technology.

5.1 Three Political-Cultural Visions on the Relationship Between S&T and Society

Prior to 1947, civil society initiatives were focussed on science education, communication, and popularization. Post-1947, such engagements include people's science movements (PSM), movements against specific policies, projects, and institutions, as well as initiatives for promoting the development of alternative technologies. At the risk of simplification, the responses to S&T in India can be organized into three categories: Nehruvian, Gandhian, and the leftist vision of the PSM.

The Nehruvian approach represents the dominant understanding and thinking based on state-led S&T, and faith in its power and potential for socio-economic development. S&T is also regarded as an alternative mode of thinking and practice, and the Nehruvian scientific temper is part of this. This understanding had an almost unquestionable faith in S&T, and saw only the positive aspects of S&T, ignoring the negative ones as exceptions, or failures of individuals and organizations, rather than as a quality inherent in S&T. Hence, it supported large dams, nuclear power, green revolution, and other technology missions.

The Gandhian thinking inspired institutions and individuals who accepted the view that science without morals is a form of sin, and that S&T should be used for people, and decentralized production and consumption. Its rejection of the idea of endless growth is in a sense a harbinger of the current notion of de-growth. This response to S&T is concerned with an uncontrolled expansion of S&T that results in a concentration of wealth, growing inequities, and centralization of power and control. As a result, its supporters sought human-centred alternatives that focussed on community concerns and technology in the hands of communities. There are many institutions that are inspired by Gandhi and his ideas on S&T. Some of them are supported by the state—in particular, the Science for Equity Empowerment and Development (SEED) Division of DST—while others are based in institutions of higher learning and research. While these institutions are more focussed on developing alternatives and getting adopted, the people's science movement has provided both a critique and suggestions for alternatives.

The leftist PSM in India is critical of S&T policies. It favoured linking science with social revolution and alternative approaches to S&T. It took positions that were critical without romanticizing village life or questioning technology solely on the basis of size and impact. Inspired by the USSR and China in the initial years, the PSM later built an indigenous discourse on S&T that accepted people's knowledge without romanticizing it.

While the Nehruvian approach and the leftist PSM give importance to the modernizing potential of S&T and its use for societal transformation, the Gandhian approach emphasizes rural industrialization that meets people's basic needs of through decentralized production and consumption, and the use of small and intermediate technologies. These approaches have had their share of influence in S&T policy. In terms of TA, Nehruvian and leftist PSM consider formal TA as important. Moreover, the PSM sees public engagement and assessment as important. In the Gandhian approach, TA will be based on ethics, values, and the realization of societal goals, and how technology enables democratic sovereignty of the people, in particular the poor and vulnerable.

5.2 Governmental Participatory TA: The Case of Bt brinjal

A major exercise in TA involving the public at large was undertaken in the case of Bt brinjal. This genetically modified brinjal (also known as eggplant or aubergine) was created by inserting a crystal protein gene (Cry1Ac) from the soil bacterium Bacillus thuringiensis (Bt) into the genome of various brinjal cultivars. For example, the University of Agricultural Sciences in Dharwad, in the Indian state of Karnataka, chose six varieties (malapur local, majari gota, udupi gulla, rabkavi local, kudchi local, and GO-112) for Bt transgenic conversion (Krishnaraj et al., 2009). The initial work was started in 2000 and it took about nine years for trials to be completed and evaluated. After multi-state, multi-trials, and assessments of performance of the outcomes, Bt brinjal was recommended for commercial cultivation in 2009 by the Genetic Engineering Advisory Committee (GEAC).[7]

But this development was contested by many civil society organizations. The extensive debate on Bt brinjal brought into sharp focus the divide on the use of GMOs in agriculture, as well as questions on the regulation of agricultural biotechnology. Then, the Minister for Environment and Forest, Jairam Ramesh, called for a public consultation and sought comments and inputs from the wider public. The consultations were held in 2010, from January 13 to February 5. And on 9 February 2010 the Government of India declared a moratorium on the release of Bt brinjal for commercial use and cultivation, which is still in force. The government cited lack of evidence of safety as the reason.[8]

Another reason might have been that states like Karnataka, Uttarakhand, and Himachal Pradesh, had already decided to not allow cultivation of Bt brinjal, to avoid a confrontation in the absence of a consensus. Commenting on this controversy, Shah (2011, 37) pointed out that "The social and scientific appraisal of Bt brinjal, thus needs to be based on a methodology that can combine … scientific expertise with democratic participation, and such an appraisal also needs to include the issues of injustice in the assessment of insecurity."

This broad public consultation could be considered as a pTA, as it opened up for the first time a broader process of public engagement with technology, instead of narrowing it to issues of safety as decided by scientists and expert views. But this TA conducted by the government was the first and last one on agricultural technology, or for that matter on any technological intervention. Interestingly, while opening up the consultation to the public, the government did not indicate any preference, neither in support of nor opposition to Bt brinjal. So this exercise in TA, if we can call it so, reinforced the view that such forms of pTA are feasible in developing countries.

Despite the moratorium, the research on genetic engineering applications in agriculture has not stopped, and the divide in opinions continues. Although there have been no further approvals for the commercial use or cultivation of GM, India has not yet taken a clear stand on not using GM technology. Moreover, there is no official policy on adoption of gene-edited crops in agriculture. Thus, while this exercise in

[7] See: https://www.isaaa.org/resources/publications/pocketk/35/default.asp.

[8] See: https://prsindia.org/theprsblog/to-eat-or-not-to-eat-bt-brinjal.

TA resulted in a decision, it neither opened up opportunities for such exercises in the future, nor brought clarity in policy.

5.3 *Civil Society Engagement with S&T—Informal TA*

There have been many examples of technology development and evaluation centred on the needs of the poor, with the objective of developing and adopting pro-poor innovations. Abrol (2014, 373–374), however, holds that "pro-poor innovation generation and diffusion in India have not been successful, because … Technology platforms, ecologies, and pro-poor innovation systems were not constructed with the pragmatic aim of achieving ecological and social justice and economic empowerment of the poor—but as a residual socio-technical system without ensuring any systemic competitiveness."

But we can look at controversies as types of informal TA, using examples like the Silent Valley controversy. The Silent Valley Movement started in 1973 to save the Silent Valley Reserve Forest from being flooded by a hydroelectric project. As a result, the government abandoned the power project on account of assessments by civil society group KSSP, whose concerns were shared by others. In terms of technology development and adoption, a first example is the system of rice intensification (SRI), which is a farming methodology aimed at increasing the yield of rice. It is a low-water, labour-intensive method that uses younger seedlings singly spaced and typically hand-weeded with special tools. Although at first the S&T establishment ignored it, SRI later became widely accepted as a workable model. A second example is the promotion and adoption of community seed banks as an alternative approach to institutionalized S&T seed banking. Community seed banks were promoted by Deccan Development Society (DDS) as part of its response to technological changes in agriculture induced by the Green Revolution and the introduction of GMOs in agriculture, particularly Bt cotton. DDS works with women's groups in about seventy-five villages in Telangana State. DDS promotes natural farming and organic agriculture as an alternative to GMOs. The 5,000 women members of DDS have developed community-based food sovereignty systems based on local knowledge, including grain, and seed banks.

In all these instances, there were no formal TA activities. Instead, technologies ignored by the formal innovation system were adopted and popularized. Although not all such initiatives were successful, it is not unknown for attempts by civil society actors result in a certain reorientation in thinking. Thus despite the lack of state support, various informal TA-like activities have resulted in the development and adoption of technological and/or organizational alternatives through demonstrating their viability and feasibility.

6 Conclusion

This chapter has provided an overview of the TA landscape in India, as an example of TA in a developing country. The example of India shows that despite the lack of a specialized TA organization or institution, TA activities are included in a broad spectrum of governmental STI initiatives and agencies, as well as in STI-focussed activities of civil society. We described five formally institutionalized governmental TA-like activities (Table 2) and three informal TA-like grassroots activities (Table 3).

6.1 Governmental TA Activities

Since the end of the 1980s, India has set up governmental TA-like capabilities for technological foresight in general (via TIFAC), and for agricultural, medical and pollution abatement technologies in particular (Table 2). Such activities are mainly performed by experts and aim to strengthen India's technological capacities in the above-named fields. While there is still some focus on the utilization phase of technology, in particular technology transfer, India nowadays is involved with the entire innovation chain; from research, development and demonstration towards market introduction and upscaling. Because of its tradition in the field of technology transfer, India has gained a lot of experience regarding the fact that technology is only useful if it matches the needs and the technological, economic, environmental, and social context of the user. In particular, TA in the field of agriculture (TAR) and medical technology (HTA) has given serious attention to issues of access, equity and inclusion.

The various governmental TA activities show a mix of top-down expert- and technology-driven studies on the one hand, with attention to the needs of users and the social context on the other. This seems to reflect a mixture of the Nehruvian and Gandhian views on the relationships between science, technology, and society. Finally, the government only once employed participatory TA, as a response to the public controversy around the introduction of a genetically modified eggplant (Bt brinjal). This is despite the fact that the S&T and Innovation Policy of 2013 mentions public engagement, and the Economic Survey of 2018 has highlighted the need for public engagement in science and by scientists (DoEA 2018, 129).

The governmental TA-like activities take into account technical, economic, institutional, and environmental factors, but none of them assess or take into account all four. For example, in the case of GMOs, it was questioned to what extent all relevant scientific factors were considered (Aga, 2022, 170–172). The TA cell and HTAIn are new TA-like initiatives. It would be valuable and timely to assess to what extent these TA-like activities meet the needs of society and to what extent the methods employed are adequate for assessing emerging technologies.

Table 2 Overview of characteristics of five governmental TA-like activities in India

Characteristics	TIFAC (1988)	TAR (1995)	Bt brinjal (2010)	HTAIn (2017)	TA cell (2019)
Performance by	Technology Information, Forecasting and Assessment Council (TIFAC)	Indian Council of Agricultural Research (ICAR); KVKs; Central Institute for women in agriculture	Ministry for Environment and Forest	Health Technology Assessment in India network (HTAIn)	Technology Assessment Cell as part of the Ministry of Environment, Forest and Climate Change (MoEFCC)
Directed at	Government departments dealing with STI (see Box 1)	Farmer community	Genetic Engineering Advisory Committee (GEAC)	Health departments in central and state governments	Department of Science & Technology and India Innovation Hub
Type of technology	All kinds	Agricultural technology	GMO in agriculture	Medical technology	Pollution abatement technology
Stage of technology	Entire innovation chain	Entire innovation chain, in particular technology transfer	Market approval	Utilization phase	Utilization phase (e.g. technology transfer)
Institutional goal	Strengthen national capabilities in technological planning and assessment for improved socio-economic and industrial planning	Strengthening capacity to assess agricultural technology	Dealing with societal protest	Strengthen institutional capacity in the field of health TA (HTA)	Strengthen technological capacity to prevent, control, and abate pollution
Policy goal	Global competitiveness, sustainable development	Produce and transfer technologies that are suitable, based on the needs and aspirations of (female) farmers	Clarifying regulation of GMO in agriculture	Public health	Prevention, control, and abatement of pollution

(continued)

Table 2 (continued)

Characteristics	TIFAC (1988)	TAR (1995)	Bt brinjal (2010)	HTAIn (2017)	TA cell (2019)
TA-like activity	Technology forecasting and needs assessment	Technology Assessment and Refinement (TAR)	Public consultation	Health technology assessment (HTA)	Evaluating technological potential
Engagement	Experts	Experts, (female) farmers	Experts, stakeholders (incl. civil society organizations), citizens	Experts	Experts
Factors addressed	Technological, economic, societal needs	Technological, economic, ecological, gender, livelihood	Safety, social	Technological, economic, health gain, access and equity	Technological, economic

Table 3 Overview of characteristics of three informal TA-like grassroots activities in India

Characteristics of TA-like activity	Silent valley movement	System of rice intensification (SRI)	Community seed banks
Performed by	Civil society organization KSSP	Farmer organizations	Deccan Development Society (DDS)
Directed at	State	Farmers	Female farmers
Type of technology	Hydroelectric project	Agricultural technology	Agricultural technology
Stage of technology	Implementation	Development and implementation	Development and implementation
Goal	Save the Silent Valley forest	Increasing the yield of poor farmers with poor soil	Promoting community-based food sovereignty systems
Policy goal	State stops hydroelectric project	Strengthening livelihood of poor farmers	Natural farming and organic agriculture
TA-like activity	Societal movement and controversy as informal TA	Informal constructive TA: Grassroots development of technology suitable to the needs of poor farmers	Informal constructive TA: grassroots development of technology suitable for female farmers
Engagement	Silent Valley Movement	Poor farmers	Female farmers
Factors addressed	Technological, ecological, social	Technological, economic, ecological, social	Technological, economic, ecological, social

6.2 Informal Societal TA Activities

Besides governmental TA-like activities, we described three informal TA-like grassroots activities in India (Table 3). These activities are driven by civil society organizations, which often choose one or more of the following three strategies (cf. Cramer, 1990, 145):

(1) educating or mobilizing the public and stimulating the public debate on STI,
(2) putting an emphasis on influencing governmental STI policy or trying to stop governmental projects (as in the case of the Silent Valley movement), or
(3) developing exemplary alternative technologies and organizations (as in the cases of the system of rice intensification, and the community seed banks).

As noted above, Rip (1986) denotes public controversies, which are related to the first two strategies, as informal technology assessment. In line with that argument, the third strategy could be described as informal constructive TA.

The informal TA-like grassroots activities provide a contrast to the governmental TA-like activities. While informality is one aspect, these grassroots activities often represent and give voice to marginalized stakeholders, and in some cases provide an alternative option in terms of technology and organization. The system of rice intensification (SRI) is now recognized by the formal agricultural research and extension system of the state. The Silent Valley Movement questioned the logic of generating electricity at any cost. Community seed banks are part of informal seed and germplasm conservation and various development initiatives. But there are not many such informal TA-like initiatives in India. Moreover, there is often a weak linkage between informal TA-like activities and the formal innovation ecosystems of universities or institutions of higher learning.

6.3 Lessons from India for Developing Countries

So India does have both formal and informal TA, which according to Kebede and Mulder (2008) are almost absent in most developing nations. In terms of TA, therefore, India cannot be seen as a typical developing country. We should note, however, that Kebebe and Mulder made their observation in 2008 and a lot may have changed since then. This certainly applies for India, which has expanded its TA capacity, especially in the field of HTA and pollution TA. Moreover, the Indian government organized a participatory TA event on the introduction of Bt brinjal in 2010.

In Sect. 2, we identified three important TA topics for developing countries: technology transfer and needs assessment, TA for access, equity and inclusion, and participatory TA, including the role civil society or informal TA can play. The developments in the field of TA in India indeed show the importance of these three TA topics. Below, we briefly review these three topics and identify a set of parameters that are important for the deployment of TA in developing countries.

Historically, TA was first given a place at the end of the 1980s in the field of technology transfer, and in particular in determining which technical areas India needed, related to societal needs and challenges (see Sect. 3.1 on TIFAC). It is interesting to note that this desire to put state-led innovation policy more at the service of societal challenges is a relatively modern turn of events in the European Union (cf. Mazzucato, 2015, 2018). It also shows that for such state-led socio-technical mission oriented innovation, TA is a natural partner. The following parameters, therefore, play a crucial role in determining the desired role of TA for developing countries:

(1) government-driven or market-driven innovation;
(2) phase of the innovation chain: beginning, middle or end;
(3) type of grand societal challenges; and
(4) institutional capacity in STI, including TA.

Access, equity and inclusion are important social issues within TA that are especially relevant for developing countries. In India, within governmental TA activities, we see attention to these issues, in particular in the fields of agricultural TA and HTA. Of course, the three described informal TA-like grassroots activities are strongly driven by the above three public values.

Finally, governmental TA in India is characterized in particular as expert-driven and technocratic, and by a lack of approaches that seek the participation of societal interest groups or citizens. This is despite the fact that the following aspects form a good breeding ground for organizing participatory TA activities:

(1) the existing attention within government institutions in the field of STI towards societal needs and issues such as access, equity, and inclusion are in principle a good breeding ground for participatory TA;
(2) the identified need for public engagement in science in various policy documents;
(3) the critical self-reflective Indian political culture with regard to the relationship between STI and society—especially the Gandhian and the leftist vision of the PSM; and
(4) the presence of an active public debate on the societal role of STI, as evidenced by the three described controversies surrounding technology and related informal grassroots TA activities.

Finally, institutional capacity in the field of participatory TA is an important precondition for the implementation of participatory TA. It could have significant impact on STI if India, and other developing countries, would choose and be able to develop such a capacity in the coming years.

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Global Challenges and TA

Climate Change—Does the IPCC Model Provide the Foundation for a Potential Global Technology Assessment Framework?

Peta Ashworth and Elliot Clarke

1 Introduction

Climate change has been identified as the "perfect moral storm"—global in nature with long-lasting intergenerational impacts (Gardiner, 2011) with a lack of the political will necessary to address the issues. The anticipated damage that ecosystems and society will bear because of adverse climatic events will place a significant burden on people, societies, the environment and the global economy unless greenhouse gas (GHG) emissions are significantly reduced. While there is now, a dedicated move towards net-zero emissions through stated aspirations of various industries and the laws of some governments, there is still a need for a pressing upheaval of existing systems, if the world is to remain well below the 2°C target of the Paris Agreement (UNFCCC, 2015) or the 1.5°C target outlined in the Special Report of the Intergovernmental Panel on Climate Change (IPCC, 2018a).

Beyond the hard science, climate change has become much more than just an aggregation of scientific data from the natural sciences. As Hulme (2010a, 267) states, the adverse impacts of a changing climate include "political, social and psychological functions", requiring important consideration of cultural interplays, value systems and regional differences that exist between the global north and south, and developed and developing countries.

Contribution to: Technology Assessment in a Globalized World—Facing the Challenges of Transnational Technology Governance.

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Integral to the global response to climate change are two international bodies. The first, the Intergovernmental Panel on Climate Change (IPCC), was established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) in 1988. The IPCC serves as the core scientific advisory body delivering evidence-based climate policy recommendations from global scientific data into international climate negotiations convened by the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC comprises 197 countries and entered into force in March 1994 with the aim of preventing "dangerous human interference with the climate system" (UNFCCC, 2015). Understanding the potential societal impacts of mitigation technologies and supporting science that unpacks the use of resources and practises across sectors is a key function of the advice from the IPCC. Such a process of providing independent scientific advice is also at the heart of technology assessment (TA).

Here, we examine the structure, practises and methods of the IPCC as a legitimate scientific institution and its interplay with the global political decision-making forum of the UNFCCC and compare it with TA theory and practice. The principal aim is to investigate if such an institutionalised process of co-design, between governments and the researchers who gather scientific evidence for policymakers, could serve as a potential global TA model that can be applied to other global challenges. Through examining successes, shortfalls and some criticisms of the IPCC process, we identify how these challenges may be mitigated. We use TA analytical and impact frameworks (Belluci et al., 2002; Hennen et al., 2004) to investigate whether an image of legitimacy can be realised from a global governance perspective, and whether this can also help to build trust in science advice at the country and community level (Sanz-Menéndez, & Cruz-Castro, 2019). In short, this chapter applies a critical lens to the IPCC as one potential global TA model, arguing for the inclusion of grassroots participatory TA alongside traditional governance and reporting frameworks to deliver holistic solutions to climate change outcomes, and ideally other global challenges.

2 Technology Assessment

There is a long history that outlines how TA aims to support policymakers, and ultimately society, when making decisions surrounding the value of existing or emerging technologies and the potential risks and challenges they may present (Michalek et al., 2014). Historically, it originated as a science-led policy consultation device within economically developed institutions (Scherz et al., 2019). Framed as neutral decision-making advisories, immune from ideological or political interference, the use and prevalence of TA frameworks has varied across societal, geographical and temporal scales. This has resulted in a range of TA methods being developed over decades as a way of finding solutions to controversies and associated risks with the introduction of new scientific breakthroughs and technological innovations (Cruz-Castro & Sanz-Menedez, 2005).

At its core, TA provides the knowledge and processes to help society cope with innovation and mitigate potential social and environmental risks in future. The focus on societal outcomes has mutually implicated a strong reliance on political elements and influences (Ladikas & Hahn, 2019; Van Est & Brom, 2012). In so doing, TA as a source of advice, "must compete—and try to co-exist—with many other sources of information that politicians, governments, bureaucrats or parliaments use" (Cruz-Castro & Sanz-Menedez, 2004, 106). Competing sources of data for global problems like climate change are complex and require a global TA response at the corresponding scale. However, what often happens is that the experts that constitute TA advisories and policymakers as target audiences, often disagree about what path to take (Ladikas, 2019). This may result in a standoff, total inaction, or ineffective untested solutions being implemented-often decided in efforts to win votes and remain in power rather than being truly solutions oriented as recommended by the science. Evidenced in the climate change domain, this can have dire and often irreversible consequences.

The call for TA to be applied as a global model stems from the ever increasing need to address real-world problems through international cooperation and dialogue (Ladikas & Hahn, 2019). While some technological solutions have resulted in positive impacts, it is also evident that there can be unintended consequences across geographic regions of the world (Scherz et al., 2019). This is further influenced by the type of political system in which the technology is being deployed (i.e. liberal versus autocratic) and the country's level of economic development,[1] as this limits or enables capacity to respond. Van Est and Brom (2012) also refer to the importance of normative frames and an openness to consider and include alternative views as part of TA responses. Despite leading TA scholars acknowledging the need to bring together diverse cultural and societal nuances into a global framework (Ladikas & Hahn, 2019), there remains limited consensus on what a TA model at the global scale should look like, and how, or who by, it should be implemented.

While global TA has merit for dealing with complex challenges, there is also some discussion about its inability to accommodate different levels of scale. For example, some concerns remain surrounding how the deployment of TA solutions transpire locally. Currently, TA remains a high-income state-driven pursuit in more economically developed regions of the world (Ladikas, 2019). While there is a clear need for a global TA framework that transcends socio-economic and neo-liberal considerations, there is also recognition that local problems will require solutions that exist beyond a global TA framework to "consider contextual circumstances and aid decision-making in different settings" (Ladikas, 2019). The EUROPTA analytical framework (Bellucci et al., 2002), with a focus on participatory TA, provides a starting point for identifying necessary elements of what may constitute a global TA framework. It does this through recognising the interplay between society and institutional contexts and how participatory systems are organised. The solutions,

[1] The *World Economic Situation and Prospects* classifies all countries of the world into one of three broad categories: developed economies, economies in transition and developing economies.

outputs and corresponding advice generated from TA can be understood in terms of impact.

The connotations applied to "impact" within TA are often described as subjective. For decades, TA scholars have strived to balance the need to reflect normative endeavours without rigid expectations in the form of hard policy as its impact. Hennen et al. (2004) describe impact in the form of a three-dimensional typology aimed at policymakers that includes: (1) raising knowledge and/or awareness, (2) forming opinions and attitudes and (3) initialising action.

Raising knowledge can be viewed as an increase in the visibility of technical knowledge, or a broad overview of potential societal outcomes as a consequence of a new technological development (Hennen et al., 2004). This is because it is important to understand the social impacts of advances in technology, rather than solely an assessment of implications through scientific data. This can be further extended to an exploration of existing policies and objectives (Hennen et al., 2004). Second, forming attitudes and opinions helps in agenda-setting through influencing public discourse or stimulating public debate. This is invaluable when the public and other stakeholders are exposed to new technology and ideas with a relatively high level of uncertainty. These can be further explored through participatory TA activities such as scenario constructions or deliberative processes, which both present imagined futures of the technology as well as meeting expectations of procedural fairness through democratic deliberation (Hennen et al., 2004). The third dimension to the proposed impact typology references initialisation of action that may result in policy development, delivery and decision-making. There are also pathways towards introducing new models of governance, process implementation and other tangible initiatives (Hennen et al., 2004).

These understandings of impact aim to include varying outputs and lend themselves to a wider definition of impact: "Impact of TA is defined as any change with regard to the state of knowledge, opinions held, and actions taken by relevant actors in the process of societal debate on technological issues" (Hennen et al., 2004, 61). This is also true when considering climate change.

Across the world, the public are increasingly exposed to the potential social and ecological impacts of climate change, with those countries least able to respond to climate change being the ones most vulnerable to its impacts (UNFCCC, 2020). To overcome this, there are a range of mitigation and adaptation solutions being generated, particularly, as the urgent need to mitigate GHG emissions becomes even more apparent (IPCC, 2021a). Some of these are challenging the status quo, or traditional ways of working, as well as associated cultural rituals. Given the complex and global nature of the climate crisis, a global TA response has been positioned as a necessary framework to address the corresponding risks. The IPCC offers a substantive global TA model that not only provides scientific advice to policymakers but may also be applied to other grand challenges. Understanding the influence of the IPCC and climate change on real-world outcomes requires further investigation of the constructed and definitional nature of 'impact' as a consequence of distributed climate assessments. The impact of IPCC advice through Hennen et al.'s (2004) typology holds true for how advice is received and inserted into public debate, particularly when attempting to measure its influence on policy. Reflecting on the current state of play for climate change mitigation suggests the IPCC framework, while not perfect, provides one potential model for an effective global TA framework, as detailed below.

3 The IPCC Model: Potential as a Global TA Framework

3.1 History of the IPCC

Established by the World Meteorological Organisation (WMO) and the UN Environment Program (UNEP), the IPCC was endorsed by the UN General Assembly on 6 December 1988. Its initial task, as outlined in UN General Assembly Resolution 43/53, was to review and prepare climate change science and outline the ecological, social and economic costs of environmental degradation (IPCC, 2021b). The IPCC brings together scientists from approximately 80 countries across the world. Critical to its relevance to governments is its recognition as a government institution, as demonstrated in its name; "Intergovernmental". The IPCC releases an update on the latest science every 5–7 years. The first assessment report (FAR) was released in 1990, which "underlined the importance of climate change as a challenge with global consequences and requiring international cooperation" (IPCC, 2021b). The second reporting cycle was released in 1996, and directly guided decision-makers prior to the finalisation of the Kyoto Protocol in 1997. These were subsequently followed by a third report (2001) aimed at addressing adaptation, and a fourth report (2007) that laid the foundations for a post-Kyoto world. The fifth report, issued in 2013, directly advised what would become the Paris Climate Agreement on December 12, 2015. Currently, in its sixth assessment period, the IPCC has recently produced "AR6 Climate Change 2021: The Physical Science Basis" from Working Group 1 (IPCC, 2021a), along with technical papers, methodology reports and special summary reports (IPCC, 2021b).

Throughout these periods of assessment, releases and reporting cycles, the IPCC asserts that their advice has accelerated peer-reviewed literature on climate science, increased public awareness, and fostered collaboration and participation between different actors to achieve the targets set by the global community. In its view, this consistently leads to international climate change decision-making and policy reforms (IPCC, 2021b). Notably, in 2007, IPCC authors, in conjunction with Al Gore, were awarded the Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change". There is possibly no higher recognition of their contribution and policy impact on the world.

3.2 IPCC Structure

The IPCC has a sophisticated structure which is integral to its success and operations. It comprises three core working groups: Physical science basis, impacts, adaptation and vulnerability and mitigation of climate change; and a Task Force Bureau that oversees the National Greenhouse Gas Inventories Programme (IPCC, 2021c). The nature of these working groups in many ways resembles what has been described as expert TA, where experts come together to gather scientific information in relation to an identified problem (Van Est & Brom, 2012). Using Hennen et al.'s (2004) typology, much of this early work would fit under the first stream of raising knowledge and awareness of the issues at hand. Each working group consists of lead authors, review editors, and chapter scientists who are tasked with collating and presenting relevant research. As experts in their own fields, IPCC authors have been approached by member governments to participate and, if accepted, volunteer their time to do so (IPCC, 2021c). There is also a large external cohort of government representatives and researchers who operate as expert reviewers, based on their fields of expertise. All of this is underpinned by a secretariat which coordinates the wider IPCC organisational, administrative, and planning matters.

The IPCC 195 member governments, along with representatives from observer organisations, convene at least once a year (more during assessment cycles), in the form of Plenary Sessions. This government mechanism is known as "the Panel" and is critical to the overall functioning and success of the IPCC. "The Panel works by consensus to decide on the organisation's budget and work programme; the scope and outline of its reports; issues related to principles and procedures of the IPCC; and the structure and mandate of IPCC Working Groups and Task Forces. The Panel also approves and adopts IPCC reports and elects the IPCC Chair, other members of the IPCC Bureau and the Task Force Bureau." (IPCC, 2021c, 1). Whether the structure and mandate of the Panel can be replicated will be an important consideration for a global TA model.

3.3 Processes

The IPCC processes, and any subsequent reviews, are advised by a set of 10 sub-principles (IPCC, 2018b). These include reaching consensus amongst working groups for decisions relating to procedures; deciding when IPCC findings are made official; matters relating to time-frames for participating actors; issues surrounding how reports are made available, by when, and in what languages; process scheduling; financial procedures; and how elections are conducted (IPCC, 2018b). The resulting processes can be understood in terms of (a) reporting, (b) writing and reviewing, (c) error protocol, (d) conflicts of interest, (e) funding, (f) communication, (g) gender and (h) observer organisations.

Firstly, IPCC publications consist of three sub-channels to deliver climate advice. IPCC Reports include "Assessments, Synthesis and Special Reports, their Summaries for Policymakers, and Methodology Reports" (IPCC, 2021d). These are supported by technical papers and other materials inclusive of workshop proceedings and databases to assist other generational processes. Second, writing and review processes are subject to Review Editors that include the "consideration of the range of scientific, technical and socio-economic views" (IPCC, 2021d). Third, error protocols were introduced whereby concerns surrounding reporting can be investigated. Fourth, a conflict-of-interest component of the procedural process is designed to protect the legitimacy and integrity of the IPCC's reporting and associated activities: "individuals must disclose circumstances that could lead a reasonable person to question an individual's objectivity, or whether an unfair advantage has been created, constitute a potential conflict of interest." (IPCC, 2021d). Fifth, IPCC funding is sourced from member organisations and parent bodies, the WMO and the UNEP. Further support is provided as in-kind contributions from governments providing experts to produce the advice generated by unpaid member-sponsored experts (IPCC, 2021d). Finally, communication constitutes who the audience is, that is, which policymakers are viewed as important in the global climate discussion and which are not. This can be problematic throughout the internalised decision-making process when selecting authors and editors (IPCC, 2021d).

3.4 Technologies

Relevant to any TA discussion about the IPCC are the technologies being assessed. Within the IPCC there is a focus on both mitigation and adaptation, which means there are a range of technologies being examined. With mitigation, the IPCC reports synthesise the latest peer-reviewed information on each of the technologies and the scenarios which model their potential deployment, to make an assessment on their potential for effective GHG mitigation. Most of the work to assess these technologies, i.e. the early TA component, is undertaken by other reputable external bodies, including the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA) and various other regional or country-specific researchers and research groups. This TA work tends to be funded by the different bodies who are subsequently referenced within the reports. However, at times the UNFCCC will issue calls for specific technological reviews to inform their work. The range of technologies for mitigation includes renewable energies such as solar, wind, biomass, biofuels, nuclear energy, energy storage, hydrogen and other more contentious technologies such as carbon dioxide capture, utilisation and storage.

Work is also undertaken specifically around technologies for developing countries, through the United Nations Sustainable Energy for All (SEforAll), for example. These programmes tend to focus on technologies for improving energy access and reducing harmful effects of more polluting and inefficient technologies (e.g. biomass cookstoves and kerosene lamps), prevalent in many developing countries. Coupled with this work, is the identification of necessary government support and trialling the effectiveness of various financial mechanisms to achieve greater technology deployment. Most of the SEforAll work is funded from philanthropic organisations and large aid initiatives such as UK Aid and USAid Power Africa.

For adaptation, the technologies can include anything from new land management practises, livestock systems and management of their ruminants, agroforestry, irrigation efficiencies, waste management and more novel technologies such as molecular biology, genome modification, new marine and freshwater flora and fauna and so on (de Coninck et al., 2018). The specific types of TA activities vary, depending on the level of technological development, where the TA activity is being undertaken, and what the assessment need might be. All of this information feeds into specific country targets.

4 Climate Change State of Play

Following the Paris Agreement, all countries were obligated to set national targets known as Nationally Determined Contributions (NDCs), which outline the ways in which they will reduce their GHG emissions. NDCs have been “at the heart of the Paris Agreement” (UNFCCC, 2021), and represent the initialising action stage of the typology of impacts discussed earlier (Hennen et al., 2004). It is the responsibility of each member country to set targets to reduce emissions at the nation state level and report these through the UNFCCC every five years. Other critical elements relate to adaptation, finance, transparency and accountability mechanisms for emissions trading.

Despite all these processes, the world continues to do poorly in delivering the goals and targets required by the Paris Agreement. Today, the world is 1.1°C warmer when compared to pre-industrial levels, and on a decadal average in 2020, was 1.24°C above pre-industrial level (IPCC, 2021a). This clearly requires an immediate coordinated global response, as often highlighted by the UNFCCC and other concerned scientists (UNFCCC, 2020; Union of Concerned Scientists, 2020). More recent climate data also underscores the urgency for mitigating climate change and to stay within the Paris Agreement targets of limiting global warming to 1.5°C, or at most 2°C, and achieving carbon neutrality by 2050 (UNFCCC, 2021). The International Climate Energy Related Developments Review (UNEP, 2020) and others have determined that emissions have continued to rise since the Paris Agreement and are mostly attributed to the burning of fossil fuels (Le Quéré et al., 2021).

While there is some optimism that certain countries are projected to make positive inroads towards decreasing their emissions, there is consensus that no country is doing enough to keep temperatures well below the required 2°C increase (IPCC, 2018a). Even with the countries who committed to the Paris Agreement fully implementing their NDCs, the world is falling well short of meeting the required GHG emissions reduction (Roelfsema, et al., 2020). This of course is leading to substantial consequences for the environment and the global community (IPCC, 2021a). In particular, the most vulnerable and marginalised people, who are least likely to be able to withstand the potential impacts of climate change, are unfortunately often the ones who are most exposed (UNFCCC, 2020; Rigoud et al., 2018). This places a burden on more developed countries to find solutions which, often, are technological in nature.

Accelerating the support, advice and access to information provided to vulnerable regions from wealthier states, which are tasked with fostering resilience across varying societal scales, is critical to mitigate climate change impacts. Such conclusions have real-world implications for ecosystems and livelihoods when determining vulnerability and accountability. For example, while China remains the world's leading emitter of carbon dioxide (CO_2) emissions, contributing 28% of global emissions, its contribution per capita remains relatively low, particularly when compared to the Organisation for Economic Cooperation and Development (OECD) nation states (Union of Concerned Scientists, 2020). This brings into question the responsibilities of more developed regions when measuring per capita carbon emissions, and how best to ensure the necessary climate change action, by whom and at what level (World Bank, 2016; World Bank et al., 2016).

In Europe, the European Parliamentary Technology Assessment (EPTA) network has undertaken a number of TA-focused activities in relation to climate change. Its 2015 report was designed to provide politicians with climate change information containing "…new and rigorous insight on these challenging and far-reaching questions, generally not presented by medias in proper ways for political decisions" (EPTA, 2015, p.8). More recent activities have included the Norwegian Board of Technology's focus on Norway's emerging capacity to produce green hydrogen through the availability of cheaper sources of renewables (NBT, 2021). Germany continues to focus on energy efficiency in building construction to discern adequate cost–benefit results (TAB, 2021). And, Greece has been working on tools for investigating the effects of natural disasters arising from climate change (GPCRT, 2019). Despite activities such as these, progress on mitigation remains low.

5 Reflections on the IPCC Model: Successful or Not?

Given the slow progress towards mitigating climate change impacts, there is an opportunity to unpack the interplay between the IPCC and the global political decision-making processes and the policy implementation of the UNFCCC and nation states. Acknowledging both the IPCC's successes and shortcomings provides an opportunity to understand whether the structure of the IPPC model could be more successfully developed into one possible global TA framework to be applied across multiple grand challenges. It evokes the question whether building such a model of trust and legitimacy through global science can better serve advisory outcomes for international policymakers, and ultimately broader society, around contentious issues.

Indeed, it has been a global success that an assessment of scientific data and technology to combat climate change was cooperatively established in the form of the

IPCC. Certainly, there have been more nuanced successes when measured against the impact typology outlined by Hennen et al. (2004). The first, raising knowledge, can be evidenced through the visibility of technical knowledge via the reports that are created and distributed to policymakers and made accessible to the public. Second, these reports are regularly inserted into public debates surrounding action on climate change by various actors, including NGOs, community groups, journalists, industry and policymakers. Third, states have initialised action by making commitments towards net-zero emissions as a consequence of IPCC reporting. These have manifested into policies that subsidise renewable energy projects at both a household and commercial scale, along with other mitigation and adaptation policies. However, are these successes enough? While these accomplishments can be understood and mapped to Hennen et al.'s (2004) impact typology, most countries which are signatories to the Paris Agreement will miss their reduction targets. There remains a serious discord between softer impacts and initialising collaborative real-world policies to mitigate climate change, although this does fall outside the mandate of the IPCC.

Although many are supportive of the IPCC/UNFCCC process, there remain some areas of contestation surrounding it. These include: lack of impact in achieving global emissions targets, mainly due to a lack of political will; the degree of autonomy the IPCC has when conducting a reporting cycle and communicating its findings; whether seeking consensus results in obscuring or making invisible the crucial differences between diverse global communities; the minor historical errors in reporting advice which diminished perceptions of the integrity of the advice at the time; and finally, whether the IPCC publications, at times, have been too technical, thus compromising their ability to be accessible to policymakers and other actors. These critiques aimed at the top-down model of the IPCC are expanded upon below.

5.1 A Requirement for Increasing Impact Through Initiating Action

The IPCC process was established to inform policy without being policy prescriptive, which is what allows it to gain support within government processes. However, a vacuum in mandatory oversight combined with the observed inability to initialise action at the global level, appears to be a major obstacle in generating and maintaining trust in the effectiveness of the IPCC process. Questionable and misleading claims of enforceability through the UNFCCC have also complicated the translation of the IPCC advice into real-world policy actions. Whereas in other issue areas such as the Montreal Protocol on Substances that Deplete the Ozone Layer (UNEP, 2020), marine dumping laws through the 1996 London Protocol which entered into force in 2006 (IMO, 2006), and the General Data Protection Regulation in the European Union (European Commission, 2016), international compliance remains high. It appears that the complex nature of climate change poses a significant barrier to international cooperation in meeting targets to mitigate GHG emissions, particularly if governments choose not to respond to the IPCC's advice.

An example of this is the problematic nature of the Kyoto period climate targets. The targets were thought to impact economic competitiveness, be too complicated to ensure compliance, and ultimately difficult to monitor and enforce (Victor, 2011). Without binding commitments through the decision-making arm, the UNFCCC, or some other governance mechanism, this raises an important question of legitimacy, and whether public confidence in such processes can be maintained, and more importantly if they will ever be effective.

The complications come in two forms. The first, the flexible set of country-based actions determined by each individual state (NDCs), makes serious targets difficult to enforce; and second, a lack of binding penalties (Denchak, 2021) further complicates mechanisms to penalise or encourage non-conforming states which are party to the Paris Agreement. While there have been instances of the UNFCCC enforcement branch issuing notices of Paris Agreement compliance breaches for reporting failures (UNFCCC, 2020), the examples do not recommend any action other than submissions or reviewing internalised reporting protocols. It has been suggested that implementing such a mechanism would likely undo the ability of governments and scientists to reach agreement in the first place.

While enforceability, and lack thereof, at the global level through the UNFCCC is outside the remit of the advisory role of the IPCC, the failure to meet current global mitigation targets suggests the need for additional measures alongside the scientific advice and recommendations of the IPCC process. This corresponds with the initialising action stage of Hennen et al.'s impact framework, which implies there may be a role for regulators which are not involved in steering the science to play a role in mitigating poor outcomes (Van Est & Brom, 2012). Alternatively, another peak body could be established for this purpose, but either way, it is a question that will need consideration when trialling any global TA model in future.

5.2 Consensus and Situated Knowledge

The scientific community has conferred support for the overarching consensus on climate change knowledge claims, including the advice and modelling by the IPCC. Agreement can also be found outside the domain of science within government institutions. For example, US, UK and other European officials are charged with providing direct advice to politicians and committees. The IPCC has found allies in civic society, activists, and NGO groups aligned with environmental matters (Ray, 2011). However, the push for consensus through the UN process has been accused of simultaneously "making invisible" localised challenges and individual struggles at the community scale. How climate knowledge is created or discarded, respected or shunned, or determined to be of value within the scope of the IPCC reporting cycle may exclude some knowledge into the periphery. However, given the nature of the synthesis, which combines the work of over 50,000 research outputs, this is not unexpected.

Researchers are not arguing against the need for a global model to approach TA and climate change, rather Kunelius et al. (2016) and Hulme (2010a, 2010b) are mindful of presenting knowledge as a universal truth determined by consensual processes that ignore key concepts such as identity, sense of place and time (Hulme, 2010a, 2010b). "Rather than seeking a consensual global knowledge which erases difference and allows the most powerful to determine what is "known", we need to pay greater attention to the different ways knowledge comes to be made in different places and how different kinds of knowledge gain hold in people's minds, traction in different cultures and assent in global fora. This is spectral knowledge which emerges from a cosmopolitan perspective." (Hulme, 2010a, 2010b, 563).

Potentially "washing over" situated knowledge of climate change in the quest for consensus may curb nuanced understandings. This is especially true for indigenous knowledge and other cultural representations that are often neglected in the IPCC reporting in favour of positivist Western ways of knowing and understanding a changing climate (Corbera et al., 2016; Ford et al., 2016). Ford et al., (2016, 351) argue the importance of prioritising indigenous knowledge in the next round of IPCC reporting. This highlights an important challenge confronting the IPCC that has not been solved. How does the IPCC maintain a global purview while acknowledging the diverse cultural and situated experiences and knowledge at the community scale? This is particularly so if not all indigenous knowledge has been published in the more traditional literature formats, which is also a requirement of the scientific approach to knowledge. Ladikas and Hahn (2019, 10) acknowledge this challenge as important to any global TA framework that may be developed.

5.3 *Public Trust in Reporting: Integrity, Errors, and the Need for Transparency*

Similar to the discussions on TA, the IPCC is not always considered a neutral knowledge base. Authors, editors, reviewers and the UNFCCC which responds to the advice of the IPCC are all compromised by their own norms and values that determine what knowledge is valuable and what is not (Corbera et al., 2016; Ford et al., 2016). While Ford et al., (2016, 349) acknowledge the importance of the IPCC in delivering climate advice, they also argue that applying a critical lens to IPCC reporting reveals inequalities hidden by a specific technocratic approach to knowledge and consensus: "… it has also been noted that the procedural rules governing how the IPCC operates and the positionality of the author teams (for example, disciplinary background) has resulted in the privileging of positivist science and technocratic perspectives, the marginalisation of other ways of knowing (for example, local, traditional and indigenous knowledge) and the prioritisation of scenarios and modelling approaches" Ford et al., (2016, 349).

Arpino and Obydenkova (2020) concede there has been a decline in trust in the United Nations and its associated bodies since the 2008 financial crisis. This coincides with ongoing miscommunication problems that destabilise or erode trust between the scientific community and the general public (Rabinovich et al., 2012). These concerns are exacerbated by the ever-increasing complexity of the inter-related nature of climate change and the evolving consequences that need to be absorbed by the public in order to take effective action (Rabinovich et al., 2012).

The IPCC as an international organisation is no different to others of equivalent standing, and has been subject to various criticisms. For example, it has been challenged about the lack of transparency in assessment models and questionable funding agendas within the research community (Robertson, 2020); the "Climategate" issues associated with the email hacking of the Climate Research Unit at the University of East Anglia in 2009 which impacted overall trust in the process (Nature, 2010); and issues challenging the ambiguity of its assertions in relation to Himalayan glaciers and Amazon rainforests which were later clarified (Ray, 2011). Clearly, issues of transparency need to be proactively addressed and considered for any global TA model.

5.4 Accessibility: Understanding and Scale

Harold et al. (2020) suggest that some of the IPCC information and data is, at times, considered too technical for policymakers, and therefore requires improved presentation to make the information more accessible. Criticisms have focused on the information being difficult to understand and inaccessible to non-specialist audiences, especially policymakers, primarily based on poor readability of the text (Barkemeyer et al., 2016; Budescu et al., 2014; Mach et al., 2016) and the structure of documents (Stocker & Plattner, 2016).

This challenge can be further extrapolated to the overall process of national country actors identifying their nationally determined contributions (NDCs). While the NDCs may be developed with the best intentions, they too can become inaccessible to those at the state and local government level, not to mention local communities. This has been attributed to both a lack of clarity surrounding the information, and also the required mechanisms for implementation. This suggests that while there is a need for a global TA model, attention must also be given to making the information accessible across different scales, rather than leave it solely to national governments.

Since the 1990s, there has been a long history of change in TA practises from more expert-centred advice to more participatory practises (Joss & Belluci, 2002), implementing methods such as consensus conferences, citizens summits, and future panels, for example. In climate change, citizens' panels provide a model that enables local communities to engage with the science and technological innovations in an evidence-based way. Implementing local deliberative panels could easily work in unison with the global and national level TA models outlined above to ensure translation at the local level. Key authors in the field have long argued for new and innovative ways to include citizens in decision-making. They assert the need for new pathways and innovative TA models that create cooperatives of experts, citizens, and policymakers (Ladikas & Hahn, 2019). Similarly, Van Est and Brom (2012, 312) contend that TA can be "positioned as a more general and open process for involving the public in policy dialogues and building societal consensus on issues of technological change."

What is not clear is how this may be accomplished in developing countries with varying levels of capacity to participate. If the underlying assumption of participatory TA implies participation of the range of stakeholders impacted by the technology, then careful consideration must be given to involving developing countries in these processes. Fortunately, the IPCC funding model, which sponsors developing countries to attend the range of meetings that form the process of the assessment period, has allowed for the participation of some key representatives from the developing countries at these meetings. However, whether such sponsorship is all inclusive, allowing equal participation from the range of developing countries remains to be seen. There is also a need to consider how to engage at local sites to maximise stakeholder participation within countries. Fortunately, the experiences gained from the development literature is also of value here, presenting tried and tested processes for engaging with local communities across developing countries (Gaventa & Barrett, 2012; Najam, 2005).

One example of how collaboration has been facilitated between the developed and developing world through multilateral funds is seen in the Kigali Amendment to the Montreal Protocol (UNEP, 2021). In the amendment, where countries "agreed to phase down Hydrofluorocarbons (HFCs) over the next 30 years and replace them with more environmentally friendly alternatives" (UNEP, 2021), it was agreed that developed countries would take the lead from 2019 and then, through a phased approach, developing countries agreed to "freeze" their HFC levels in subsequent years beginning from 2024. All countries participated in reaching the decision, but the roll-out approach provided greater consideration to the needs of those in developing countries. This provides an example where the developed world took the lead to learn the process and then assist developing countries through capacity-building and shared knowledge. Such knowledge-sharing across all scales is a key part of the successes of the IPCC.

6 Discussion

The IPCC model of bringing together scientific experts from across the world to synthesise scientific evidence that relates to climate change, provides an encouraging framework for one possible global TA model. However, given the slow progress towards climate mitigation goals we recommend there is a need to address the identified deficiencies to ensure a truly effective model. There is also scope to better understand what the barriers to change have been and then assess whether information or political and economic processes are the best ways of addressing these. A global TA model ideally needs to have some influence on both policy and real-world outcomes to be considered as having impact-providing leadership and direction for appropriate and long-lasting solutions to persistent problems. Further, there will always be other institutions or actors that produce competing information, including regulatory bodies, think tanks and lobby groups on contested issues which governments and individuals must grapple with (Oreskes & Conway, 2010). TA needs to compete with these other forms of information if it is to have a significant influence on decision-making at the highest levels, and of course be based on the best scientific evidence. The interplay between governments and researchers in the IPCC process provides hope for this.

The four central challenges of the IPCC identified were: (a) lack of impact through initiating action based on current government commitments; (b) the pursuit of consensus-based and situated knowledge; (c) reporting inaccuracies leading to mistrust; and (d) accessibility of information across different scales. While these deficiencies lead to matters of legitimacy, they are not dissimilar to the ongoing discussions of TA scholars. We suggest there is potential for each of these deficiencies to be addressed using lessons learned from TA scholarship and frameworks that may result in more authentic and accepted outcomes.

For example, establishing legitimacy through TA processes has been fostered through the inclusion of participatory TA and deliberative democracy as grassroots ways to address matters of scale, inclusivity and knowledge production. Admittedly, there are challenges with translating deliberation in social trust, and results can vary depending on how strong a country has been at conducting deliberation historically (Jørgensen et al., 2016). This is made even more challenging in poorly organised civil societies or in political environments closed from public participation (Jørgensen et al., 2016). Such considerations are reflected in the EUROPTA analytical framework (Bellucci et al., 2002), which recognises that within social and institutional contexts Participatory TA has three dimensions. These include: (i) set-up and process—ultimately focusing on the design and interaction arrangements; (ii) values assumptions and goals—that relate to the problem definition and justification for participation; and (iii) outcomes—directly referring to communication of the results and impact. Importantly, herein remains a normative challenge. Neither shared visions nor values result in tangible impact or political outcomes by default, and therefore cannot be guaranteed (Delvenne & Parotte, 2019). This could be due to a lack of reflexivity amongst actors, or an explicit or implicit preference towards a matter within TA communities for political reasons (Delvenne & Parotte, 2019). Whether shared visions or values are aligned or divergent is also a matter for consideration across scales.

Similarly, when considering participatory TA models across jurisdictions, there has been extensive debate around whether the processes developed for one country can be simply introduced into another country without modification (Joss & Torgersen, 2002). Whether this is possible or not, will be influenced by the role the participatory TA method is expected to play. What is the issue being investigated, and who should participate to ensure the process is truly inclusive and representative across scales? What assessment is being sought and for whom? When considering a global TA participatory framework, it will be important to acknowledge where governance systems either converge or diverge, as this will impact the likely success of the process and its perceived legitimacy. Similarly, how marginalised groups are treated within such participatory processes will also significantly affect outcomes and whether the results are valued. Trying to extrapolate these considerations across scales is not without its challenges, and should not be underestimated.

In relation to climate change, Michalek et al. (2014, 17) suggest that: "A lack of consensus on the global level greatly affects the local, where, for example, the negative effects of climate change are often mostly visible. In this sense, sustainable behaviour can only be fostered by participation of the general public in local policies (e.g. the e2democracy project, 2012)." This global versus local impact is relevant to many global challenges beyond climate change, and is why considerations of other TA activities that work at different scales is important. This confirms the need for an expanded role for participatory TA at the grassroots level while continuing to deploy global TA based on either the IPCC or other models. Such a process would allow for broader political debate and directly manage the linkages between science, policymakers and society more generally (Van Est & Brom, 2012). Subsequently, it develops a deeper understanding of the social dimensions of technology (Van Est & Brom, 2012), and can foster more viable visions for the future use of technology or issues across the different scales and through discussion, helping to facilitate knowledge acquisition across broader society, beyond the experts (Ely et al., 2011, 2).

Rabinovich et al., (2012, 11) also highlight the value of the interactions and deliberation between actors when reconciling trust in science between those communicating the message and those receiving it. "…the success of communication often does not reside within the message itself (however masterfully it may be constructed and framed), but within the dynamic interaction between the communicating partners … Of paramount importance to such interactions is communication partners' ability to recognise each other's position and the fact that this position may be different from one's own." This applies for almost any contested topic. It reinforces how the communication of scientific information can benefit from public deliberation between actors and citizens. Ultimately, this allows for a broader TA model that is inclusive of public input, leading to less confusion on the topic. In addition, where scientific information is localised and contextualised this could also improve its accessibility across scales: geographical, societal and temporal.

Outside the IPCC and participatory TA models, there is a clear shift away from the linear historical understanding of how technology is incorporated and used in our lives. This is important, as technology and society are in a mutually fluid, dynamic relationship. Van Est and Brom (2012, 316) note: "During the mid-1980s, the central tenet of science and technology studies (STS) became that technology and society co-construct each other. This implies that technology not only effects society but is also shaped by society." This interplay is heavily reflected in more recent discussions surrounding the legitimacy of TA. It is therefore critical that social, economic and political dimensions are acknowledged across IPCC processes to further develop legitimacy through transparency. This advice is similarly suggested by other scholars advocating for ongoing awareness of the political role of science across all forms of TA (Delvenne & Parotte, 2019; Van Est, 2019).

A word of caution is required in relation to translating the IPCC model into one potential global TA framework. One example that shows the difficulty in replicating the IPCC is the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). This began with the intention of being a science-led arrangement. However, as it failed to gain traction, it subsequently tried to integrate governments using the IPCC model, but failed (Larigauderie & Mooney, 2010). Criticisms of the IPBES suggest this is because governments saw it as the research community attempting to gain influence over policy rather than a legitimate approach to co-design. Other criticisms surrounding the IPBES include the difficulties of trying to gain consensus over the very localised and regional nature of specific biodiversity loss, compared to the global need to reduce GHG emissions. This need for consensus is exacerbated by the increased demand for diversity (i.e. youth, other stakeholders, knowledge systems) amongst those participating in the process, beyond just the expert view (Diaz-Reviriego et al., 2019). This lack of unity across the scientific community of biodiversity experts has exacerbated its ability to influence policymakers and has negatively impacted its overall credibility (Masood, 2018). However, those from within the IPBES are proactively working to overcome these challenges in an attempt to maintain the legitimacy of an important scientific area (Borie et al., 2020).

A final consideration, if the IPCC framework is to be applied more broadly as a potential global TA framework, is the issue of funding. In 2017, the IPCC formed an ad hoc task group to reflect on its financial stability because of a concern about the overall drop in long-term funding. The establishment of the IPCC Trust Fund early in the life of the IPCC has helped it to be sustainable over the longer-term (IPCC, 2017). However, this success is very much based on the generous contributions of member organisations, combined with the large in-kind contributions from governments who provide not only experts and their associated advice and attendance at meetings, but also host IPCC events at no charge (Takashima et al. 2010). Reliance on such generosity is perhaps one of the greatest weaknesses for the IPCC model if it is to have potential as one such global TA model. While this will need special consideration, the existence of the EPTA network suggests some governments are already supportive of TA, and therefore provides hope that this might be extrapolated to a more global approach to funding. As always, consideration for how developing countries are provided for within these frameworks must remain a priority.

7 Conclusions

The IPCC process as a TA model has achieved significant success in raising public awareness and informing attitudes towards climate change. Recent reporting corresponded with clearly discernible responses from the international community charged with policy construction and delivery. This continues to instal optimism in the ongoing quest to mitigate climate change impacts. However, despite wider public awareness and engagement across different scales and between diverse actors, there are known barriers that have impaired the IPCC's progress. The problems identified in this chapter included measuring the effectiveness of impact through commitments, the problematic nature of consensus and accommodating situated knowledge, transparency and reporting accuracy and accessibility of information across scales.

Applying TA analytical and impact frameworks to these problems suggests these challenges are not insurmountable, especially when the global successes of the IPCC are taken into consideration. Improving transparency through participatory approaches across scales is at the heart of TA. There are examples of TA participatory practises in both democratic and non-democratic states which provide further insights for building a global TA framework that will help in overcoming the concerns surrounding trust, inclusivity and communication across scales.

All grand challenges, including climate change, need a sustained social and political commitment to overcome them. Integral to the IPCC process is the influence of the Panel and the unique co-design elements between government and researchers in setting parameters for ongoing assessment and reporting. Coupling these insights with the analytical TA framework underscores a process that accommodates the fluid nature of how humans and society interact with technology. Using participatory processes, which are mindful of situational and institutional contexts and allow stakeholders to co-create their own understandings provides hope for demonstrating a concrete way forward: One, that is inclusive of cooperation between the state, industry and citizens to inspire and strengthen innovation fairly. The reflexive nature of participatory TA, combined with the learnings from the IPCC process and its interactions with the UNFCCC, solidifies a point of departure for delivering one such practical global TA framework more broadly in future.

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Challenges of Global Technology Assessment in Biotechnology—Bringing Clarity and Better Understanding in Fragmented Global Governance

Sophie van Baalen, Krishna Ravi Srinivas, and Guangxi He

1 Introduction

Biotechnology deals with a matter that is fundamental to each person on earth: life itself. Worldwide, there may be different views on how we deal with different forms of life, and to what extent we, as human kind, are at liberty to alter and use animals, plants and other organisms for our own benefit. However, the (possible) impacts of developments in biotechnology touch on fundamental and universally-shared concerns such as our (shared) genetic heritage, illness and health, the safety and availability of food, and even the continued existence of our planet. In the current globalized world, a French scientist and an American scientist jointly won the Nobel prize (Ledford & Callaway, 2020) for a discovery that was used by a Chinese scientist to modify the genome of two embryos that grew into babies (Greely, 2019); a virus that originated in China has been able to bring nations worldwide to a halt, and (GM) crops, livestock products and food are distributed and eaten across the globe (MacDonald, 2015). Biotechnology therefore requires reflection on a global scale as well as international standards, agreements, and regulations.

Biotechnology involves the use and manipulation of living organisms such as plants, animals, humans, and biological systems, or parts of these, to modify their

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characteristics in order to create desired organisms or products. Traditional forms of such processes, such as brewing, baking, and fermenting with selected micro-organisms, or breeding of animals and plants, have been utilized by humans for centuries, and are referred to as "old" biotechnology. In the 1970s, new methods to directly manipulate genes were developed. This field of genetic engineering forms the basis of "new" biotechnology, opening up a large amount of possible new applications in the fields of medicine, agriculture, and industry. But, it also raises a vast array of concerns, such as environmental and (human) health risks, moral objections to tampering with nature, and possible wider societal impacts. As such, new biotechnology has led to both public and political concerns.

This chapter investigates how technology assessment (TA) can contribute to a global approach to dealing with global issues concerning the use of biotechnology. Biotechnology development touches on many aspects that are central to TA. Concerns about the impact of engineered organisms on the environment, ethical issues regarding the relationships between humans and nature, and contributions to economic growth and broad prosperity are all factors that affect the societal acceptability of biotechnology. These factors clearly highlight a need for governance and legislation, since the interests of all stakeholders need to be taken into account. From the first breakthroughs in the 1970s, several activities have been undertaken to debate biotechnology developments and establish instruments for their governance. Examples of TA activities are stakeholder consultations evaluating the environmental risks of engineered organisms, analysis of the economic opportunities of biotechnology products, and ethical assessment of the modification of the genome of future generations. Similarly, instruments for the governance of biotechnology have taken shape on a global scale in different forms, for example regulating the trade of biotechnology products through trade agreements,[1] or fixing values in human rights treaties regarding the human genome.[2] However, developing governance structures on a global scale is challenging, because of regional cultural and social differences (Ladikas et al., 2015), and because there is no global authority that can adopt and enforce binding rules at the global level (Marchant, 2021).

In this chapter, we examine what institutions and types of regulations organize global governance on these matters; what (available) TA studies, insights and methodologies have contributed to global reflection, deliberation and governance; and what the challenges, requirements and opportunities for global TA are when dealing with issues concerning biotechnology. Section 2 gives a general introduction to international developments and governance responses concerning biotechnology since the 1970s. In Sect. 3, we discuss the global debate and activities in the field of TA on three key topics in biotechnology: genetically modified (GM) food and crops, synthetic biology, and human genome germline editing (HGGE). In Sect. 4, we discuss public perceptions, representing the cultural differences and perspectives

[1] E.g. the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and the *Cartagena Protocol on Biosafety,* see Sects. 2 and 3 of this chapter.

[2] E.g. the UNESCO Universal Declaration on the Human Genome and Human Rights, see Sect. 3 of this chapter.

that need to be taken into account when trying to find ways toward global governance of biotechnology. In the final section, we reflect on the way ahead for global TA of biotechnology.

2 Early Developments in Biotechnology and Its Governance

An important breakthrough for modern biotechnology was the development of recombinant DNA technologies in the 1970s, with which DNA can be implanted (via a virus) into the genome of a bacterium (Jackson et al., 1972). From the beginning, it was evident that this was a controversial technology, encompassing both great potential benefits and risks. Therefore, activities to investigate and debate the consequences of biotechnology, and the possible actions that can be taken to mitigate the potential risks while stimulating the potential benefits were soon initiated.

A well-known example of this was what later came to be known as the *Asilomar Conference.* Biochemist Paul Berg, together with other scientists, initiated a voluntary moratorium on performing experiments with recombinant DNA technologies, awaiting an international conference regarding the biohazards of such experiments (Berg, 2008). At the 1975 International Congress on Recombinant DNA Molecules, at the Asilomar Conference Center in California, 140 biologists, lawyers, physicists, journalists, and government officials discussed the conditions under which experiments could safely continue. The recommendations formulated at the conference outlined the types of containment in the laboratory for different types of experiments. These recommendations formed the basis for the US National Institutes of Health (NIH) guidelines that were established in 1976. According to organizer Paul Berg, the Asilomar Conference is a good example of gaining the public's trust in science by taking their concerns seriously, and openly discussing the risks and the considerations that led to the resulting consensus. However, the Asilomar Conference is also criticized for adopting a narrow view of "risk", omitting other implications, such as social, political, and economic factors (Hurlbut et al., 2015). Similarly, a narrow range of viewpoints was included, as most participants were biologists from the US, with a few from Europe and none from the developing world, and no experts from other fields (i.e. social sciences) were included. Another criticism is that the conference focused overly on worst-case scenarios, setting a precedent for other debates about biotechnology and having a negative effect on public trust (Briggle, 2005). Thus, in hindsight the Asilomar Conference was perhaps not the best approach to discuss risk and uncertainty in science, technology and innovation.

Since the days of the Asimolar Conference, much better methods to take into account (often uncertain) impacts on both the environment and society of innovation, including genetic engineering, have been established in the related fields of Responsible Research and Innovation (RRI) and Technology Assessment. RRI is distinctive from TA by adding explicit ethical reflection (Grunwald, 2011). It has its origins in the need to address concerns with the emerging field of nanotechnology in the 2000s, in order to avoid negative impacts and to prevent the lack of acceptance and active resistance by the public, as was the case with biotechnology (Rip, 2014). Moreover, as a response to the developments in biotechnology, many approaches to TA that emphasize public participation were developed (Einsiedel, 2012).

The first practical and commercial applications of biotechnologies emerged in the 1980s, together with the first regulations. For example, the first firms exploiting recombinant DNA technology were founded, the US Supreme Court ruled that recombinant micro-organisms can be patented under existing law, and a technique for recombination of DNA was patented. The judgment in Chakrabarty versus Diamond (1980) in the US paved the way for this, and resulted in rewriting the law in patenting of products of nature. This enabled the then nascent biotechnology industry to use intellectual property rights as a strategic tool for growth and attracting investments.[3] In 1982, the production of synthetic human insulin in a genetically modified bacterium (*E. coli*) was approved by the US Food and Drug Administration (FDA). As the commercial and international aspects of biotechnology became evident, TA activities that also include these aspects were initiated. In the US, the Office of Technology Assessment (OTA) published the report "Commercial Biotechnology: An International Analysis" (OTA, 1984), and a series of five reports on "New Developments in Biotechnology" in the late 1980s.[4]

In the 1980s and 1990s, the possible risks and benefits of biotechnology on a global scale were addressed by institutions such as the Organization for Economic Co-operation and Development (OECD), the Food and Agricultural Organization of the United Nations (FAO), the World Health Organization (WHO), and the World Trade Organization (WTO). Attempts were made to deal with global issues related to biotechnology, i.e., to set up structures for the governance of biotechnology through international consensus, coordination, and agreements. The OECD issued a report on international trends and perspectives on biotechnology in 1982, addressing the potential hazards of releasing genetically modified organisms into the environment (Bull et al., 1982). It also addressed the relationships between academic institutions and industry, and between fundamental and practical knowledge, with regards to biotechnology. The report also mentions the need for international discussion and coordination concerning the patenting of life-based products and safety issues in order to avoid differences in legislation and practice between countries. The OECD has since addressed issues related to biotechnology regularly. In 1993, the OECD established the Internal Co-ordination Group for Biotechnology (ICGB) to coordinate the impacts of biotechnology on different sectors such as: agriculture and trade; environment; science, technology and industry, bringing together different working groups, working parties, committees and fora that have activities related to biotechnology (OECD, 2021).

[3] See: https://cip2.gmu.edu/2021/01/29/forty-years-since-diamond-v-chakrabarty-legal-underpinnings-and-its-impact-on-the-biotechnology-industry-and-society/ (accessed 8-4-2022).

[4] On (1) the Ownership of Human Tissues and Cells (1987); (2) Public Perceptions of Biotechnology (1987); (3) Field-Testing Engineered Organisms: Genetic and Ecological Issues (1988); (4) U.S. Investment in Biotechnology (1988); and (5) Patenting Life (1989). See: https://ota.fas.org/otareports/topic/btopics/ (accessed 8-4-2022).

In 1991, the FAO and WHO released a joint consultation report on the safety of food produced by biotechnology, which was meant as a first step toward international consensus and providing guidance for the safety assessment of foods obtained using biotechnologies (FAO & WHO, 1982). In 1994, the WTO attempted to facilitate global trade by bridging the differences in Intellectual Property (IP) rights among its members and setting global standards, with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). According to the TRIPS agreement, the requirements for patentability, i.e., novelty, inventiveness and industrial utility, apply to biotechnology inventions as well. Hence, if new biological material is obtained through non-biological processes (such as genetic engineering), it is patentable. Member states do have the freedom to exclude plants, animals, and "essentially biological processes" from patentability.[5]

Biotechnology has been a central topic in the (institutionalized/parliamentary) TA community since the first OTA reports in the 1980s. From early on, an important question has been how to balance precaution with obtaining the possible benefits of biotechnology through regulation (POST, 1994; Torgersen & Bogner, 2004). This has been an ongoing discussion, as new developments in the field reveal gaps in the existing rules and regulations (see for example Habets et al., 2019 on the regulation of genome editing of plants and crops using novel gene editing technologies in the EU).

3 Key Topics in Biotechnology

In this section, we introduce three key topics in biotechnology: (i) genetically modified (GM) foods and crops, (ii) synthetic biology, and (iii) human genome germline editing (HGGE). Although these three topics do not cover all existing developments in biotechnology (i.e., pharmaceuticals, industrial biotechnology, genetic information, and privacy, etc.), together they cover many issues that are relevant for global governance of biotechnology in general. GM foods touch upon global trade and innovative competitiveness that can be in conflict with regional rules and values. It foregrounds issues such as food security, consumer rights to information, and transparent food labeling. The emergence of synthetic biology foregrounds issues of dual use and biosecurity. HGGE is considered to require a global approach as the human genome is often seen as matter that concerns all of humanity (i.e., a "heritage of humanity" in the words of UNESCO).

[5] See: https://www.wto.org/english/docs_e/legal_e/27-trips_04c_e.htm (accessed 8-4-2022).

3.1 Genetically Modified Foods and Crops

GM foods and crops are presented as a possible solution to hunger by organizations such as the United Nations (UN, 2021) and the WHO (WHO, 2021), as genetic engineering might increase crop yields, resistance against insects and disease, and nutritional values. The advantage of genetic engineering over traditional methods to breed new varieties of crops is that genes that code directly for a desired trait can directly be transferred from one variety to another. This makes it a faster and more accurate method. Moreover, the transfer of genes from one species to another is also possible. Hence, traits that naturally do not appear in a certain species can be introduced.

But, it has also led to fierce opposition by NGOs, for example by Greenpeace, which is internationally lobbying against GMOs because of the unknown risks and their unforeseeable environmental, social and health impacts (Greenpeace, 2021). One of the major concerns is that the novel gene might be transferred to other plants, such as wild relatives of the crop species, leading to the development of resistant "super weeds" and the destabilization of ecosystems. Other concerns relate to risks for human health, for example, when novel genes that originate from species that are usually not eaten by humans or animals are introduced to food crops. The concern is that this might lead to the introduction of unknown allergens into the food chain. Other objections to GM crops include tampering with nature, the monopolization of agrochemical and plant breeding companies, and negative consequences of introducing GM crops to agriculture, such as upscaling and a high use of pesticides and herbicides. In addition, freedom of choice for consumers and trade issues are considered to be important issues (Habets et al., 2019). The system of IP and patenting can lead to monopolization of GM seed producers and push prices up. If, as a result, only rich and large companies are able to afford the more expensive GM seeds, then the cultivation of GM crops will largely be in the hands of large companies, and small farmers might not be able to benefit from increased yields of GM crops. The humanitarian argument that GM food technologies might help to feed hungry people is thus contested by the concern that the benefits might not be equally distributed.

The global debate and governance of GM food

As food is traded across the globe, the governance of GM food and crops on a global scale mostly applies to trade-related agreements. The TRIPS agreement (1994) has helped globalization of biotechnology as it expanded the scope for patenting, and the leeway to exclude from patentability was limited. This could make investing in the development of GMOs more profitable. Under Article 27.3(b) patents on plant varieties was made possible, and although "essentially biological processes" could be excluded from patenting, patenting of plant varieties opened up the scope for patents on GMOs, and processes related to developing GMOs; as patents can also cover seeds, it ensured that plant variety protection was available for GM crops. The TRIPS Agreement, while providing flexibility to countries on granting IP rights over plant varieties, ensured that at least some form of protection should be granted. By expanding the scope of IP rights on plant varieties, it also transformed the IP rights scenario related to seeds.

This flexibility left countries with limited choices, as they had to grant at least some form of IP protection rather than exempting plants and seeds, as was possible before. Because biotechnology was increasingly used to develop new plant varieties with new traits, IP protection was increasingly sought and granted on DNA fragments, genetically modified gene parts, and genetically modified organisms including plants. This expansion helped large companies like Monsanto to capitalize on IP protection and to consolidate their position in the global seed industry. In developing countries, such as Argentina and in India, such moves were met with resistance. In India, the government resorted to price control and reduced the amount of royalty demanded by Monsanto-Mahyco (Van Dycke & Van Overwalle, 2017). Whether or not the scope of this protection extended to subsequent generations of cultivars became a contentious issue in the US and Canada, where more than one form of IP protection was available.

The TRIPS agreement has also been resisted by developing countries for not sufficiently taking into account cultural, political-economic and ecological dimensions, and for pushing globalization while disadvantaging local practices (McAfee, 2003).

The Cartagena Protocol on Biosafety aims to protect biological diversity from the potential adverse effects of GMOs. It is an international agreement annexed to the 1993 Convention on Biological Diversity, entering into force in 2003. Central to the Protocol is the precautionary principle, which states that a lack of full scientific certainty is no reason to postpone measures to avoid or minimize risks posed by a living modified organism resulting from biotechnology. It allows developing nations to balance public health with economic benefits. The Cartagena Protocol applies to the transboundary movement, transit, handling, and use of all living modified organisms that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health (Article 4 of the Protocol, SCBD 2000). Some major GM crop-producing countries (i.e., the US, Argentina, and Canada) have not ratified the Cartagena Protocol, while others (India and Brazil) have.

Central to regulation of GM foods, plants and crops are containment of risks, transparency, freedom of consumer choice, and marketing issues. Therefore, regulatory regimes lay out rules for risk assessment, risk containment and labeling, and among others. The EU currently has the most harmonized and comprehensive framework for GMOs, covering contained use, field trials, marketing of GMOs, post-market monitoring, labeling, and traceability (Srinivas, 2020). Commercial cultivation of GM crops only occurs in Spain, but large amounts of GM soya and corn are imported as animal feed. Similar to the Cartagena Protocol, the precautionary principle is a fundamental principle of European legislation, and the EU GMO Directive 2001/18/EG is in line with this principle.

Fundamentally, there are two ways for countries to assess the risks of and regulate GMO crops: process based—defining plant varieties based on the process by which they were created, and product based—defining plant varieties based on the properties of the resulting product. The EU is an example of the first: classic mutagenesis methods, introducing small, random changes to the DNA of crops are exempted from the GMO Directive, because no foreign DNA is introduced. The recent emergence of new genome editing techniques, such as CRISPR-Cas9, allow for the deletion or replacement of single base-pairs, rather than introduction of foreign DNA as in recombinant DNA techniques. In the EU, this has sparked a debate about whether genome-edited crops should fall under the GMO Directive. Proponents argue that genome editing techniques are similar to classic mutagenesis techniques, as no foreign DNA is introduced. Opponents argue that safety for public health and the environment has not been proven. In 2018, the European Court of Justice ruled that gene-edited crops should be considered as GMOs.

The US is an example of the product-based approach to regulating GM food, where regulations are based on the GM foods and how they are used, rather than the technologies that were used to make them. Hence, the safety of GM foods in the US is assessed using the same rules as all other foods, and no special labeling or pre-market approval applies. The introduction of GM plants in the field is regulated by the US Department of Agriculture (USDA) that prevents the spread of (potentially) invasive new plants in the US. USDA requires companies to submit information on the plant, such as field test reports, experimental data, and publication and description of the genotype and phenotype, before GM plants can be planted, and regulates where GM can be transported and how much can be planted. Finally, if GM plants produce insecticidal substances, regulations concerning the effect of pesticides on human health and the environment apply.[6]

According to a survey among 33 countries and the EU, process-based regulations were employed by 15 countries and the EU, among which are Brazil, China, New Zealand, and Australia, whereas 14 countries employed product-based regulation, including Argentina, the US, Canada, the Philippines, and Bangladesh (Ishii & Araki, 2017). Hence, the regulatory landscape for GM foods is fragmented globally, and there is no harmonization of norms and rules of GM foods across the world. A current pressing issue is how different regulatory regimes will react to genetically edited foods. Some countries might choose the option of deregulation of genome edited crops, or treating genome edited crops as equivalent to plant species developed by traditional plant breeding methods, while others might treat genome edited crops as GMOs.

TA work on GM foods

GM foods have long been on the agenda of TA institutes, raising questions concerning biodiversity and sustainability (i.e., Meyer et al., 1998), as well as social consequences (i.e., BAS, 2008). TA has also been concerned with the public and political debate, organizing citizen panels (i.e. TA-Swiss, 1999 and many more, see Einsiedel, 2012, Table 1 for an overview), and monitoring technical and scientific developments. In 2009, the European Parliamentary Technology Assessment (EPTA) network issued a report about the challenges to European policy on GM plants (Bütschi et al., 2009).

[6] See: https://www.usda.gov/topics/biotechnology/how-federal-government-regulates-biotech-plants (accessed 8-4-2022).

These challenges related to new driving forces for GM plant introduction, including agriculture for non-food products such as bioenergy and biomass; the development of new types of GM plants, technologies and applications; public acceptance of GM plants; labeling of GM products, and consumer choice and international trade rules. On each of these issues, the EPTA network provides options for action to policymakers.

In recent decades, public discourse and policymaking have been focused around regulations and issues like food safety and environmental impact. Likewise, the concerns regarding genetically edited crops have also been on governance and regulation (Entine et al., 2021) or on risk assessment (Kawall et al., 2020). Here, discussions have also focused more on specific aspects than on a holistic assessment.[7] One of the aims of TA, however, is to include other impacts of technological developments like GM food, such as economic impacts, environmental impacts, impacts on women, impacts on health, and impacts on labor (Chaturvedi & Srinivas, 2019). TA methods could be helpful to assess such broad impacts of GM foods. Moreover, the issues and impacts of GM foods are not similar for each country: there are different regulations, needs, and cultures in each country. A globalized TA effort can help to gain insight into the broad implications of (the governance of) GM foods for the diverse situations in various countries across the globe, and the impact of globally standardized governance in each of these situations.

3.2 Synthetic Biology

In the early 2000s, synthetic biology (or SynBio) emerged at the center of biotechnology developments. Synthetic biology is the engineering of biology to (re)design organisms or complex biologically-based systems which display functions that do not exist in nature and that are useful for mankind. A fundamental difference between genetic engineering and synthetic biology is that, with the latter, it is possible to redesign a biological system or organism, or to create a totally new organism not found in nature. As such, synthetic biology creates new opportunities and raises new expectations and concerns. Therefore, existing regulatory regimes created for genetic engineering may not be suitable to regulate synthetic biology (Srinivas, 2020). Globally, a Do-It-Yourself biology (DIY biology) movement has emerged making protocols and kits available online, allowing amateurs to experiment with synthetic biology at home. The DIY biology movement is now diverse in terms of geography and location. The international genetically engineered machine (iGEM) competition, held since 2004, provides a platform for novel ideas and experiments in synthetic biology. So far, synthetic biology has not been dominated by multinational corporations and there are strong countervailing forces like the DIY biology movement to prevent this.

[7] For example, see: https://www.europarl.europa.eu/cmsdata/232239/Booklet%20WS%20Genome%20Editing%2015-04-2021_final.pdf.

The global debate and governance of synthetic biology

The discourse about synthetic biology is fueled by its potential benefits, such as the production of medicine by artificial bacteria, biofuel from algae, or developing biosensors that improve measuring instruments. At the same time, synthetic biology raises concerns. How far can we intervene in the living world? Can we foresee the consequences? The international debates relate to issues of biosafety and biosecurity, intellectual property and the international framework on *ethics and human rights*. Across the globe, different discourses relating to innovation, risk, power and control have emerged, involving different actors. In contrast to the first attempts at regulating genetic engineering, which was mainly initiated by experts at the Asilomar Conference, many different actors, including NGOs, have been involved from the beginning, and the need to incorporate stakeholder and public questions and concerns into policymaking has been on the agenda from an early stage (Stemerding & Rerimassie, 2013). Moreover, the global nature of the developments, due to the international interconnectedness of academic disciplines and the industrial sector, has been mentioned as one of the central features of synthetic biology (ibid.). This brings out the need for transnational governance and international coordination. Currently, governance of synthetic biology is evolving, with countries following different approaches (Trump et al., 2020) without moving toward global harmonization. However, the extension of regulatory regimes developed for genetic engineering/GMOs is also emerging as an option. The ongoing discussions under the Convention on Biological Diversity relate to the question of whether synthetic biology would be covered by the Cartagena Protocol on Biosafety (Lai et al., 2019). Synthetic biology was discussed at the Convention on Biological Diversity and the Ad-hoc Technical Experts Group (AHTEFG), but there was no consensus on the assessment of new genetic technologies, such as synthetic biology. Major differences occurred between parties that grow and export GM crops and other parties that take more precautionary approaches. The AHTEFG has proposed establishing a “Multidisciplinary Technical Expert Group on Synthetic Biology to carry out the horizon scanning, monitoring and assessment process” (Third World Network, 2021).

TA and synthetic biology

Synthetic biology is currently receiving much attention from the (institutional/parliamentary) TA community (i.e., EPTA, 2011; POST, 2008, 2014; Stemerding & Rerimassie, 2013; TAB, 2015). Synthetic biology has dual-use potential and there are concerns about *biosecurity,* the potential for misuse and *biosafety*, and the potential unintended consequences of the technology (see: NASEM, 2018). One suggestion has been that prospective TA in combination with ethics is necessary (Schmidt, 2015), or that it can be complemented with an analysis based on Responsible Research and Innovation (RRI) (Stemerding, 2019). One way to go about this is to review the literature and case studies of TA in dual use in other fields such as cybersecurity (e.g. Riebe & Reuter, 2019), and draw lessons from that. Synthetic biology was one of the topics of the Global Ethics in Science and Technology (GEST) project (2011–2014), which compared the role of ethics in science and technology policy as it was developing in Europe, China and India. But the real challenge lies in using TA in technological convergence: the "tendency of different systems to eventually evolve, blend, and synergistically reinforce and interact with each other, sharing and extracting resources and energy to produce new and unique meta-technological products and outcomes" (McCreight, 2013, p. 12). This convergence has the potential to improve human lives, but also to be put to use in warfare and, as such, have disastrous consequences for the global balance of power. Synthetic biology is often mentioned as one of the technologies that has this potential, together with artificial intelligence, neuroscience, nanoscience and robotics. Utilizing foresight methodologies from TA, such as scenario analyzes and horizon scans, can be helpful in developing governance that anticipates future developments. An example is the techno-moral future scenarios on synthetic biology, developed by the Rathenau Instituut and the 2012 iGEM University College London team.[8] Together, they present a range of possible futures for synthetic biology in our society and in our lives, and support politicians, scientists and the broader public to reflect on the possible positive and negative impacts. This facilitates the conversation between policymakers, stakeholders and the public about what role they envision for synthetic biology in society, and how we can stimulate this through governance while limiting the negative consequences.

3.3 Human Genome Germline Editing (HGGE)

In the first decades after 1970, the assessment of the consequences of biotechnology focused on environmental and health risks and (global) trade, but in the 1990s the assessment of underlying values and the role of ethical principles for the governance of biotechnology became more prominent. As the science of genetic engineering and molecular biology progressed, attention turned toward the engineering of the human genome. In 2003, the entire human genetic code was mapped for the first time, the outcome of the Human Genome Project which had started in 1990 (NIH, 2021). The expanding knowledge of the genetic basis of human traits and disorders, and new technologies for modifying genes, could in time make it possible to alter the building blocks of our lives: human DNA. When the DNA in the cell of a human embryo or in cells that could grow into reproductive cells is modified in the laboratory, we speak of *human germline genome editing* (HGGE). When a child grows out of a genetically modified embryo, the DNA of their offspring will also contain the modification. HGGE could have a variety of social repercussions that require governance with a strong basis in values from society.

[8] See: https://www.rathenau.nl/sites/default/files/2019-01/Future_scenarios_synthetic_biology.pdf.

The global debate and governance of HGGE

In response, international and global agencies have attempted to curtail modifications of the human genome through regulations and treaties. In most countries, human genome editing is prohibited by law (Ledford, 2015). In addition to national prohibitions, various human rights treaties curtail modifications of the human germline, such as the Universal Declaration on the Human Genome and Human Rights (UNESCO, 1997), which considers the human genome as “the fundamental unity of all members of the human family, as well as the recognition of their inherent dignity and diversity. In a symbolic sense, it is the heritage of humanity.” (Article 1) The Council of Europe addressed genetic modification of the human genome in Article 13 of the Oviedo Convention, stating that an intervention to modify the human genome may only be undertaken for preventive, diagnostic or therapeutic purposes, and only if its aim is not to introduce any modification in the genome of any descendants (Council of Europe, 1997). In the European Union, eugenic practices and cloning of human beings are both deemed to be in violation of human dignity and are rejected in Art. 3(2b) of the Charter of Fundamental Rights (2000). More recently, the European Clinical Trial Regulation (2014), which entered into force in 2019, also prohibits the alteration of heritable DNA by providing that, “No gene therapy clinical trials may be carried out which result in modifications to the subject’s germ line genetic identity.” (European Clinical Trial Regulation, 2014, p. 51).

In 2012, a new technology was discovered for modifying DNA: CRISPR-Cas9 (Jinek et al., 2012). In contrast to earlier genome editing technologies, CRISPR is often referred to as a ‘molecular scissor’. Scientists regard the technology as ‘easy to use, precise and relatively inexpensive’. Within the medical field, scientists, doctors and patients hopefully anticipate the possibility of preventing the transmission of (severe) heritable diseases through HGGE (De Wert et al., 2018; Liang, 2015).This development has reopened the discussion about the modification of heritable DNA.

At the international level, different initiatives to discuss and reflect on human genome editing have been initiated. For example, at the two “International summits on genome editing” in 2015 and 2018[9] experts have discussed the scientific state-of-the-art and the ethical and societal questions, and concluded that it was, at that time, irresponsible to use germline genome editing in a clinical setting, to alter the genetic make-up of future persons. Firstly, because the technology was deemed not safe and efficient enough, and secondly, because of a lack of broad societal consensus about the acceptability of clinical use of HGGE. Despite worldwide consensus that the use of gene editing technologies to modify the DNA of future persons is not acceptable due to ethical concerns, as well as issues with safety and efficacy, and despite that HGGE for reproductive purposes were prohibited, the Chinese scientist He Jiankui announced that the world’s first gene edited babies had been born in China on November 26, 2018 (Cohen, 2019). This led to an outburst of reactions from within and outside the academic community, and calls to consider a temporary worldwide ban on the reproductive applications of HGGE until adequate reflection has taken

[9] See: https://www.nationalacademies.org/our-work/international-summit-on-human-gene-editing (accessed 8-4-2022).

place at the national and international levels (i.e. Lander et al., 2019). It soon became clear that many scientists from around the world were aware of He's plans to let babies grow out of genetically altered embryos (Cyranoski, 2019). The announcement by He Jiankui was taken by the Chinese government as an opportunity to enhance the ethical governance of emerging technologies by establishing a National Science and Technology Ethics Committee and issuing the "Regulations on the Administration of the Clinical Application of New Biomedical Technologies", which improved the management system for the clinical application of new biomedical technologies at different risk levels.

In the aftermath of this incident, the WHO founded the advisory commission on Developing Global Standards for Governance and Oversight of Human Genome Editing, that issued a Framework for Governance and Recommendations on the topic in 2021. In this set of documents, the committee gives advice and recommendations on appropriate institutional, national, regional, and global governance mechanisms for HGGE.[10] It recognizes that governance is needed at national and transnational levels, because both the research and the societal effects will go beyond national borders. Therefore, it recommends that the WHO should take leadership and work with others to establish international collaborations for effective governance and oversight. According to the committee, good governance in this context is value-based and principle-driven, and it provides a list of the values and principles that should inform governance decisions. By putting forward seven scenarios, the committee illustrates the practical challenges that can be encountered when establishing good governance of HGGE.

In 2020, the US National Academy of Science and the UK Royal Society International Commission on the Clinical Use of Human Germline Genome Editing issued a report that aims to provide a "translational pathway" from preclinical research to clinical application that governments can use to introduce HGGE in their countries should they decide to permit such use (NAM, NAS, and the Royal Society, 2020). Notably, it also asserts that "extensive social dialog should be undertaken before any country makes a decision on whether to permit clinical use of heritable human genome editing (HHGE)."

Because the current global regulatory landscape regarding HGGE is very fragmented and no global authority that can adopt and enforce binding rules at the global level exists, it is unlikely that a single mechanism will be sufficient. A mixture of different soft-law mechanisms, such as international registries, conferences and (nonbinding) governance frameworks by international organizations such as WHO, and guidelines from professional societies such as the US National Academy of Science and the UK Royal Society will nonetheless be beneficial to develop global consensus about what HGGE activities are ethically unacceptable, and mechanisms to detect and report them (Marchant, 2021).

[10] See: https://www.who.int/news/item/12-07-2021-who-issues-new-recommendations-on-human-genome-editing-for-the-advancement-of-public-health (accessed 8-4-2022).

TA and HGGE

In the early 2000s, the main concern raised by TA was the possibility to read the human genome (PACE, 2001; POST, 2000), and this is still an ongoing debate (POST, 2015; STOA, 2008, 2021). TA institutes have analyzed the possible benefits of these developments, such as more precise characterization of medical conditions, better diagnostics and disease prevention, as well as potential (unwanted) impacts such as the commercialization of (individual) genetic information. More recently, the possibility to edit human DNA has technically become more realistic, with the discovery of "genetic scissors" CRISPR-Cas9. TA institutes have assessed the possible benefits, risks and ethical issues of these developments concerning genome editing in plants, animals and humans (ITA, 2016; POST, 2016; TAB, 2015; Van Baalen et al., 2020), and have been involved in the organization and analysis of broad public dialogs about HGGE (Van Baalen et al., 2021). For this dialog, a set of four techno-moral future scenarios were developed.[11]

4 Public Engagement in Biotechnology and TA

As one of the central aims of TA is to aid the democratic control of developments in STI, participation of a range of stakeholders and the wider public is an important element of TA. This is all the more important for TA of biotechnology, as biotechnology challenges some of the conceptualizations that people use to make sense of the world, such as between sickness, health and enhancement, between living and non-living, between nature and technology, and between biology and engineering. Moreover, over recent decades, the debate has broadened from micro-organisms to plants to human beings (STOA, 2008). As these developments have such a tremendous impact on our bodies, lives and surroundings, they should not be left to driving forces such as science, industries and markets. Rather, policymakers and citizens—the public-should be aware of the developments and enabled to take part in the discussion about their desirability and acceptability.

Moreover, citizens are demanding to have a say in the governance of these developments: from the 1990s onward, biotechnology has increasingly became the subject of public and societal debate, often sparked by single events, such as the creation of Herman the transgenic bull in the Netherlands in 1990, the first commercial production of GM food in the US in 1994, and Dolly the cloned sheep in 1996 (see: Einsiedel, 2012; Hansen, 2011). In the early 2000s, public concern with genetic engineering, most notably genetically modified crops and other food products has had considerable influence on GMO policy throughout the globe. As such, an important task of TA in biotechnology is to include a range of perspectives from the public and societal groups in the assessment of technologies.

[11] See: https://www.rathenau.nl/en/making-perfect-lives/discussing-modification-heritable-dna-embryos (Accessed 8-4-2022).

Box 1. Public Attitudes to Human Genome Germline Editing (HGGE)

Public surveys

Public surveys in China and the US show that 72.5%, 72.8%, and 70.9% of Chinese respondents clearly expressed their support for the clinical use of HGGE to prevent fatal diseases, prevent non-fatal diseases, and reduce the possibility of serious diseases, respectively, compared to 71%, 67%, and 65%, respectively, in the US. Nearly half of the Chinese public supported the clinical use of HGGE for the purpose of enhancement, a larger proportion than that of the American public (48.6% vs. 12%).

An international survey among Canada, the US, Brazil, Germany, Sweden, the Netherlands, the UK, France, Spain, Italy, Poland, Czech Republic, Russia, South Korea, Japan, Taiwan, India, Singapore, Malaysia and Australia (Pew Research Center, 2020a), shows that 70% of participants think it is appropriate to use HGGE to treat a serious disease or condition the baby would have at birth, 60% think it is appropriate to use HGGE to reduce the risk of a serious disease or condition that could occur over the baby's lifetime, and 14% say it is appropriate to use HGGE to make the baby more intelligent. The third scenario evokes the widest diversity of opinions across publics: from 8% percent agreement in Japan to 64% agreement in India.

Societal dialog

In the Netherlands, politicians request societal dialog about controversial topics. In 2019 and 2020, a broad societal dialog to ascertain the views of society towards the clinical application of HGGE was organized by a consortium of Dutch societal partners, financed by the Dutch Ministry of Health, Welfare and Sport (Van Baalen et al., 2021). In general, participants had no fundamental and absolute objections towards HGGE technology. However, they only deemed HGGE to be acceptable when it is used to prevent serious, heritable diseases and under strict conditions, without affecting important (societal) values. A small group of participants found HGGE fundamentally unacceptable because it would cross natural, socio-ethical or religious boundaries. 69% of the respondents agreed with HGGE to prevent a serious muscular disease, 37% agreed with HGGE to protect a child against a serious infectious disease, and 8% agreed with HGGE to make a future child more intelligent (DNA-dialoog, 2021). Compared to the respondents in the Chinese and US studies, the Dutch respondents are more cautious towards the use of HGGE.

Biotechnology and the need to include public perspectives have been an important factor in the establishment of TA-institutions throughout Europe and the development of approaches to TA that emphasize public participation, such as *participatory* or *interactive* TA, and related methodology, such as *consensus conferences* (Einsiedel, 2012). Different issues play a role in these debates. For example, religious beliefs and concepts of nature, health, disease, and parenthood. Members of the public voice ethical concerns on "messing with nature" or "playing god" when intervening in the fundamental building blocks of plants, animals or humans is discussed (Evans, 2001). But they are also concerned with the direct and indirect risks of using advanced genetic engineering technologies when not all aspects of the biology are known. Can we introduce genetically modified plants or animals safely into the environment? Are GM foods safe to eat? Is it possible that artificially introduced genes may be transferred to natural forms? And does this impose a threat to the natural environment and biodiversity? And how can we make sure that targeted DNA-modification of an embryo (a future child) does not introduce off-target modification. Moreover, the public is also concerned with the interests of other stakeholders: who decides whether these risks are acceptable and who will benefit? Especially in the debate on GM crops, the concentration of power in large, global agrochemical and plant breeding companies is objected to, while in the debate on HGGE, the public is concerned with long-term social consequences, such as the genetic consolidation of pre-existing socio-economic inequalities (Van Baalen et al., 2020; Habets et al., 2019).

Despite these concerns, almost all the scientific associations and UN organizations such as FAO and WHO are assured that GM foods are safe. More importantly the reports (i.e., FAO, 2004; NAS, 2014; Nuffield, 1999) point out the need to take into account concerns related to ethics and values and urge greater engagement with the public and better communication on risk and benefits. A report about TA on converging technologies by STOA (Panel for the Future of Science and Technology at the European Parliament) concludes that "there was a need for values and criteria" and that "almost all agreed on a need for more public input" because "there is still little awareness about converging technologies despite their far-reaching potential." (STOA, 2006, p. V) The biotechnology patent debate revealed deep moral concerns about basic genetic research that should be taken into consideration by TA. To adequately address moral and public concerns, a more contextual approach is needed, which integrates various forms of interaction between biotechnology and society (Hoedemaekers, 2001). Given the importance of ethics and public consultation and engagement, many tools and methodologies have been identified or developed, and put into practice, such as citizens' forums, consensus conferences, focus groups, public hearings, and scenario workshops (see Beekman et al., 2006 for different decision-making frameworks and public consultation methods).

Box 2. Public Perception of GM Food and Crops in China and Worldwide

The acceptance of GM food and crops by the Chinese public has consistently declined over the past decade. In 2000, 83% of Chinese consumers were willing to buy nutritionally improved GM food, registering the highest proportion among the ten countries surveyed (FAO, 2004). In 2006, the proportion of Chinese urban consumers accepting GM food was about 65% (Huang et al., 2006), and in 2011, 42.1% of the respondents clearly support the promotion of genetically modified rice in China (Guangxi et al., 2015). In 2016, 63.2% of the respondents opposed the promotion of GM rice in China and only 27.1% expressed their support; 74.1% of the respondents were reluctant to eat GM food, compared to only 17.8% who were willing.

An international survey in publics across Europe, the Asia–Pacific region, and in the US, Canada, Brazil and Russia finds that across the globe, a larger proportion of the public thinks that GM foods are unsafe to eat than the proportion that think that GM foods are safe (Pew Research Center, 2020b).

Some information on the public perception of HGGE (Box 1) and GM foods and crops (Box 2) is presented. Although these only cover a few countries, and much more can be said about the public perception of these technologies, the information in these boxes shows three things. First, public perceptions differ from country to country. Generally, the attitude of Christians, especially those in the West, are more cautious toward HGGE than religiously unaffiliated people, although acceptance of HGGE is not uniformly linked with religion. For example, Hindus and Muslims in India are equally likely to view research on HGGE as appropriate (Pew Research Center, 2020a). The Chinese public, under the influence of the pragmatist cultural tradition, generally show a higher acceptance of new biological technologies. These differences are also reflected in the way ethics related to such new technologies are managed: in China this is driven "top-down" by the government.

Second, surveys on HGGE broadly show similar patterns: that modifying the genetic traits of offspring is controversial, and its acceptance depends on the purpose of the application. Preventing serious heritable disorders is regarded as an acceptable application more often than human enhancement. However, the outcomes of surveys disguise more nuanced considerations that will be useful for political decision-making. For example, from societal dialog in the Netherlands a set of values were derived that need to be protected in policy-making. These are: safety/precaution, the prevention of suffering or illness, protection of early human life, respect for the autonomy of the future child, autonomy, accessibility, diversity, inclusivity, non-discrimination, equality and solidarity (Van Baalen et al., 2021). Finally, the declining public acceptance of GM foods and crops in China shows that public perception is not stable and can change over time (see Box 2), for example, in response to public controversies.

How ethics, values, risks, and benefits are considered and what role they play in the public perception of these technologies differs from country to country and over time. This is a challenge for the global governance of biotechnology, as public perceptions of these technologies have played a major role in the resulting regulations in place in different countries. Developing an overarching governance system that takes into account the various perspectives across the globe will be a major challenge and is possibly not feasible. However, an effort should be made to coordinate the different systems of governance in such a way that it allows for variations across countries and regions. For this, forms of participatory (pTA) can be employed to include a range of (informed) deliberations, perspectives, concerns, and values from members of society in the policymaking process (Hennen, 2012).

5 Global TA of Biotechnology: The Way Ahead

The analysis of three key topics in biotechnology shows that a central feature of biotechnology is that the science is evolving globally and the products that it brings forth are traded across the globe. Yet, there are major differences between the regulation and governance of the academic and industrial sectors between countries. These stem from different needs and interests per country, as well as differences in traditions, cultural differences and public perceptions. To develop an integrated global TA framework on biotechnology the following have to be considered.

International trade

As we have seen, there are different approaches to risk assessment of GM products and emerging biotechnology developments such as gene-edited foods and synthetic biology. WTO agreements aim to bring coherence, in order to facilitate international trade. For example, the technical barriers to trade (TBT) agreement's objective was developed to ensure that technical regulations, standards, and related assessment processes are non-discriminatory, while enabling countries to set suitable standards to ensure protection of the environment and human health. Countries are expected to have international standards as the basis for regulation and base their risk assessment on scientific evidence. Similarly, the objective of the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) is to strike a balance between the rights of governments to protect food safety, plant and animal health on the one hand and these measures becoming unjustified trade barriers on the other. But in practice, this has become a contentious issue. A classic example is the European Community's (EC) Measures Affecting the Approval and Marketing of Biotech Products (Biotech Dispute) case, in which SPS measures pertaining to seven products containing genetically modified organisms were questioned by the US and other countries. At the heart of this case was the use of the precautionary principle by the EC and disputes over interpreting and implementing "science-based risk assessment". Although the dispute settlement body of WTO did not agree fully with the EC's arguments in this regard, the case did not bring in any change in the policy and practice of the EC on imports of GMOs or in risk assessment.

Such disputes show that harmonization of standards and consensus on science-based risk assessment are very difficult to achieve. According to Islam (2019, 16), "The SPS Agreement has not yet addressed the weaknesses of its international standardizing bodies, the inherent tension between the evolving nature of scientific research and the conclusiveness of scientific evidence in assessing risks and the implementation difficulties faced by developing countries with limited or no scientific capability". In short, the SPS agreement, relying on scientific evidence as a conclusive risk assessment criterion, falls short in addressing scientific uncertainty surrounding biotech products (ibid). The differences in risk assessment arise on account of applying the precautionary principle, setting higher standards in the name of protecting human health and environment, and policies on regulation of risk. The international standardizing bodies set levels, and when a country considers them to be too low, if it thinks that it should set a higher standard it has the option to do so. For example, the Appellate Body took the position in the Beef Hormones dispute that the CODEX international standard was not mandatory and WTO Members could opt for a scientifically established standard that was higher than that of CODEX. So, in case of biotech products, risk assessment, application of the precautionary principle and standards are issues. A European consortium has recently analyzed how the precautionary principle is applied in the European Union, how it relates to innovation and how its future application can be improved.[12]

In addition, the issue with the TRIPS agreement, which is meant to make the development and trade of biotech products profitable through patents, is that it mostly seems to benefit large companies in richer parts of the world while disadvantaging small farmers and local businesses in poorer parts.

Differences in regulations

Global governance of biotechnology is likely to be caught between the process-orientation and precautionary principle of the EU and product-oriented regulation by the US. At the same time, many countries follow their own mode of governance which differs from both. For example, in crop genome editing, Canada follows an approach that is centered on novel traits to regulate. Argentina has developed its own approach to crop genome editing (Lema, 2019). Using the definition of living modified organisms (LMO) in the Cartagena Protocol as the basis, Argentina uses the criteria of whether the crop is a GMO or not. According to Lema, "the Argentine regulation calls for any crop developed using gene editing to be presented to the biosafety commission in order to establish, case by case, if it is GMO or not. This determination is mostly based on the changes present in the genome of the plant intended to be introduced in the market, i.e., the final stage of the breeding process" (p. 148).

The challenges for global governance are many. Should older approaches like product-oriented regulation and process-oriented regulation be applied with modification, or should genome edited crops be regulated as "'normal" crops developed using traditional plant breeding varieties? Risk assessment is likely to be an issue, as treating them as equivalents of crops developed using traditional plant breeding varieties without doing assessment for specific risks will be contested. The scope for countries developing sui generis frameworks cannot be ruled out. Differences in consumer acceptance, labeling requirements, and co-existence are other issues that have implications for global governance.

[12] The results will soon be published on their website: https://recipes-project.eu/. A comprehensive description of case studies on CRISPR-based gene drives and GMOs can also be found on their website.

Cultural variation and different value-systems between countries

Regional cultural variations and differences in underlying values of governance between countries and regions result in variations in how biotechnologies are valued and assessed. This makes it difficult to define rules and regulations that are acceptable to all nations. It also leads to issues such as ethics dumping (Schroeder et al., 2018), in which scientists revert to countries with more lenient regulations or less governance capacity to perform experiments that are not permitted in their own country, and moral free-riding, where countries benefit from R&D that is permitted in their country for moral reasons. An example of the first is the "three parent baby" that was born in New York in 2016. Because the method that was used ("spindle nuclear transfer") was not approved in the US, the doctor went to Mexico to perform the procedure.[13]

Difference in countries' capacities

Not all countries have similar capacities in R&D or utilizing biotechnology innovations. Hence, biotechnologies are unevenly adopted across the world, and different countries may have adopted different generations of biotechnology. This also leads to differences in issues that need to be addressed by governance and regulation. This is also a challenge for a globalized TA: As biotechnology has been unevenly adopted across countries in terms of applications, research in biotechnology and adoption, context-specific TA may be more relevant than global TA.

There is not much literature on TA and biotechnology in developing countries, as TA is generally weakly institutionalized in developing countries. A case study on public engagement with decision-making on Bt Brinjal in India shows the divide between scientists who were in favor of approving it for commercial use and, civil society groups (amongst others) opposing it (see also Srinivas and Van Est, this volume). According to Pandey and Sharma, "As a result, the exercise ended up being an exception rather than constituting a norm and the scientific establishment reverted back to mechanisms of communicating the "right" information to the public through "proper" channels, so that they can make decisions that follow a techno-economic rationality" (Pandey and Sharma, 2020, 164).

Public engagement

Other challenges to the global governance of biotechnology are the moral dilemmas and public concerns raised by developments in the various fields. Public engagement and social debate are required, but are difficult to organize on a global scale, and it is questionable whether or not it is feasible to define a set of values and principles that take into account all existing cultural and social perspectives. TA, especially forms of pTA, can be beneficial by analyzing the possible societal impacts, providing methods for stakeholder and public participation, and uncovering the national and international value-systems that play a role in policymaking (Hahn & Ladikas, 2019). But applying pTA globally may turn out to be challenging given the lack of TA in

[13] See: https://www.newscientist.com/article/2107219-exclusive-worlds-first-baby-born-with-new-3-parent-technique/ (Accessed 8-4-2022).

biotechnology in many countries. National TA institutes can play a role here by attuning their public engagement approaches to each other and by attempting to find shared values underlying public perspectives on biotechnologies.

Conclusion

In conclusion, as global governance is fragmented with little scope for harmonization, global TA of biotechnology can bring clarity, better understanding, and enable better governance. In order to do so, an integrated global TA framework should find ways to address the differences in risk assessment and other relevant regulations between countries, often stemming from cultural differences and different underlying values. Furthermore, different countries are in different stages of adoption and development of biotechnology, focus on different sectors and applications of biotechnologies, and have different capacities for R&D and implementation of biotechnologies or performing TA. Moreover, emergence of new GM food technology, genome editing and synthetic biology have complicated matters, as countries approach governance of these in different ways, with some approaches borrowed from experiences in regulating genetic engineering-based biotechnology. These issues will make the development of a globalized TA framework and collaboration between TA-institutes across countries challenging.

Addressing these challenges will only be possible if there are country-level and regional-level initiatives to 're-invent' a TA of biotechnology. Rather than focusing on harmonization of governance, a global TA of biotechnology should focus on assessing the impact of developments and decisions in one country to other countries, and clarifying both differences and common grounds between countries, for example when it comes to values underlying public perspectives on biotechnology topics or the use of the precautionary principle to assess risk and warrant safety. TA institutes across the globe can work together to fill the gaps in global governance of biotechnology by coordinating their efforts toward national and international governments to ensure that developments are acceptable for all, regardless of cultural differences, and help make sure that countries are not faced with "faits accomplis" due to globalization and rapid developments elsewhere.

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Artificial Intelligence—A New Knowledge and Decision-Making Paradigm?

Lei Huang and Walter Peissl

1 Introduction

Artificial intelligence (AI) has been considered as one of the critical technologies to address the future grand social challenges in a global context (Kaplan & Haenlein, 2020). Major economies are engaging to promote the R&D of AI through substantial policy efforts (Margetts & Dorobantu, 2019). Machine learning, neural networks, natural language processing (NLP), smart robots, knowledge graphs, and expert systems are among the key technical sub-systems that construct the current AI technological paradigm (Cresswell et al., 2020; Yablonsky, 2019). However, AI also raises concerns with regard to risks for society—from fundamental ethical considerations, through impacts on democracy, to the labor market. These risks and opportunities call for scientific policy advice on the basis of interdisciplinary technology assessment (TA) activities.

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AI is believed to represent an interruptive potential regarding economies and societies. The application scenarios of AI are understood to cover many social domains (Di Vaio et al., 2020; Fosso Wamba et al., 2021; Perc et al., 2019; Popkova & Sergi, 2020), for instance, autonomous driving in transportation, robotic surgery in health care. The interaction between machines and humans may evolve to a new paradigm that human beings are transforming into data beings (Breazeal et al., 2016; Dautenhahn, 2007a, 2007b; Sheridan, 2016).

Meanwhile, some of research has claimed that AI should be considered as a general-purpose technology that generates grand implications in all sectors of the economy and society. For instance, deep learning technology will not only create market profits for online platforms, but also provides high-efficiency tools for social governance. In addition, with the accumulation of applications in specific economic and financial domains, AI technology presents the potential to change social structures (Klinger et al., 2018; Rasskazov, 2020). Hence, to achieve a better understanding of the potential impacts and necessary governance, we aim to identify the critical research topic of AI from a TA perspective.

In this chapter, we sketch a picture of global developments in AI and discuss potential fields of application as well as the demand for TA. In order to do so, in Sect. 2, we provide a short overview of historical developments of AI, and identify stakeholders involved in current AI R&D. In Sect. 3, we describe major activities in the international policy arena. Section 4 is devoted to TA activities with regard to AI in Europe and beyond. In Sect. 5, we conclude with the demand for future cooperation in global TA on the issues at stake.

2 The Identification of Stakeholders in a Data-Driven Artificial Intelligence Context

AI is a rapidly growing domain based on developments since the 1950s (Fosso Wamba et al., 2021). In 1950, Alan Turing offered the preliminary concept of "thinking machines" on the level of human beings (Turing, 2007). Based on the level of development, there are three types of AI: artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial super intelligence (ASI) (Lorica & Loukides, 2016). ANI is also termed "Weak AI", due to the limited information processing capability of specific tasks (Yadav et al., 2017). AGI or "Strong AI" refers to machines which can perform on the level of the human mind, performing a general level of intellectual tasks (Roitblat, 2020; Wang & Goertzel, 2012). ASI refers to the cognitive performance of machines that will surpass that of human beings (Narain et al., 2019). Actual AI systems refer to the "Weak AI" level so far.

Although some academic definitions have been made, there is no universal definition for AI (Helm et al., 2020; Legg & Hutter, 2007). Due to rapid development in this domain, the definition of AI is continuously changing. According to the EU AI watch report, *Defining Artificial Intelligence 2.0: toward an operational definition and* *taxonomy of artificial intelligence*, the definition from the High-Level Expert Group on Artificial Intelligence (HLEG) has been considered as an operational definition of AI, as follows (European Commission. Joint Research 2020):

> Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that given a complex goal, act in the physical or digital dimension by perceiving their environment through **data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal.** AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behavior by analyzing how the environment is affected by their previous actions.

According to this operational definition, AI is a certain kind of information system for processing data to achieve the given goal of making the machine think or act like human beings (Russell & Norvig, 2009). Hence, for information systems, a "stakeholder" means *"participants [being individuals, groups or organizations who take part in a system development process] … whose actions can influence or be influenced by the development and use of the system whether directly or indirectly."* (Pouloudi & Whitley, 1997).

The definition of AI has evolved since Turing's research on machine thinking. The core of the definition of AI is to make the machine think and act like a human being, as far as possible. The technological system of AI is a complex system. However, the basic logic of AI definitions is that machines need to learn from data, which is provided by humans via information exchange. Based on the current technological nature of AI systems, information exchange works in a digital format, which is called "Data" (Al-Jarrah et al., 2015). To achieve this goal, scientists have been developing relevant sub-technological systems that include hardware, algorithms, and human–machine communication interfaces (Shin et al., 2016). For instance, computational capability has increased 300,000 times from AlexNet (2012) to AlphaGo Zero (2017). More powerful computational capability means more efficient data processing for AI development (Al-Jarrah et al., 2015; Jordan & Mitchell, 2015).

Although the current AI ecosystem is still far from Strong AI, it has presented great potential for digital society and the economy (Mahadevan, 2018). Most of the current AI-relevant policies highlight the importance of data resources for AI development (as shown in Sect. 3, 'The international policy discussion'). Data-driven technologies and application scenarios are contributing to the training of algorithms, machine learning devices, and human-AI feedback systems. For instance, a large scale of graphic data has been applied to train the visual recognition algorithm (Lu et al., 2018). Data-driven technological progress presents one of the most critical differences between the AI technology from Turing's era and current AI (Chen et al., 2019). In addition, data-driven AI is not only a technological challenge but also a grand social challenge (Alyoshina, 2019). Most of the data resources which are used for AI development come from human societies.

Hence, the stakeholders of AI are those participants that can influence or be influenced by the development and use of AI systems, directly or indirectly. Furthermore, based on the HLEG operational definition of AI, data processing is the essential characteristic for current AI systems. The stakeholders of current AI system development participate in data processing either directly or indirectly. However, according to the HLEG definition, the data processing capability must achieve the specific purpose that makes AI systems gain the function of decision-making by adapting their behavior to interact with the real world. Based on this specific purpose, the stakeholders of AI will also be involved in the intersystem behavioral interaction of AI systems. AI systems are evolutional systems based on data-driven information and communication technology (ICT) systems. All of the stakeholders in an AI system participate—on different levels and with different impact—in the construction of the ecosystem that includes technology innovation, application scenarios, and human-AI interaction interfaces (Dayton, 2020; Samoili et al., 2020).

AI is now generating value for different kinds of stakeholders involved in the technology systems development and use. A multi-stakeholder perspective on AI also considers the benefits, which are related to the value-creation process, for both industry and society (Güngör, 2020). Consequently, in line with the comprehensive review of the HLEG operational definition and the value-creation of AI, participating multi-stakeholders directly or indirectly process data from technology, industry and society, in order to develop the AI system.

The current developments of an AI definition show a significant feature of data-driven innovation. Hence, basic research and technology applications of AI strongly rely on the allocation of data resources from the R&D of technologies, economies, and societies. In addition, more stakeholders should be involved in AI development in terms of variant contribution of data resources and values represented by these data. We intend to illustrate the data-driven characteristics of AI development for further discussion in the TA domain.

AI systems and technology development

AI systems are complex systems that are built by subsystems of technology. For instance, machine learning, expert systems, smart robots, knowledge graphs, and natural language processing. At the current stage of development, those subsystems are designed and built on one of the most important principles: to process a large scale of data resource with effective and economical methods to achieve knowledge exchange between the AI system and the physical world (Duan et al., 2019; Eisenstein, 2019; Gu et al., 2018; Hassanien & Darwish, 2021; Kusiak, 2017).

AI system and industrial development

AI systems have been widely applied in the industrial domain. For example, in business intelligence analytics, autonomous driving, and intelligent manufacturing. Combined with specific algorithms, current data-driven business intelligence analytics gain more potential capability to process a large scale of data from multi-stakeholders from the market (Corea, 2019). Data-driven AI systems will offer a more stable autonomous driving system based on the R&D of semi-autonomous vehicles (Huang et al., 2019). For intelligent manufacturing, data-driven technologies have been considered as the fundamental layer of the entire system (Feng et al., 2020).

AI systems and societal development

AI systems are merging with societal systems (Garcia et al., 2020). Society offers a large scale of data resources for the development of AI systems (Rohlfing et al., 2020). At the same time, AI systems have the potential to change the entire social structure (Fosso Wamba et al., 2021). Decision systems based on AI have been applied in the domain of health and social care with a large scale of data-driven technology or application (Cresswell et al., 2020). AI has been widely used in the development of data-driven education since the millennium (Baldominos & Quintana, 2019; Guan et al., 2020). Data-driven algorithms have been adopted for research regarding social welfare improvement, e.g., improving refugee integration, incident management and pandemic control (Bansak et al., 2018; Elvas et al., 2020; Esposito et al., 2021). Furthermore, artificial intelligence assistive technologies have been widely applied in communication, politics and marketing (Margetts & Dorobantu, 2019; Van Esch et al., 2019). AI systems have also been implemented in many private and public security applications, such as biometrics, predictive policing and predictive recidivism algorithms in the judicial system. However, all of these bear a tremendous potential for surveillance and are prone to biases (Dressel & Farid, 2018; NIST, 2019; O'Neil, 2016).

3 The International Policy Discussion

Policy discussions are a crucial component of research related to TA. According to this perspective, we developed a comparative analysis of AI policies in global contexts. We operated a comparative policy content analysis of AI policies across two dimensions: a country comparison and an application area comparison.

For this chapter, we analyzed national-level AI policy documents, strategies and plans. The policy analysis covered major economies and societies and include agriculture, taxation, transportation, education, and science etc. The current policy debate on AI has attracted widespread attention worldwide. Many international organizations and institutes have constructed databases of policy research. For example, the European Union Agency for Fundamental Rights (FRA) constructed the AI policy initiatives (2016–2020) database at European Union level for the research project "*AI, Big Data, and Fundamental Rights*".[1] However, in order to develop a more comprehensive and integrated comparative analysis of AI policies in a global context, we adopted the *OECD.AI Policy Observatory Database (OECD.AI)* as the main source using more detailed sample data. This database contains more than 600 policy entries from major sectors, and gives an overview from different perspectives and sources—from statistics and national strategies, to assessment reports on economic and societal implications.

[1] Source: https://fra.europa.eu/en/project/2018/artificial-intelligence-big-data-and-fundamental-rights/ai-policy-initiatives, Access date: 30/11/2021.

We analyzed these sources with regard to specific domains of AI impact, and in relation to countries and geopolitically relevant regions. We adopted the policy document content analysis methodology to operate the comparison and conclusion of the current pilot policy practices. We also adopted *Pandas* as the data cleaning package in *Python* to remove duplicated policy data.

3.1 Different Discourses in Different Regions

According to the OECD.AI, more than 60 countries have already released a national-level initiative, policy or strategy of AI development. After removing duplicates in the OECD.AI Policy Document Dataset, there are 576 remaining documents. In terms of the yearly budget range, there are 14 documents (2%) marked as "More than 500 M (million in USD)", 13 documents (2%) marked as "100–500 M" and 154 documents (27%) marked as "Not applicable".

The USA, China, the EU,[2] and the UK are the AI-advanced majorities in terms of the amount of scientific publications on AI from 20 areas, including economy, digital economy, transport, health, industry and education. In the policymaking domain, the USA released 47 national-level documents of AI policy, initiative and strategy. The EU released 44 policy documents. The UK released 39 national-level documents.

USA

The USA has constructed a comprehensive policy framework of AI development. In 2016, the USA released three important policy reports, including *Preparing for the Future of Artificial Intelligence, National Artificial Intelligence R&D Strategic Plan,* and *Artificial Intelligence, Automation, and the Economy*[3] by the National Science and Technology Council (NSTC). The three reports clarified the purposes of and targets for USA AI development. In February 2019, the former US president Trump addressed the *Executive Order 13859: Maintaining American Leadership in Artificial Intelligence.*[4] This document emphasized the importance of USA leadership in the domain of AI, with applications in the areas of economy, society, security, and the military. The USA did not release any document that directly mention a yearly budget above 500 million (USD) held within the OECD.AI database. However, two documents from the USA have the yearly budget range of "100–500 M". One is *Joint Artificial Intelligence Center (JAIC)* released by the Department of Defence

[2] In OECD.AI database, the European Commission is responsible for the policy documents from the European Union. For instance, https://oecd.ai/dashboards/policy-initiatives/http:%2F%2Faipo.oecd.org%2F2021-data-policyInitiatives-27087, Access date: 25/05/2021.

[3] https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf, Access date: 25/05/2021.

[4] https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-promoting-use-trustworthy-artificial-intelligence-federal-government/, Access date: 25/05/2021.

(DOD);[5] the main objective of JAIC is to set up a department to enhance the performance of AI R&D in the domain of security and military. The other document was released by the National Science Foundation (NSF), *NSF AI Research Institutes;*[6] it is a national AI research institutes program to promote longer-term R&D to maintain U.S. leadership in AI.

EU

According to the analysis of the policy documents in the OECD.AI database, EU AI policies have focused on the upgrade by AI applications in various areas which include industry, manufacturing, health, and energy. The EU has promoted the cooperation of R&D in the AI domain by releasing policies and member state-level plans, setting up research funding, and building up a laboratory. For instance, to emphasize willingness to cooperate on AI, the EU released the *Coordinated Plan on Artificial Intelligence*[7] in 2018. Furthermore, EU AI policy has underlined the research of ethics and humanity. In March 2020, the EU released a white paper, *On Artificial Intelligence—A European approach to excellence and trust,*[8] to declare the solution of information transparency in AI development, data security, privacy protection and the regulatory framework. In April 2021, the European Commission released a *Proposal for a Regulation laying down harmonized rules on artificial intelligence,*[9] which is the first legal framework for AI.[10] In addition, the EU has also emphasized specific areas to promote AI applications based on the niches with EU advantages. In 2017, the EU released *The Report of the High-Level Group on the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union (GEAR 2030)*[11] to enhance AI applications in the automobile industry.

UK

Aiming to become one of the most important AI innovation centers, the UK has also released a series of national-level strategies and plans to promote AI development. In 2017, the UK published the *Industrial Strategy: Building a Britain fit for the Future (White Paper)*[12] to set out the government's plan to create an economy to promote AI application that fits the national industry strategy. In January 2018, the UK released

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[5] https://dodcio.defense.gov/About-DoD-CIO/Organization/JAIC/, Access date: 25/05/2021.

[6] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505686, Access date: 25/05/2021.

[7] https://digital-strategy.ec.europa.eu/en/library/coordinated-plan-artificial-intelligence, Access date: 25/05/2021.

[8] https://ec.europa.eu/info/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en, Access date: 25/05/2021.

[9] https://digital-strategy.ec.europa.eu/en/library/proposal-regulation-laying-down-harmonised-rules-artificial-intelligence, Access date: 25/05/2021.

[10] See Footnote 9.

[11] https://ec.europa.eu/growth/content/high-level-group-gear-2030-report-on-automotive-competitiveness-and-sustainability_en, Access date: 25/05/2021.

[12] https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future, Access date: 25/05/2021.

UK Data Trusts Initiative[13] to offer the independent stewardship of data to secure AI development; the UK government also emphasized the relationship between AI and the digital economy in this document. Also in 2018, the UK set up an *Office for Artificial Intelligence (OAI)*[14] to enhance cooperation between different government departments, ministries, and multi-stakeholders in the domain of AI.

China

In the OECD.AI policy database, there are only eight documents regarding China's AI development. However, these policy documents cover the most important areas, including the national plan, industry guidelines, laboratory construction, and the education plan for current AI application and development in China. In 2017, The State Council for the People's Republic of China released the *National New Generation AI Plan (新一代人工智能发展规划)* [15] which has been considered as the cornerstone policy for China's future AI development and application. This national level plan involved a comprehensive policy framework for China's AI development initiatives and goals in specific domains that cover R&D, industrialization, talent development, education and skills acquisition, standard-setting and regulations, ethical norms, and security. In addition, China's Ministry of Science and Technology (MOST) released the *Governance Principles for New Generation AI- Developing Responsible AI (新一代人工智能治理原则——发展负责任的人工智能).*[16] This initiative highlights that China is emphasizing responsible AI development with the eight principles of harmony, friendliness, fairness, inclusiveness, respect for privacy, security and controllability, shared responsibility, open collaboration, and agile governance.

Other East Asian countries

Japan and South Korea have also presented an active policy attitude to AI development. In 2019, Japan released the national-level *AI Strategy (AI戦略)*[17] to clarify that the motivation of AI development should respond to the critical social challenges, including the aging society and sub-replacement fertility. In December 2019, South Korea released the *National Strategy for Artificial Intelligence (*인공지능 국가전략*)*[18] with the yearly budget range "More than 500 M". In this policy document, South Korea not only emphasized global digital competitiveness by 2030, but also declared to create 455 trillion Korean Won (approx. 405 billion US dollars) of

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13 https://datatrusts.uk/, Access date: 25/05/2021.

14 https://www.gov.uk/government/organisations/office-for-artificial-intelligence, Access date: 25/05/2021.

15 http://fi.china-embassy.org/eng/kxjs/P020171025789108009001.pdf, Access date: 25/05/2021.

16 http://most.gov.cn/kjbgz/201906/t20190617_147107.htm, Access date: 25/05/2021.

17 https://www8.cao.go.jp/cstp/ai/index.html, Access date: 25/05/2021.

18 https://www.msit.go.kr/SYNAP/skin/doc.html?fn=b94d1781d5ef394ac6a63e274d3949be&rs=/SYNAP/sn3hcv/result/, Access date: 25/05/2021.

economic surplus and to enhance the living standard for the entire society through AI development.[19]

South America and Africa

Meanwhile, South America and Africa are still on the lower level of AI development in terms of the comprehensive comparison of scientific publications and policy performance. Six South American countries, Argentina, Brazil, Chile, Columbia, Peru, and Uruguay have already released national-level AI-related policies. In 2019, Brazil presented the *Brazilian Artificial Intelligence Strategy (Public Consultation) (Consulta Pública da Estratégia Brasileira de Inteligência Artificial).*[20] This strategy document declared AI development implications on the economy, ethics, development, education, and jobs. However, most of these South American policy documents are still directly related to the digital transformations and data governance.

In Africa, there were only four countries, Egypt, Kenya, Morocco, and South Africa, that released national-level AI-related policy, initiative or strategy documents. In those policy documents, similarly to South American countries, AI policy content was only mentioned in relation to digital development and data governance.

International policy conclusion

According to this comparative review of countries and regions, AI policy practices show the characteristics of diversity in a global context. Major economies have developed AI policies with a strong focus on their own economic, social, and technological development characteristics. For instance, policies from the USA presented the demand of maintaining leadership in every AI application area. AI polices from the EU placed more emphasis on governance of ethics and humanity. China's national AI plans strike a balance between promoting the development of specific application areas of AI and comprehensiveness. To promote economic and societal development is the most important policy target for all AI policy practices.

3.2 Areas of Application

According to the OECD.AI Policy Observatory Database (OCED.AI), 20 policy areas are related to AI application. Within these 20 policy areas, the economy and the digital economy are the most significant domains in terms of publications. The OECD.AI policy areas cover the major fields of economy and society, and include environment, health, agriculture, transportation, science and technology, and social and welfare issues.

[19] https://oecd.ai/dashboards/policy-initiatives/http:%2F%2Faipo.oecd.org%2F2021-data-policyInitiatives-26497, Access date: 25/05/2021.

[20] https://www.oecd.ai/dashboards/policy-initiatives/http:%2F%2Faipo.oecd.org%2F2021-data-policyInitiatives-26729, Access date: 25/05/2021.

Based on the statistical analysis of policy documents and scientific publications within OCED. AI, the AI & economy area is the most significant domain of AI policy. Most of the AI policy documents involve economic development and boost. In the area of AI & economy, policy research and documents concern AI application in new business models, data analysis, information systems and management performance. The application of AI has a potentially tremendous implication on the economy (Pratt, 2015). Data has been considered as a critical resource for the market, and AI technology will enhance the performance of data resources (Mirowski, 2007). However, there is the possibility that potential benefits in efficiency and profitability go hand-in-hand with a great deal of automatization, which may replace a large part of the workforce and may lead to unemployment, poverty, and fundamental structural changes.[21]

Hence, the digital economy is also one of the most active AI application domains. Further advancement of AI has augmented the digital economy with significant implications for the specific policy domains (Watanabe et al., 2018). The AI & digital economy area covers multiple applications that include data governance, digital security, privacy protection, and communication networks. Based on the sharing of data resources, AI development could create more application scenarios for the disruptive knowledge creation mode for the digital economy (Holford, 2019; OECD, 2020).

AI development is also generating more application scenarios within specific economic areas that include finance, industry, entrepreneurship, investment, and employment. In the area of finance and insurance, governments have already noticed that the application of AI enhances financial data processing efficiency in terms of the dynamic market status-quo and risk assessment (Bahrammirzaee, 2010; Heaton et al., 2017; Palmie et al., 2020; Sharma et al., 2020). In the area of industry and entrepreneurship, the application of AI is currently accelerating the process of digitalization with emerging business models (Garbuio & Lin, 2019). In addition, AI may substantially affect the investment environment by the application of the self-improving AI system (Hall, 2007; OECD, 2021). AI-driven industry and entrepreneurship will also significantly change the labor force structure and the employment environment. The automation systems of AI will replace more employed people (Zhou et al., 2020a, 2020b). Hence, the AI-driven employment environment may need massive evolution in the current education system with higher skills teaching and learning (Roll & Wylie, 2016).

Currently, the autonomous vehicle is one of the most important AI applications in the mobility area (Stead & Vaddadi, 2019). The autonomous vehicle has been considered as the biggest transition of mobility (Lăzăroiu et al., 2020). However, the autonomous driving system is by no means an independent technological system, it is rather a complex system that merges with the social and economic system (Kassens-Noor et al., 2020). For instance, besides the high efficiency sensor data transmission support system, the autonomous driving system relies on updated traffic regulations and new public infrastructure construction (Huang et al., 2019; Raiyn, 2018). Furthermore, the cost and potential environmental benefits will also be essential dynamics

[21] There is a broad discussion on this issue, for details see Sect. 4.2.

of the development of the autonomous vehicle (Noruzoliaee et al., 2018; Vosooghi et al., 2020).

In healthcare, AI application enhances the performance of diagnosing disease and health risk assessment (Waring et al., 2020; Zhou et al., 2020a, 2020b). AI systems can process a large scale of personal data to facilitate personalized healthcare and precision treatments and medicine (Ali et al., 2021), for instance, improving patient care with precision medicine and mobile health, high-performance management of health systems, better understanding public health, and facilitating health research and innovation. (Abdel-Basset et al., 2021). With the large scale of data resource integration from different areas, AI may generate more health care application scenarios (Dwivedi et al., 2021; Price & Cohen, 2019).

In terms of the comparative study, we found that current AI policies promote AI as a fundamental technological ecosystem in every application area. AI policies from different application areas all mentioned the importance of data resources for the development of AI technology. At the current stage, AI technological ecosystem and application scenarios are highly dependent on the integration and utilization of various data resources. The development of AI is showing strong characteristics of a data-driven innovation. This crucial dependency on data for training issues as well as for actual performance of its function leads directly to the discussion of the potential risks of widespread AI application. In the following Sect. 4, we will look more closely at AI-related TA activities in Europe and beyond, and finally will uncover the most striking issues discussed with regard to the societal implications of AI.

4 TA Activities in the Field so far and Options for the Future

4.1 Analysis of EPTA-Activities

The policy documents discussed above provide an overview of diverse national AI policies, mainly with regard to promoting AI as a key factor for future economic (and societal) development. This section analyses studies and findings from TA institutions around the world. The main focus here lies on the—often unintended—societal and ethical issues.

To date, most institutionalized TA activities are located within Europe and the USA. However, there is increasing interest around the world in TA and TA-like activities. EPTA is a network of organizations doing TA within or for their respective parliaments at a regional, national or European level. Since the U.S. Government Accountability Office (GAO) became an associate member in 2002, EPTA has extended beyond Europe and currently comprises 23 parliamentary TA (PTA) institutes. This process of global networking between PTA institutions now includes Chile, Japan, Mexico, and South Korea (Peissl & Grünwald, 2021). EPTA provides a joint website[22] which is based on a database of TA projects, reports, policy briefs and news. We undertook a title and abstract search for the period 2008–2021 using the search strings "AI, machine learning, algorithm, robot, social media, and democracy". Based on the results we identified 173 entries; 73 projects, 39 reports and 61 policy briefs.[23] Cleaning the dataset by removing duplicates, including news and policy briefs for projects where a report was also available, we ended up with 80 entries for analysis.

The data show that PTA institutions have been aware of upcoming technology and related questions since 2008. The abstracts of these 80 entries were analyzed and clustered depending on the respective primary focus of the report or project. These PTA activities were mostly associated with AI (35) and robotics (13) in general. Together with digitalization (6), autonomous systems (5), algorithmic decision systems (7), and algorithms (3), this covers 69 of the 80 entries. The remainder address emerging technologies (3), labor (2), democracy, social media, surveillance, 5G, quantum technology, and financial technologies.

In a second step we found a set of keywords associated with areas of research. These show the characteristics of (P)TA studies: they are often interested in the general overview (25) of a development and try to figure out impact in several dimensions. The second domain of interest was the labour-market and implications for the workforce (12), third is the aspect of democracy (9), followed by ethics and healthcare (6 each). The legal framework for AI (4) and mobility and education (3 each) bring the total keyword analysis to 68 out of the 80 included entries. The other 12 deal with sustainability, the pandemic and space (2 each) and specific themes like surveillance, robot maintenance, quantum computing, precision farming, drug production, and consumer protection.

4.2 Main Areas of Discussion

In this section we will discuss some of the main areas of research on AI and society undertaken by PTA institutions. As already mentioned, there is a lively discussion about the effects of AI, automation, robots, and digitalization in general on the labor market. An overview of the different approaches in EPTA-member countries is given in the EPTA report of 2016 (EPTA, 2016). Unfortunately, a sharp distinction between the different domains is not possible, therefore the different areas are examined together. This is not problematic for our context, as AI can be seen as a basic technology for robots, automation, and digitalization of jobs beyond the production line.

The debate was triggered by a study by Frey and Osborne (2013), which showed that about 47% of all jobs in the USA were at high risk of being computerized within approximately 20 years. The main objection raised against this study's findings was

[22] www.eptanetwork.org.

[23] Search conducted 31.05.2021.

its historical analogy, which claims that all technological advances in history have also led to an increase in new (other) jobs. This argument, however, ignores the fact that economic conditions were different in earlier periods (Cas & Krieger-Lamina, 2020). With digitalization, we are facing completely new challenges, with ICT and AI flooding all areas of life, not only the production and service sectors.

The 2013 study has also been criticized for its methodological approach, but has been repeated in different contexts. An overview is given in Cas and Krieger-Lamina (2020), based on Lovergine and Pellero (2018). Although the high number of affected jobs was not replicated in other studies, the mere fact that the potential impact could be so large has led to discussions of the future labor market and unemployment. This attention may lead to less of an impact being seen in the future, as when we address the future, it is usually the beginning of shaping that very future.

The same applies to the area of social media platforms and their impact on societal communication, polarization and democracy. An EPTA-report provides an overview of different approaches to tackle the theme of "digital democracy" by EPTA-member States (EPTA, 2018). The digitalization of communication in the form of the internet originally gave rise to the hope that it would make democratization and broader participation possible. However, the developments of the last few years in the field of social media show that, in contrast, democratic structures and processes can be endangered. AI is not an insignificant contributor to this. The algorithms used by online platforms lead to a reinforcement of extreme positions and thus enable polarization in the spectrum of opinions, which makes constructive discourse more difficult. As shown by the examples of both campaigns in 2016 for the election of President Trump in the US and the Brexit vote in the UK micro-targeting on social media can be used to specifically approach voters and provide them with very different targeted content. In this way, general awareness-raising and fair information, by for example traditional media, are counteracted, and influence is exerted on these elections. Furthermore, there is a danger that these digital tools and infrastructure can be attacked and misused from the outside. This means that central elements of the political sovereignty of states can be undermined.

The relationship between new communication possibilities and AI-driven social media and democracy and the rule of law is of particular importance. TA-institutions at the European Parliament, in Germany, the Netherlands, Norway, Switzerland and the USA have conducted specific studies on this (Bieri et al., 2021; EPTA, 2018; GAO, 2020; Kind et al., 2017; Kolleck & Orwat, 2020; Marsden & Meyer, 2019; Neudert & Marchal, 2019; Tennøe & Barland, 2019; Van Est & Kool, 2017). Almost all other studies by EPTA members dealing with the effects of the widespread use of AI also address this fundamental challenge.

4.3 Responsibility, Transparency and Ethics

In more than a quarter of the analyzed TA-studies from EPTA members we can find basic issues like responsibility, transparency or ethics included in the abstract. These issues are also discussed in the broader existing literature on AI and societal impact. It clearly shows that the most striking issue besides the direct effects on the labor market/workforce and communication and democracy are the more fundamental issues of responsibility, transparency and ethics. AI applications are intended to widely support decision-making or, even more riskily, autonomously decide upon certain actions. Processes triggered by AI systems may have impact on individuals or groups, their chances of societal participation, or even their very existence. So, it is fair to ask, who should be responsible for these decisions? In order to be able to locate problems or failures in algorithms, or other parts of the algorithmic decision-making systems (ADM), there is a need for transparency with regard to their internal mechanisms and the context of application.

Therefore, here we will present some lines of argumentation in depth. A prominent example of AI is its use in speech recognition and language processing. As the core element of digital assistants such as Smart Speakers like Alexa, Google Assistant or Siri, AI has found its way into many households and smartphones. Therefore, machines or systems have found their way into our households (and to some extent also to public offices) where they can not only comprehensively monitor our behaviour, but also influence it, from the way we communicate with machines, to how we communicate with each other, and how we move around our own homes. Since it is foreseeable that in the future, voice commands and thus digital speech recognition and language processing will be used in other areas (from cars, to systems' control in offices, and manufacturing), some fundamental questions arise: What is AI, what can it do and where are the limits to its application, if there should be any at all? What ethical principles guide considerations about what we want machines to do in the future, and what we don't?

For an ethical discussion, here we focus on an aspect of these definitions that comes from earlier approaches to AI. What does "artificial intelligence" mean? This is all the more difficult because there is no comprehensive, conclusive definition of "intelligence". For technical developments, the ISO established a definition for "artificial intelligence" in 2015. In this understanding, AI is the *"capability of a functional unit to perform functions that are generally associated with human intelligence such as reasoning and learning."* (ISO/IEC JTC 1, 2015). However, "reasoning" and "learning" fall short of describing human intelligence comprehensively. In any case, AI research and development is trying to teach machines behavior that is modelled on, and as close as possible to, human behavior and decision-making processes. A distinction is usually made between weak and strong AI. In weak AI, algorithms solve individual, specific tasks, but do so quickly and, depending on the subject matter, to a very high quality. Examples include analyzing large amounts of data, pattern recognition, and predictions based on recognized patterns. Strong AI, on the other hand, describes a state where machines should have comparable intellectual skills to humans, and ultimately have consciousness similar to humans. However, this is primarily a visionary philosophical concept whose realization is widely doubted for the foreseeable future (Apt & Priesack, 2019). The discussions about a "superintelligence" which could ultimately prove superior to human intelligence and even dominate humans, also fall into this area. Although this is a controversial topic, it is more likely to belong to the realm of science fiction.

From today's perspective, all available AI systems belong to the "weak AI" category. In addition to the above-mentioned advantages/abilities, they also have some fundamental deficits. These include a low capacity for abstraction, especially in the transfer of experience and learned knowledge to other contexts, high requirements for the pre-structuring of data, information and environments, and a lack of understanding and reasoning in the empathic sense. Even Alpha Go Zero, one of the most elaborate AI systems, is not able to do so. As a result, AI systems lack experience, tacit knowledge, judgment, empathy, and courtesy, as well as social learning and emotions that characterize humans and human intelligence. Or as Zweig (2019) puts it "an algorithm has no tact".

AI systems are designed to make more or less "autonomous" decisions based on available data and predetermined algorithms. When consequences for people or things result from these decisions, the question of responsibility arises. This usually becomes relevant in the case of negative consequences. So, who bears responsibility for the decisions made by AI systems? The systems themselves currently have no legal personality. However, responsibility is not only borne for negative damaging events. Responsibility is also derived to a certain degree from knowledge and competence. Therefore, one could also assume responsibility of such systems (which do not exist) for positive events. For example, what happens when a digital assistant hears someone calling for help, when children say they are being beaten, etc.? (Vlahos, 2019). Should a digital assistant then be required to call for help, or report assumed crimes? To this end, it is possible to discuss the question of when a certain type of reaction appears to be called for. This can be solved relatively easily by analogy with comparable situations involving humans. Appropriate behavior would then have to be programmed into the AI's algorithms. Much more fundamental, however, is the question of how a digital assistant comes to know about such situations in the first place. If it has been activated by one of the persons concerned, the system will listen in a permissible manner. However, since it could be argued that the digital assistants could be helpful in an emergency (sound the alarm), it would be conceivable to argue for their permanent activity. Here, however, an ethical conflict arises that points to the fundamental discussion of the security which can be brought by surveillance, and the cost of that security, in terms of, for example, loss of privacy. The decision is very much context-bound: under particularly threatening circumstances, such as in a hospital intensive care unit, we would like to be comprehensively monitored. But what about in everyday life? Do we want to be bugged everywhere so that we can potentially get assistance at some unknown point in an emergency (which will not necessarily occur)? How much "insecurity" can we humans stand, how much is reasonable for us, and how much security can actually be generated by additional surveillance?

AI systems are already integrated into many aspects of everyday life. They are interaction partners and also filters. Streaming services (Netflix, Spotify, etc.), Facebook, or even digital assistant providers such as Amazon and Google contain a large scale of personal data resources that can be applied to precise user portrait purposes

(Taffel, 2021); this means that they already know more about our personal preferences than our closest friends. Algorithms reinforce our purchasing decisions and solidify preferences. They thus determine the preferences of their users. In response to criticism of this, algorithms have been proposed which will make alternative suggestions in order to strengthen the sovereignty of users. But, this does not solve the problem, rather the opposite: they have an even more manipulative effect because they suggest an apparently objectified determination of preferences. But the result is the same in that the sovereignty of the user is—intentionally or not—drastically reduced (Stubbe et al., 2019).

Another problem in human interaction with AI (Amershi, 2019; Cai, 2019) arises from the attempts which are being made to make the systems as close as possible to the human way of communicating. However, no AI has yet passed the Turing test (Turing, 1950). Problematically, there is a strategic aspect of communication hidden in many applications of AI. That is, the systems try to feign a human counterpart in order to gain trust—which machines do not have a priori. However, this is not the same as two people talking to each other. Openness and transparency are important for the sovereignty of humans in interaction. Digital assistants have a similar effect, often docilely simulating an emotionless exchange with little controversy. Communication here loses its ambivalence, which humans know how to deal with through social experience, and through which we find out how we appear to others, and who we are to the other person. From an ethical perspective, this kind of communication with AI, which simulates a supposedly cooperative social interaction, whilst behind the scenes it pursues strategic purposes, is highly questionable (Stubbe et al., 2019). Current developments attempt to intentionally "enhance" the perfection of computers with human flaws and weaknesses. Unlike classic robot voices, Google Duplex, for example, inserts irregularities into sentences. Thus, apparent pauses for thought can be heard, or a "Mhmm" muttered now and then, together with abrupt pauses in speech. This gives the impression that the AI is responding to the conversation partner, or thinking (Kremp, 2018). Duplex was supposed to be integrated into Google Assistant on a test basis in 2018 (Herbig, 2018) and is now active in 49 states of the US and some other countries like Australia, Canada, India, Mexico, New Zealand and the UK (Callaham, 2021). Even if these applications currently only work in limited contexts and are trained for specific situations (hairdresser appointments, restaurant reservations), it nevertheless points to a fundamental ethical problem: users must be aware and able to know when communication with a machine is taking place.

A very different dimension of an AI application in communication is the MOODBOX smart speaker, introduced in 2016. It is primarily used to play music, but has built-in AI—called EMI—via the MOODBOX that is supposed to be able to detect the emotional status of the user from their utterances. The smart speaker checks how the owner is feeling and plays music to match the emotional state (Gineersnow, 2016). In this technology, of course, there is also great potential for the marketing of other goods and services, whose marketing/advertising is tuned to be easier to sell in certain psychological states.

With regard to emotion detection, we face some fundamental issues in AI and biometrics. The range of applications already include automated analyses of individual behavior patterns, such as a person's individual way of walking, as well as facial and emotion recognition, which are particularly controversial due to the enormous social risks. Emotion recognition is not only used in the advertising industry, but also to some extent in job interviews, in call centers and also in robotics/AI development (Masoner, 2020) (e.g. in the field of autonomous vehicles or for human–robot interactions). Toyota's new Concept-i series of automobiles is said to use AI systems and application of biometrics to recognize the driver's emotions by analyzing facial expressions and tone of voice. Thus, if the system (the A. I. Agent Yui) detects that the driver is stressed, it shall switch to autonomous driving mode ("Mobility Teammate Concept"). Alternatively, if the system registers signs of decreased alertness, the driver's sense of sight, touch and smell should be able to be stimulated to put the driver in a more alert state. In this way, the driver's stress level can be increased by smells, etc., but can also be reduced vice versa. The system is also designed to access a range of data from social media platforms, as well as activity and conversation content, in order to identify the user's preferences (Cheng, 2017). Furthermore, Toyota has announced that it has entered into a partnership with Microsoft, as have a number of other manufacturers in the automotive sector (Dudley, 2016). Emotion recognition is also controversial in AI research itself, both in terms of scientificity and meaningfulness, and a number of experts are calling for bans on emotion recognition (Honey & Stieler, 2020).

Machine ethics and ethics for AI

Machine ethics has been discussed frequently. It deals with rules in the field of AI and robotics. A distinction must be made here between ethical rules for AI systems and robots, and the so-called ethics of machines, or machine morality. The moral machine, which gives itself rules and then acts according to them, will only become relevant with the implementation of so-called strong AI, but is currently rather more the topic of science fiction than AI research.

The starting point for many considerations on the ethics of AI are the early robot laws of Isaac Asimov. These three laws, which Asimov developed in 1942, are supposed to counteract the robot's potential danger to humans by prohibiting actions (or omissions of actions) that cause harm to humans (first law), leaving the power of command over the robot with the human (second law), and ensuring the robot's self-preservation (third law). The laws are hierarchically structured, i.e. the third law may only be followed as long as the first two laws are not violated by it. However, as influential as Asimov's work was initially, it does not provide a sufficient and effective basis for the design of robots in general (Čas et al., 2017; Clarke, 1993, 1994).

Transparency as central requirement

The evocation of a potentially emerging "superintelligence" has certainly fueled the media hype surrounding ethical (and often dystopian) issues of AI. But there are also enough questions about the current state of the art and the expected further development of weak AI that should be discussed and resolved in a broad societal discourse. This is all the more so as AI already plays an important role in people's everyday lives, and will play and influence many more in the near future. A central demand in this discourse is that of transparency, both about the use of AI (see above), and the modes of its operation, the built-in algorithms and their mode of action. Transparency is a necessary but not sufficient condition to control systems and thus build trust in them, which can also promote social acceptance. Society, and affected users or persons concerned, need to know how it works, but they also need a legal framework to be able to call for disclosure and sue for damages. There is also a need for institutions, which are able to both legally and technically deal with open questions from those affected. This leads to ongoing discourse on different levels of transparency and the respective means of governance.

Catalogue of ethical principles for AI

Besides transparency and (ex-post) evaluation of algorithmic systems there is a fundamental need to set standards for the whole development process from the very beginning. There are already a large number of initiatives of various kinds around the world that deal with ethical principles for AI. These include supranational associations such as the OECD, international professional associations such as the IEEE, and civil society initiatives.

A few examples illustrate the aims of these initiatives and their overlaps: fundamentally, the European Group on Ethics in Science and New Technologies of the European Commission published a declaration on artificial intelligence, robotics and "autonomous" systems in March 2018 (EuropeanCommission; DG Research & Innovation, 2018). This calls for the launch of a process that would pave the way for the development of a common, internationally recognized ethical and legal framework for the design, production, use, and governance of artificial intelligence, robotics, and "autonomous" systems. The declaration also proposes a set of ethical principles, based on the values enshrined in the EU Treaties and the Charter of Fundamental Rights of the European Union that can guide the development of this process:

- Human dignity
- Autonomy
- Equality and solidarity
- Responsibility, accountability
- Justice
- Democracy, rule of law
- Safety, security
- Physical and mental integrity
- Data protection and privacy
- Sustainability.

These fundamental principles should guide the development process on a meta-level, but there are also more specific requirements. In 2017 the Asilomar AI principles were developed—23 demands in the domains of research, ethics and values and long-term issues (Future of Life Institute, 2017). In 2018, the U.S.-based NGO

Public Voice published universal guidelines for AI (The Public Voice, 2018) and presented them at a major privacy conference in Brussels.

In 2019, a group of experts presented a policy paper with guidelines for the EU (AI HLEG, 2019). Based on fundamental rights and ethical principles, the guidelines list seven key requirements that AI systems should meet to be trustworthy:

- Human action and oversight
- Technical robustness and security
- Privacy and data management
- Transparency
- Diversity, non-discrimination and fairness
- Social and environmental well-being
- Accountability.

They are more or less equivalent to the dimensions raised in Public Voice guidelines. However, they go further by demanding the prohibition of secret profiling and making the general statement that governments must not generalize citizen assessment.

As can be seen from these lists, there seems to be a consensus that human dignity must be preserved, and humans should have ultimate control over systems. In turn, the resulting accountability can only be exercised if there is transparency regarding the modes of operation and algorithms. Transparency is also a basic condition for the establishment of efficient control systems, which are indispensable for effective regulation. In the context of global competition for the further development of AI, Europe tries to gain a quality advantage and thus a competitive edge with high ethical (and technical) standards. This is one of the main objectives of the proposed AI Act by the EU-Commission in April 2020.[24] Even though this proposed Act evolved from a consultation process, it does not cover all respective issues, deemed important from different stakeholders. However, it opens up public discourse on issues like high-risk AI systems, profiling, data protection, and biases in AI systems and ethics. This means that the limits society wants to set for advanced AI will have to be discussed. What do we want to delegate to machines, and what do we never want machines to decide?

According to Grimm (2018), "in order to use the Promethean potential of digitalization for a good life, we need … a digital value culture based on four pillars: (a) education and training (promoting ethical digital competence), (b) business and industry (value-conscious leadership, sustainable data economy), (c) research (interdisciplinary projects that bring together ethical and technological perspectives), and (d) political will (promoting value-based technology research)". In a global context TA could be a valuable partner in this enterprise, contributing on different levels.

[24] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206.

5 Conclusions on Practical Perspectives for Increased Global TA Co-operation and for Including Global TA in International Debate and Governance

This paper shows some of the hopes and fears regarding the widespread use of AI in more or less all areas of living. Visions of technological development, economic growth, higher efficiency and a better life are contrasted with a potential loss of workforce, poverty and dangerous development of cultures of discourse, which—combined with power inequalities—may lead to erosion of democracy.

AI as an emerging policy context has attracted widespread attention from governments, industry, culture and research in major economies around the world. Driven by policies in major economies such as China, the EU and the US, AI is gradually moving from basic research to more concrete application scenarios. However, there are still a number of issues and challenges before AI can become a truly general-purpose technology. Along its way, AI needs open discourse based on scientific facts, taking into account societal values. There is already input from TA institutions around the world on the specific features and potential impact of AI implementation. But there are open questions, which need translation from technological development to every-day life and back—and even more so on a global level.

As AI will influence nearly all areas of life, the context of use will be very diverse. In order to foster the development of responsible AI, **there is a need for a global ethical baseline for AI developers, implementers and users**. Elaborating general and globally accepted guidelines or codes of conduct need broad discourse and the participation of all those potentially involved together with affected stakeholders.

Transparency of AI systems is a fundamental prerequisite for accountability and control. There is a gap between understanding this requirement and the often mentioned “black-box” in AI, which supposedly makes it impossible to get full transparency over system-internal processes of decision-making. So, what kind of transparency is achievable, and what is needed? What does it mean if those demands don’t match? Clarifying this in an interdisciplinary manner and communicating possible options to politics is a basic function of TA.

The diffusion and application of AI technologies has the potential to bring about tremendous changes to the social structure. The digitalization of human society will continue to be accelerated with the application and diffusion of AI technologies. However, AI as a new social resource will also be affected by the differences in resource allocation due to the previously existing problems in the traditional social structure. The development of AI will increase the potential risk of digital inequality on a global scale.

Responsible AI urgently requires global collaborative governance in a multi-cultural context. While AI has demonstrated the potential to become a general-purpose technology in a global context, the application scenarios of AI technology in specific countries and regions will be influenced by social, economic, cultural, and religious differences. Responsible AI should be based on the premise that it respects the diversity of people, and cultural and social settings, as well as the AI scenarios and the diversity of governance concepts. Based on the diversity of governance concepts, all countries should enhance the transparency and credibility of AI development through collaborative governance in a global context. In addition, responsible data is the cornerstone of responsible AI.

The development and application of AI technologies will have a significant impact on geopolitical relations on a global scale. There are huge differences between developed and developing countries in terms of data resource allocation, basic research and development capabilities, and the level of industrial transformation. Accordingly, if AI is treated as a general-purpose technology, the realization of AI application scenarios will potentially create new global development imbalances that are detrimental to the achievement of the UN Sustainable Development Goals.[25]

Abundant empirical research is required to determine whether AI can be regarded as a general-purpose technology. As mentioned in the policy discussion in Sect. 3, current policies of application areas promote AI as a fundamental technological ecosystem in every domain. However, AI is still far from a general-purpose technology in terms of economics and societal performance. In addition, the development of AI strongly relies on the integration of related data-driven technologies. Data resource allocation is the key to determining AI as a general-purpose technology. However, a large amount of data resources (including personal data) is now controlled by giant online platform companies with significant market power. From a long-term perspective, data resource monopoly is not conducive to sustainable innovation in AI technologies. Therefore, both policy research and practice require an integrated view that data governance, platform governance and AI development be viewed as an intact ecosystem.

All of this calls for accompanying research and monitoring, as well as cross-cultural negotiation processes about desirable properties of AI systems and limits of application. TA can constructively contribute to this, if it succeeds in establishing corresponding global processes and institutions.

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[25] Source from: https://sdgs.un.org/goals, Access date: 14/01/2022.

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Global Systems Resilience and Pandemic Disease—A Challenge for S&T Governance

Marko Monteiro, Florian Roth, and Clare Shelley-Egan

1 Introduction

The twenty-first century has been referred to as a time of emerging systemic risks (OECD, 2003). Many such risks relate to biological agents: emerging infectious diseases (EIDs) such as SARS, Ebola and Zika have become global threats. Because of its specific characteristics, COVID-19 has posed novel and unanticipated challenges to all social systems on a simultaneous, global scale, something not seen in recent human history. At the same time, it has laid bare pre-existing fragilities in health, economics and politics all over the globe. Such fragilities will be accentuated or make recovery from the pandemic more challenging in all countries (Baral, 2021).

Historically, the largest share of health risks has been assumed by people in the Global South. Fighting infectious diseases has rarely been a top priority for global politics. COVID-19, however, has become a uniquely relevant threat, not only for least developed countries (LDC), but also for global health systems in affluent societies. Just as the effects of COVID-19 are interconnected, emerging responses to the pandemic have become interdependent. Billions of dollars were invested in the

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global scientific response to address the pandemic, and researchers from many countries were mobilized to undertake unprecedented efforts and start new international collaborations in finding solutions to the crisis. In this way, COVID-19 has not only exemplified the global nature of risks in a hyper-connected world, but also that resilience needs to be conceptualized and fostered on a global scale.

In this chapter, we argue that COVID-19 has posed significant challenges, but also offers a valuable opportunity to rethink and improve how to effectively govern global health risks in ways that consider the potential unintended consequences of risk mitigation measures. We focus on fostering innovation capacities as a key feature of adaptive and transformative resilience in any complex system (Folke, 2006). In the context of health crises, technological innovations play a particularly important role. For instance, powerful algorithms can support local and national governments in managing large amounts of data and maintaining situational awareness; new surveillance tools can facilitate the tracking of those who are infected and mitigate the spread of the virus; and innovative medical research methods can provide treatments and vaccines to the population, offering hopes for a return to normality. But in many ways, the full potential of these innovations was not fully realized as imagined; tracing apps, for instance, are mistrusted by many people and often do not function across national borders. A lack of international solidarity slowed down the development, production and distribution of vaccines (Dosi & Soete, 2022). At the same time, vaccine hesitancy and low scientific and public health literacy sometimes propelled by the spread of misinformation and conspiracy theories have hampered the effectiveness of mass vaccination campaigns.

To make the best use of available and emerging technologies, we, therefore, need transparent and trustworthy innovation governance structures that attend to potential risks for the wellbeing of society. Studies in the field of technology assessment (TA) have shown that the cost of inaction may sometimes be greater than the need to make decisions quickly in response to emerging threats (van Baalen et al., 2021), but the accelerated development of technology may also create unintended and undesired consequences (Monteiro et al., 2017). In the case of COVID-19, there is a massive demand for rapid innovations (Lorgelly & Adler, 2020), and many challenges with respect to the proper conduct of detailed assessments. Technology assessment must consider the potential benefits, costs and risks of new medical treatments (Alkhaldi et al., 2021), but how can this be achieved in a global crisis?

This chapter suggests an answer to this question through outlining the elements which we believe should guide TA initiatives related to COVID-19. Such efforts should, as an a priori, engage global publics and involve institutions from different countries and regions. Assessing potential unintended effects of technologies adopted during a fast-moving crisis, including vaccines and apps, involves the incorporation of reflection on how vaccinations may interact with social cohesion, or how perceived risks to civil liberties in the context of new surveillance regimes affects uptake of tracing apps. Yet current governance structures and assessment protocols insufficiently consider both the immediacy of global health challenges, and the increasingly international nature of innovation processes.

To better understand the governance challenges of global technological innovation processes under the pressures of a global health crisis, this chapter looks at two technologies that have played a key role in public health strategies used to mitigate the COVID-19 pandemic: vaccines and tracing apps. We argue that these technologies and their governance have faced three interrelated challenges: problems of scale, trust and politics. These challenges, as they played out in the emergent use of these technologies, help us to identify some of the failures of governance and indicate potential ways to improve resilience for the future. We hope to provide inspiration for local, national or even international TA exercises to incorporate these principles into the way technologies with a global reach are developed and incorporated into responses during emergencies and beyond. The chapter argues that these three elements need to be considered when imagining and implementing such frameworks.

2 Technological Innovations for the Management of Global Health Crises

Governance of technologies during a pandemic involves various interrelated challenges; TA that is tailored for and reflexive to such challenges is needed to achieve flexible, effective and inclusive responses in a fast-moving crisis without losing sight of potential risks (Eckhard et al., 2021). In the context of COVID-19, advances in the fast-growing domains of information and data sciences as well as biotechnologies have received broad attention as key areas in the response against the virus. Governing these powerful, but potentially also risky technologies, involves stakeholders such as public and private health actors, alongside research and policy approaches.

Past examples are useful for reflection on the role of governance during emerging pandemics: the Zika outbreak in the Americas (2015–2016) is an example of how such biological risks can emerge and spread with high speed, challenging global response mechanisms. In these scenarios, inadequate policy choices can lead to public distrust in science or expertise, and can fail to adequately protect the population, save lives and prevent future risks. In the case of Zika, the different responses implemented in various countries and the expertise produced by multilateral organizations were the object of intense and widespread controversy. This included the way in which women's rights and poverty in LDC countries were framed (Roa, 2016), and how the use of untested technologies such as transgenic mosquitoes (Ribeiro et al., 2018) was decided and implemented, especially in Global South countries. These cases contributed to undermining trust in multilateral organizations and the manner in which they offered advice to respond to the pandemic, and raised issues related to the disparities in how countries were affected by and were able to respond to a global outbreak. These challenges would come up again with COVID-19, but on a much larger scale, involving the whole world.

The COVID-19 pandemic is also wrought with controversy and disputes around science, technology and expertise. The use of big data tools, including tracing apps and other technologies to track and isolate individuals with COVID-19, in an attempt to slow the spread of the virus, was widely debated throughout 2020, the first year of the pandemic (Gasser et al., 2020). While in some countries, contact tracing apps quickly gained broad public acceptance and became a cornerstone of efforts to mitigate the spread of COVID-19, elsewhere they failed to achieve the necessary public penetration to become effective (Altmann et al., 2020). As will be discussed in detail below, the success or failure of tracing apps strongly depends on the availability of governance structures to introduce these health innovations in a transparent, trustworthy and risk-aware fashion.

Controversies around how surveillance should be used to manage pandemics, or the introduction of new technologies, have, therefore, been widespread during the COVID-19 pandemic. Comparative studies have shown, however, that controversies were not uniform across societies (Jasanoff et al., 2021). In many countries, misinformation and political polarization were major obstacles in getting innovations to the population. This was most visible perhaps in the US and Brazil, countries among those with the highest numbers of infections and deaths, in contexts where widespread extremist and denialist groups forced public debate to deal with anti-science, and anti-vaccine positions, which even questioned the existence of the pandemic.

In both the US and Brazil, anti-China positions have been significant elements in political responses to the crisis. This has shown the importance not only of taking stock of the available knowledge to support decisions, but the importance of understanding how political disputes can undermine a public health response, or even wholly impede the development of mitigation strategies. Vaccine hesitancy, for example, has been recognized as a challenge to public health policies, and it has been potentialized by organized misinformation in many countries (Tokojima Machado et al., 2020).

Each of these scenarios was a factor in explaining the number of deaths in specific contexts, and thus are crucial in understanding where specific countries failed or succeeded in curbing deaths from COVID-19. But building global resilience to pandemics requires reflection on the measures and principles which can be applied across different contexts, and in country-specific policy regimes. Therefore, understanding policy and governance failures on a global scale (like those related to COVID-19) requires reflection on broader patterns, and poses challenges to building one-size-fits-all solutions (Jasanoff et al., 2021).

3 Facing the Challenges of a Global Crisis Response: Scale, Trust and Politics

To face the governance challenges posed by global crises, we need to broaden how we imagine and practice governance of technologies to include social, cultural and political issues. To achieve this, we need to acknowledge a threefold challenge present in the COVID-19 pandemic, which can help us better understand the gaps which need to be addressed. These challenges include issues of scale, trust and politics. Each of these elements is inevitably interrelated with the others, but can be separated analytically to provide insights regarding the enduring difficulties involved in building resilience to future crises. Calls for reimagining governance are not new: Global institutions have already called for responses and governance of technologies to become more dialogical, responsive and globally interconnected if we are to build longer-term resilience to future pandemics (UN, 2020). Our discussion builds on this emerging debate and outlines three elements which should inform global governance frameworks and assessment practices.

3.1 Scale: Dealing with Global Risks

A central issue in mitigating a pandemic is the sheer scale of the crisis: The speed of transmission and adaptation of the virus; the interconnected nature of global commerce and supply chains (Hobbs, 2020); the need to develop simultaneous responses at global, national and local levels, etc. Without a global approach, linked to other levels of governance, resilience alone will never be robust enough for similar situations. (see Ladikas and Stamm; Hennen and van Est, this volume).

There is thus broad debate about global pandemics needing concurrent global solutions (UN, 2020). In these discussions, countries are discouraged from seeking exclusively national or regional solutions. In the early spread of COVID-19, and in the challenge posed by emerging variants, tracking infections across national borders has been a continuous challenge. In the first half of 2020, when global production chains of health supplies were pressured to the limit, and a China-centered global division of labor also became a global problem (as most medical supplies in demand, including masks and ventilators are mass-produced in China), global interconnectivity became starkly apparent: Global circulation of people helped spread the virus, and global interdependencies in the economy were put to the test.

Even though the importance of tracking infections across national borders for containing COVID-19 was recognized early on by public health experts and authorities alike, most tracing apps were developed and implemented in the first half of 2020 at the national level (in countries like China and Germany) but often remained non-interoperational, mainly for technical or legal reasons (Jacob & Lawarée, 2021; Russo et al., 2021). This limitation particularly hampered the ability to contain infections in border regions with many international commuters, for example, at the German–French and German-Swiss borders. This has changed only slowly in 2021–2022, as the compatibility of several European tracing apps was improved (Blasimme et al., 2021).

Vaccines are also an example of how scale matters in TA: Vaccines were quickly developed due to a massive influx of resources (public and private), yet this has not meant that all people have had access to the resulting immunization opportunities. Treating vaccines as a market commodity (rather than a public good) has effectively concentrated the availability of vaccines in a few countries, leaving most of the world with restricted or no access (Katz et al., 2021). This concentration of buying power relates to global supply chains, also concentrated in some countries (such as India and China). But it is also connected to the global disparities in science and R&D infrastructure, which restricts capabilities of vaccine development and enables vaccine nationalism and vaccine diplomacy, which subsume vaccination efforts to global power plays between nations (Dosi & Soete, 2022). The regulatory approval processes were also indicative of the challenge of scale: As vaccination started in early 2021, the diversity of national, regional and global approval processes created confusion around which vaccines were more effective and how to organize global vaccination efforts. In regions like the EU, where parallel national and regional (EMA) processes exist, this added a layer of complexity which added to controversy around specific vaccines (e.g., Sputnik V) and affected public trust.

Some initiatives attempted to mitigate this problem, with COVAX[1] being the most important (Eccleston-Turner & Upton, 2021). While it appears to have had success in ensuring more investment in vaccine development and accelerating the roll-out of technology, the multilateral initiative appears not to have addressed problems such as vaccine nationalism, whereby countries prioritize their own citizens' needs to the detriment of more effective global vaccination efforts. This is a huge challenge for any governance effort that attempts to have significant global reach: Can we build effective global public health strategies at all, if nation-states are still at the center of decision-making, funding and distribution?

The emergence and diffusion of several variants of the COV-SARS2 virus in different world regions has put to the test the effectiveness of even the most comprehensive national vaccination campaigns in countries such as Israel. In a dramatic way, this demonstrates that no country is safe, as long as the virus is able to spread and mutate easily elsewhere. As UN Secretary-General António Guterres warned in March 2020: "The magnitude of the response must match the scale of the crisis. (…) We are only as strong as the weakest health system in our interconnected world".[2] Imagining a more effective "global TA" can become an important step in the right direction in the case of addressing problems of scale: By providing fora, concepts, and arenas of debate that enable global conversations, and enabling better articulation of local, national and global forms of action, a truly global TA can make a positive policy contribution. Will nations continue to resist broader interference from organizations such as the WHO, especially in times of crisis where those with political and economic power push their way to the front of the line for vaccines? Combining trust in global solutions with the need for local situatedness is a major scientific

[1] "COVAX is one of three pillars of the Access to COVID-19 Tools (ACT) Accelerator, which was launched in April 2020 in response to this pandemic. Bringing together governments, global health organizations, manufacturers, scientists, private sector, civil society and philanthropy, with the aim of providing innovative and equitable access to COVID-19 diagnostics, treatments and vaccines. The COVAX pillar is focused on the latter. It is the only truly global solution to this pandemic because it is the only effort to ensure that people in all corners of the world will get access to COVID-19 vaccines once they are available, regardless of their wealth." (source: https://www.gavi.org/vaccineswork/covax-explained).

[2] https://www.un.org/press/en/2020/sgsm20029.doc.htm.

and policy dilemma. How to build trust and increase the adherence of countries and publics to measures that contribute to systemic resilience on a global scale, while many of them demand collective action and impact (including vaccination), remains an open question.

Producing assessments of technologies for use in global crises presents unique challenges: The need for global and interconnected responses has been defined, but how can TA be performed when countries diverge so greatly in their histories, cultures, values and political systems? The production of global surveillance mechanisms through apps may face resistance from countries where individual freedom and privacy are relevant, but not from countries where collectivity is cherished. But governments may resist such broad surveillance without proper guarantees to each country's sovereignty as regards data, for example. Vaccination on a global scale also presents overwhelming challenges: Convincing global publics of the need to adhere to vaccination schemes seems daunting when anti-vaccination movements are so effective in developed nations, and when access to health is so unequal across the globe. Trust in expertise produced globally is also problematic, as the example of the IPCC[3]—Intergovernmental Panel on Climate Change—shows (Beck, 2012; Hulme & Mahony, 2010). So how can global institutions and publics be engaged during a crisis of trust?

3.2 *Trust: Improving Adherence and Participation*

The issue of trust can be positioned with respect to longstanding debates within STS (Science, Technology and Society[4]) and social sciences concerning the place of science in modern liberal democracies, and the shifts this relationship has undergone since the second half of the twentieth century (Miller, 2008). While science is a central

[3] Created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. IPCC reports are also a key input into international climate change negotiations. The IPCC is an organization of governments that are members of the United Nations or WMO. The IPCC currently has 195 members. (source: https://www.ipcc.ch/about/).

[4] STS, as practiced in academia today, merges two broad streams of scholarship. The first consists of research on the nature and practices of science and technology (S&T). Studies in this genre approach S&T as social institutions possessing distinctive structures, commitments, practices, and discourses that vary across cultures and change over time. This line of work addresses questions like the following: is there a scientific method; what makes scientific facts credible; how do new disciplines emerge; and how does science relate to religion? The second stream concerns itself more with the impacts and control of science and technology, with particular focus on the risks, benefits and opportunities that S&T may pose to peace, security, community, democracy, environmental sustainability and human values. Driving this body of research is questions like the following: how should states set priorities for research funding; who should participate, and how, in technological decision-making; should life forms be patented; how should societies measure risks and set safety standards; and how should experts communicate the reasons for their judgments to the public? (source: https://sts.hks.harvard.edu/about/whatissts.html).

feature of how modern democracies are imagined, its authority has been under serious question for decades (Ezrahi, 1980). The way this issue has resurfaced in the twenty-first century will undoubtedly be the subject of intense scrutiny for a long time. Here, we discuss how this was made visible in the specific technological controversies in focus in this chapter, namely how innovations used in response to the COVID-19 pandemic have been received by publics in different countries. This is important if we are to reimagine governance, preserving a place for science in democracy while respecting skepticism and resistance to expert-centered decision-making.

The issue of trust (in direct relation to politics and values) has had an impact on the way TA is theorized and practiced during the pandemic, as recognized in the European context (van Baalen et al., 2021):

> However, political decisions cannot be based on scientific evidence alone; other political, social, economic, legal and moral considerations also play a role. This has also been the case during the COVID-19 pandemic. Anti-COVID-19 measures, such as lockdowns, social distancing or the introduction of tracing apps generally had broader impacts than mitigating the spread of the virus, such as social isolation and an increased demand of health services. To decide on such measures, policymakers must also weigh different values and interests. In most cases, however, this was not communicated clearly and transparently to the broader public. Policymakers often referred to scientific evidence or experts to substantiate their decisions, without acknowledging the role of other considerations in the choices made. (van Baalen et al., 2021, 11)

Controversies about technologies and COVID-19 have a direct relationship to the issues of governance we want to raise here, inasmuch as they relate to how publics accept or reject expert advice coming from national and/or global institutions; how they trust governments with their personal data, and how they accept surveillance (e.g., in the case of tracing apps); how publics accept and trust vaccines and vaccination campaigns, which is a longstanding issue in public health; and how they respond to other measures which impinge on their freedom and their health. Over many years, risk communication research has shown that trust is a central precondition for successful political communication related to risk, but also that public trust in official risk communication messages is dependent on perceptions of the communicating individuals and institutions, as well as the specific socio-political climate (Renn & Levine, 1991). COVID-19 has sparked many such controversies in different countries and has shown the degree to which issues of trust are central to establishing longer-term resilience to global health crises.

Vaccine hesitancy, for example, has been debated and recognized as a central concern to public health in many countries (Verger & Dubé, 2020), and sentiments of mistrust directed at vaccines have emerged strongly with COVID-19. While more common in industrialized Global North countries, hesitancy has also affected other areas of the world. This can be traced back to many possible factors, such as mistrust in the speed of vaccine development, organized strategies, and well-funded efforts to spread misinformation (Jaiswal et al., 2020).

In the case of COVID-19, the pandemic has been accompanied by a veritable "infodemic" (Cuan-Baltazar et al., 2020). Misinformation (be it organized or unintended) has proven to be a prominent feature of how the pandemic evolved in many countries, affecting trust in public health authorities, technical decisions and technologies (especially vaccines). The Internet has become the main source of news and information, as well as a dangerous source of misinformation. Studies have shown that the speed and broad reach of misinformation on COVID-19 undermines trust in policies and vaccines, and is considered thus a public health concern in itself (Roozenbeek et al., 2020) in countries with disparate and distinct socioeconomic profiles. Indeed, the erosion of trust in science and institutions was a prominent trait in countries such as the US, Brazil and Italy (Battiston et al., 2020; Kreps & Kriner, 2020).

Ensuring adequate governance of the development and deployment of vaccines has already been recognized as the surest way out of the pandemic, but how can governance bodies deal with the increasing politicization of this technology? The controversies which emerge, sometimes fueled by specific political groups, or weaponized by extremists, have concrete effects on efforts to vaccinate globally, and may prolong the pandemic or even contribute to the emergence of increasingly dangerous virus variants. Addressing issues of trust is a *conditio sine qua non* for building both an effective short-term response (Islam et al., 2021) (improving adherence to vaccination, for example), but also for building resilience in terms of stronger relationships of trust between institutions and citizens (at the national level), and global trust in international governance bodies (at the international level).

The case of tracing apps shows that the importance of trust for a successful diffusion of technological innovations in the context of public health is not exclusive to vaccines. Similar to vaccination programs aiming for herd immunity, tracing apps strongly rely on broad use across society. Only if a considerable share of the population uses the apps in their everyday life are these tools able to fulfill their purpose and help to track and break infection chains. When introduced in many countries in the first half of 2020, there were high hopes that the apps could effectively slow down the spread of the COVID-19 virus, gaining time until vaccines would be broadly available. However, the usefulness of the tracing apps turned out to be much lower than expected by many policymakers and experts, mainly because too few people were willing to install and actively use the tracing apps.

Studies in various countries have shown that besides technical difficulties and fears of false positive alerts, a lack of trust in the apps was a main reason as to why these technologies were not used more broadly and today are often considered as failures (Bano et al., 2020; Beierle et al., 2021; Horstmann et al., 2021). Yet this research also shows that the issue of trust played out quite differently depending on the specific political and cultural context in which they were implemented. In countries like the US and Germany, disputes occurred around the privacy of sensitive health data (Mello & Wang, 2020; Simon & Rieder, 2021). In other countries, such as Australia, fears were more general regarding governmental surveillance, while elsewhere public discourses focused more on the possible positive potential of these technologies (Greenleaf & Kemp, 2020).

Importantly, several studies indicate that while general trust in political authorities is an important factor, it is not the only factor that influences public trust in tracing apps. Other factors that determine public acceptance of these technologies include the transparency of the technical architecture, and the societal inclusiveness of the development process, as well as the public communication measures to explain the purpose and function of the apps (Hobson et al., 2020; Oldeweme et al., 2021). In general, decentralized approaches, building on open-source technologies and backed by trusted partner institutions are found to generate high trust rates (Simon & Rieder, 2021). Since most apps were developed on behalf of governmental actors and financed with taxpayer money, this directly relates to the questions of innovation governance. As (Ranisch et al., 2020) emphasize, "(…) to minimize the risk of adverse outcomes, ethical standards should guide and complement the process of development (ethics by design), implementation, use, and evaluation of CT apps." Policymakers can actively influence the level of public trust by setting these ethical standards to ensure an innovation process that pays close attention to the concerns of societal stakeholders and citizens over potential unintended side effects, such as misuse of software for public surveillance or theft of sensitive personal data.

Building better governance and resilience, therefore, must include facing matters of trust as they relate to the science-policy interface, as this has to do with the shape of democracy itself and the role of science within modern democratic regimes. Mistrust in science, albeit often perceived as a problem, is not necessarily a symptom of anti-science, but can also reflect specific civic epistemologies, a dilemma already identified in STS (Ezrahi, 2008):

> The gap between scientific and civil presuppositions about the relations of science and politics in the contemporary democratic state poses a very difficult challenge to STS scholars who must often switch back and forth between public policy contexts where expert definitions of causality are expected to have the authority to set the boundaries of possible value choices and strategies of action, and contexts where these are the social norms and conventions that set the limits to what are acceptable conceptions of causality. This often leads to confusions between an attitude of disrespect for scientific facts as a form of intellectual opportunistic relativism and as a considered critical response to the dogmatic advance of scientific facts as a means of defying working political or normative compromises. (Ezrahi, 2008, 181).

This presents a great challenge also to assessment practices, as they try to balance expert knowledge, public engagement and their own validity as a tool for policy- and decision-making in general. How should we construct TA at different scales in contexts where there is deep mistrust of vaccines? Or when experts are mistrusted, and misinformation is rampant? Governance frameworks have to be responsive to and reflective of situated civic epistemologies (Jasanoff, 2011b), and the ways in which policies are able to relate to science in situated ways in different national and cultural contexts. Because science and society can be seen as coproduced (Jasanoff, 2004), governance and resilience must also pay attention to how these relationships are established and sustain themselves in specific contexts. TA organized on a global scale would be supportive in strengthening awareness of this interconnectedness, as well as inducing mutual learning about different national contexts that need to be taken into account when designing technologies and policies which are appropriate to existing civic epistemologies, along with the perceived needs and demands of the respective publics.

3.3 Politics: Social Justice and Global Inequalities

As discussed above, issues of trust are crucial for understanding some of the challenges posed by global governance of technologies to build resilience. Issues of trust in science and technology, however, lead us into another broad challenge: how to reflect on and integrate politics into how we build resilience. Politicization of technologies such as vaccines became a problem in several nations during the pandemic (Bolsen & Palm, 2021). Another issue was how polarizing politics mediated how people adhered to "stay at home" policies and other measures which severely affected people's lives. To begin addressing this challenge, we should reframe governance away from using a linear idea of science/policy relationships, and take into account the myriad other variables at play in such contexts (van Baalen et al., 2021), which include the core of people's personal and **collective values, and their ideas** of desirable futures and politics, as discussed in concepts such as civic epistemologies (Jasanoff, 2011a; Miller, 2008). In addition, politics pertains to how power is distributed, and how inequalities make a difference, both locally and globally.

Politics in our argument refers to the disputes around desired goals, and differing **perceptions of what is at stake** in a crisis. As in other controversies involving science and technology, the disputes at play in this pandemic are never just about the better solution (vaccines, masks, apps, etc.), but also concern a common appreciation of what the problem is, which in turn has implications for the framing of possible and desirable solutions (Venturini, 2010). Technical expertise does not by itself lower the temperature of controversy or mitigate political disputes (Nelkin, 1975), and controversies often also involve the legitimacy of who is able to provide reliable expertise or be present at the table to make decisions (Nelkin & Hilgartner, 1986). Disputes around trust and values tend to become highly visible in controversies, as STS literature has extensively shown (Collins & Pinch, 1998; Lynch & Cole, 2005).

We understand the challenge of politics to be central to any effective attempt at building longer-term resilience to COVID-19 and future pandemics, and this may be the hardest challenge that countries and governance institutions have to face. Politics here also includes issues of **how power is distributed** in a given society, how decisions get made, and who gets to sit at the table in decision-making concerning pandemics. Of course, politics permeates every aspect of the discussion in this chapter, from vaccine nationalism to disparities in health. But political contestation of specific technologies used for COVID-19, and measures imposed by governments pose some specific challenges to both the imagination and implementation of governance frameworks, which deserve to be considered here.

Politics can be a way to analyze and understand the way governance mechanisms play a role in pandemics, and how that role needs to be the object of further reflection in building resilience. Making choices about policies or the adoption of technologies is never just a matter of assessing cost and clinical effectiveness, but always an issue of politics. Acceptance of expertise; vaccine hesitancy, denialist groups and governments, etc., demonstrate how politics is not peripheral, but central to any attempt to build resilience to pandemics. It is common to see debates around the role of scientific uncertainty in political contestation (Kreps & Kriner, 2020), yet uncertainty in itself does not explain or help mitigate the political aspect of such choices, or contestation as part of responding to a pandemic.

TA can itself be seen as a political arena, in which all of these issues are made explicit in specific ways. From the choices of who gets invited to an assessment exercise, to how assessment is conducted, politics is an important element of how TA is used as a way to make choices about technologies. Aside from the internal workings of assessment, one can also look at how assessment practices interact with broader policy dynamics: How much does assessment actually affect or inform policy in specific contexts? How would a global assessment body or exercise be able to have impact in different cultures, given the various ways technology is perceived? TA, whether global or not, should be reflexive and aware of its political embeddedness, and not invest in a purist or linear understanding of science-policy relationships. This is also a point made about the IPCC (Beck, 2012), and debates about global TA can find inspiration in the critique of technocratic solutions made by studies of climate governance.

This has never been so explicit or so urgent an issue as during the COVID-19 pandemic. Politics relates inextricably to the elements discussed above. Adherence to solutions such as vaccines, or to longer-term measures which may be deemed inevitable for resilience, depend on people trusting institutions and feeling they are represented as part of the solutions being proposed. Becoming part of the decision-making process also presupposes constructing common ground for deliberations around potential solutions. Going back to scale: When we talk of global pandemics, resilience involves engaging not only publics with similar cultural and historical backgrounds, shared values and aspirations, but also global publics with widely different histories, forms of government, values and ways of organizing technical decisions. Ignoring politics on the global scale will also hamper resilience, when for example we fail to achieve a global level of mass vaccination to control a pandemic; or when we fail to address health disparities, or disparities in access to science and technology.

This problem of how science and technology relate to politics has led both the academic and policy communities to develop critical and applied reflections on how to build responsibility into governance frameworks and institutional practices (Jacob et al., 2013; Stilgoe et al., 2013), especially in the European context. TA is a practical outcome of such reflections with a long tradition of developing institutional formats and methodologies of policy advice in many European countries. Global governance to foster resilience to pandemics at a global level could benefit from this experience (Ladikas et al., 2019; Van Est, 2017). However, the COVID-19 pandemic has again emphasized questions of how to perceive responsibility as part of the response: When urgency demands incisive and speedy actions, how are countries to improve responsibility, responsiveness and reflexivity in their actions? Is the requirement for effective and fast decision-making, which characterizes any crisis, at odds with attempts to ensure inclusive political processes, or can participatory processes improve crisis responses by activating broad societal resources (Eckhard et al., 2021)? In the absence of global frameworks to distribute and make vaccines available in an affordable manner, how are countries which have been excluded from the vaccination effort to respond to calls for more "global cooperation," or even trust in global institutions, which may involve external advice relating to hygiene, changes in economic policies or limits to movements inside and outside their national borders?

Global and local-level **disparities** have played a huge role in this pandemic, as they have in other historical and recent outbreaks (Mamelund et al., 2021). These include disparate access to health, racial disparities and deep inequality in terms of available infrastructure to manage and respond to health emergencies. (Bibbins-Domingo, 2020; Brooks, 2016; Quinn et al., 2011). Importantly, the vulnerability of different social groups is dependent on their specific material coping capacities, but also by social and psychological attributes (Eriksen et al., 2020). This means that governance frameworks and responses at all levels should take this into account if they intend to be effective. This has been acknowledged in international calls for action by organizations like the United Nations to prestigious research institutions (Martinez-Juarez et al., 2020), but it remains to be seen how this will be tackled in practice.

Addressing disparities again throws us back into the need to include political choices and political disputes when discussing governance of technologies and technical advice. Building reliable international cooperation involves addressing immense disparities in access to research funding, health technology development, and the deployment and distribution of accessible and reliable information and treatments. Current vaccine nationalism in the acquisition and distribution of vaccines, and the leveraging of vaccines in geopolitical strategies by countries such as China, India and the US erode trust in multilateral or global institutions and frameworks and lay bare the absence of material cooperation between unequal partners. Likewise, extreme disparities within national borders have shown to be detrimental to national social cohesion, opening countries to chaotic responses to COVID-19, with catastrophic consequences in terms of lives lost, increases in poverty and institutional disarray (Jasanoff et al., 2021).

4 Conclusions

We have argued that building better global governance for the future involves matters of scale, trust and politics. Each element helps us to see different aspects of dilemmas posed and illuminated by the COVID-19 pandemic, as well as dilemmas for the governance of science and technology in general. Scale matters, because if risks have a global aspect, then institutions and policies need to have global reach. This demands international cooperation, trust and solidarity to overcome disparities within and between countries and regions. The production and distribution of vaccines has impacted on international relations and highlighted gaps relating to unequal distribution of R&D capacity (and how this is a risk for future resilience), as well as difficulties in producing and making vaccines available. Overcoming the pandemic means immunizing billions of people on a global scale, therefore, we have yet to establish new institutions and policies to make these risks more manageable. The COVAX facility offers some hope, but truly global solutions are still both underdeveloped and undertheorized.

Trust is important both in terms of strengthening social cohesion within countries, and enabling greater acceptance of policies, therefore, ensuring the effectiveness of responses to crises like a global pandemic. The infodemic associated with COVID-19 (but not restricted to it) has global ramifications, and needs to be addressed internationally. Trust among countries and between countries and global institutions is crucial to enable any kind of successful global governance to take effect. A gap in trust became clear during the Trump presidency in the US, for example, but mistrust between China and other countries, and between countries and the WHO or the UN also illustrate how this is relevant to global policies and resilience.

Politics are never absent and can never be ignored. From the contestations of policies and expertise within countries, to the disparities that mark the pandemic (racial, gender, economic, etc.), politics is present in all aspects of the issue. Social disparities are central to understanding who suffers most during pandemics: Poor countries, and the poorest people within countries; minorities (ethnic, racial, sexual, cultural, religious, etc.), women, and those with limited access to health in general. Ignoring disparities makes trust unreachable and undermines how expertise helps to orient policy. It undermines both science and democracy if we do not remain vigilant of their interconnectedness. Assessing risks and governing technology needs to include and reflect on its political aspects as a central part of the expertise which is mobilized to understand the risks and benefits of different innovations. The disparate capacity which countries have to produce, access and assess innovations can also become a global risk, especially during a global crisis, and is also an issue for global governance.

This leads to the question regarding how to develop governance approaches that solve, or at least moderate, the challenges involving scale, trust and politics. While some efforts aim to improve global collaboration, but often fail to secure trust across diverse social and cultural contexts, others appear stronger in building trust, but in turn struggle to achieve internationally coordinated and unified progress against global health risks. To overcome this, new modes of governance are needed, based on principles of resilience thinking, inspired by research traditions in ecology, organizational studies and other disciplines (Folke, 2006; Ruiz-Martin et al., 2018; Walker, 2020). These approaches would focus on capabilities at the local level to develop innovative strategies to adapt to new trends and risks. However, such a decentralized approach does not mean that actors work in isolation. On the contrary, a resilience approach to global governance would put a strong emphasis on networks to exchange experiences and foster transboundary learning. This could provide the basis for new forms of governance that meet the global nature of the grand challenges of our time, while paying close attention to local cultural and political contexts.

Attempts at governing globally through robust science-policy interfaces are still rare, and under construction (and dispute). The example of the IPCC as a mechanism for providing reliable knowledge for governing climate change is interesting to examine, both for its successes and its failures. One important failure relates to the issue of politics mentioned here: When the science used for global governance is produced mainly in specific institutions in the Global North, by authors from this region (Ford et al., 2012), this poses a problem for building trust and engaging nations from other parts of the world. And although science is an example of a global network of practices and institutions with some embedded aspects of global governance, it is also a structurally unequal system. Therefore, to expect trust to emerge purely from the availability of reliable scientific knowledge is to ignore other aspects important to assessing the risks and potentials of science and technology.

Global forms of governance need to address a series of issues, which are not on the agendas of the WHO or other governance schemes, but which can be mobilized to rethink global frameworks: The unequal geographies of science (Hulme, 2010) and technology which still mark the production of knowledge and the capacity to build technologies and innovations to address crises like the pandemics of the present and the future. This of course relates to the trust and politics discussed above: Governance of technologies at a global level cannot ignore issues of social justice, without which resilience will not be possible. Just as policies govern science and technologies conditioned by local perceptions, practices and histories, the knowledge that drives governance needs to also be reflected upon as emerging from unequal geographies, and therefore, needs to be governed with an aim to increase the participation of and attention to excluded and marginalized groups.

This in turn relates closely to the issue of scale: The globalizing drive in the governance of climate change, for example, runs the risk of collapsing all scales into a generic and universalized "global," which erases the local and other scales at which events and practices take shape. This view from everywhere, as discussed by Hulme (2010), needs to be critically assessed as the only possible governance scheme for global problems. As discussed above, local experiments, values and specificities have to be taken into account as another path to build resilience and global forms of governance which will be more legitimate, and therefore, engage broader global publics and institutions. TA as a practice at the interface of politics, science and the public provides appropriate structures and methodologies to enable democratic, inclusive and scientifically well-informed interactive processes of knowledge-sharing and deliberation. How to transform and apply this at a global level to foster resilience to pandemic disease is a challenge that needs to be considered from a long-term perspective.

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Outlook

The Shape of Global Technology Assessment

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1 Introduction

Technology assessment (TA) has a history that shows constant progress. In the last fifty years, since its initial conceptualisation as a strictly technocratic policy advisory, it has developed many different forms and shapes, while significantly expanding its aims and outreach. It is fair to say that in the last three decades TA has increasingly become more accessible to the non-expert world and has even created a unique relationship with the public. This development is on par with similar transformations in our societies that have resulted in publics that are more open, inclusive and aware of

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their power in influencing policymaking. Furthermore, TA has reaffirmed its relationship to social transformation regarding the realities of widespread socio-economic internationalisation and globalisation. It quickly accepted the fact that multilateralism is evident in every aspect of our lives and that the perception of global challenges is key in any Science, Technology and Innovation (STI) debate around the world. Thus, TA advanced its global outreach by developing the notion of global TA, which represents an inevitable development in its history.

This book is one of the many steps that are needed to develop a brand of TA that is truly global; in other words, a type of TA that can focus on global problems and be implemented in most national or cultural contexts equally well. This is a very high aspiration for TA, but one that is worthwhile pursuing. The European Parliamentary Technology Assessment network[1] (EPTA) and the Network Technology Assessment[2] (NTA), have been the first successful attempts to create a fully functional multicultural TA. Based on their successes, and coupled with the experience of many fruitful bilateral TA projects across the globe, the globalTA[3] Network came into existence. At present, the globalTA Network has thirty members, representing all five continents and a rich variety of TA activities in every field of STI. The creation of these multilateral networks certainly shows a strong impetus in the TA community to achieve a global outreach.

This book has provided a number of narratives that argue for the future of global TA. The juggernaut of globalisation and the STI interdependences that have been created as a result, already postulate a realistic argument for the development of global TA (see Hennen and van Est, this volume). The recent pandemic crisis was a rude reminder of the urgency of the undertaking (see Monteiro et al., this volume), while the demands of publics around the world for a viable STI create the need to design a careful approach for a viable result (See van Est and Hennen, this volume).

Overall, we find no doubt that TA is crucial in the resolution of global challenges as described in the Sustainable Development Goals (SDG) (see Ladikas and Stamm, this volume), promoting international development (see Srinivas and van Est, this volume), and regulating technologies with global outreach (see van Baalen et al. as well as, Huang and Peissl, this volume). The questions that have been raised in these narratives are: How to attain a viable global TA? What is the most effective, and most realistic, route to develop it? How to achieve widespread acceptance of TA tools in very different socio-economic and political contexts? And, how to account for a fair collaboration among economically unequal partners?

[1] See https://eptanetwork.org.

[2] See https://www.openta.net/netzwerk-ta.

[3] See https://globalta.technology-assessment.info.

2 The Institutionalisation of TA

Behind these questions is an issue that has occupied the TA community since its beginning in the 1960s: the question of modes of institutionalising TA practises, and setting up appropriate designs of TA institutions.

Any public debate or controversy on the pros and cons, the opportunities and risks, or the ethical implications of implementing and applying technological innovations can be understood as an informal process of technology assessment (Rip et al., 1995). It involves researchers and companies promoting the adoption of their innovations by highlighting their achievements and practical or economic advantages. At the same time, it involves various interest groups and affected communities, which in one way or the other are legitimatised and enabled to intervene with regulations and funding, and address their demands and concerns directly to policymakers. Finally, it involves experts with different scientific backgrounds who are drawn by different actors to support their own points of view. The opposite structure is also true: any official process or project of technology assessment can be understood as formalised technology controversies that involve all the above actors in a procedure controlled by a TA institution (Hennen, 1999; Hennen & Ladikas, 2019).

The need for and the modes of institutionalisation have been an issue of debate and practical experiments right from the initial discussions about TA as a specific concept (Sanz-Menendez & Cruz-Castro, 2004). The origins of TA are related to the 1960s debates on the perceived deficit of politics to steer technological change and intervene in controversies in a meaningful way that is based on reliable knowledge.

Thus, the most relevant, and up to now persisting, question about TA institutionalisation, has been how to relate science to policymaking in a way that avoids both over-ruling politics with technocratic expertise and the instrumentalization of science by politics. To date, many different models of independent scientific TA advice have been developed at regional, national and international policymaking levels (whether at government ministries or parliaments), all concerned with providing independent advice as well as relevance of expertise for the practical purposes and needs of policymaking (Enzing et al., 2012; Hennen & Ladikas, 2009; van Est et al., 2015; Vig & Paschen, 2000).

The second salient problem to be translated into institutionalised practises gained relevance during the 1980s: How to have a meaningful and equal representation of the interests and values of societal groups and stakeholders in TA processes? This has led to the development of a broad set of participatory methods applied by TA institutions, and a slight readjustment of the missions of those institutions, by adding the task of public engagement and public involvement to the more closed modes of interaction between scientists and policymakers (see, e.g. Joss & Bellucci, 2002). TA here has been part of the "participatory turn" in the 1980s that have been attested to S&T policymaking in general (Jasanoff, 2007).

A third relevant problem, that must always be addressed and fostered via institutional means, is the provision of access to the necessary expertise to address policy problems with reliable scientific knowledge. Here, the perceived need for reflexivity has been part of TA's raison d'etre. Uncertainties of scientific knowledge with regard to practical and deeply political problems must be dealt with, and unavoidable conflicts of expertise have to be taken into account. Interdisciplinarity and transdisciplinarity make up the necessary working mode of TA institutions. This translates into relevant staff recruitment as well as the development of procedures to broaden the scope of expertise in TA projects via regular exchanges with the scientific community (also including non-scientific expertise from stakeholders).

All this has led to different "models" of institutionalisation of TA, with different mixes of their academic/scientific, political and public "legs"—i.e. different definitions of the role of public, political, and scientific actors within the TA process (for a discussion regarding parliamentary TA institutions see Van Est, 2019). A description of the development of the debates on these dimensions of institutionalisation is beyond the focus of this chapter. It is however clear that entering into debates about how to organise TA on a global level will necessarily lead to thinking about models of institutionalisation that answer the question relating to politics, the public and science, in productive ways.

The state of TA activities and their institutionalisation differs greatly across the world. As found in this book (Hahn et al., this volume) and in the individual Country Reports (see Supplement section, this volume), especially outside of the established European TA context, developments and initiatives show a wide range of modes of institutionalisation of TA-like activities. In broad terms, these can be localised according to politics, science, and public, showing the different emphasis of country activities. Networks, TA agencies and offices, as well as academic departments provide the spaces for TA-like efforts and frame these accordingly. Yet despite this heterogeneity, the core of TA is visible throughout the different national contexts: assessments of potential risks of emerging technologies, moving towards more responsibility in research and development, addressing issues of public trust and acceptance as well as STI governance. Furthermore, similarities can be found regarding which technologies are the centre of attention: AI, digitalisation, health- or biotechnologies. There seem to be common challenges accompanying these technologies, even if there are specific national systems of dealing with them.

Regarding the processes of TA institutionalisation, the Country Reports show that the realms of academia, research and science provide a fertile ground in which expertise and methodological development can grow. Capacity building through (academic) TA studies and international exchange is another important aspect regarding potential institutional representation of TA. This in turn highlights the importance of a networked and adaptable character of global TA, especially to support countries with little or precarious TA-like activities in sustainable ways. As the history of TA shows, its institutionalisation also depends on factors outside of its influence and control (e.g., political commitment and key change agents). Therefore, the long-term aim of actual institutionalisation may not be realistic in many countries, which then implies that the efforts of the globalTA Network and specific bi-or multilateral projects must be advanced.

3 Models for a Global TA

The definition of TA that permeates the book is that developed by Bütschi et al. (2004):

> Technology assessment is a scientific, interactive, and communicative process that aims to contribute to the formation of public and political opinion on societal aspects of science and technology.

This definition clearly stipulates three key aspects for the development of TA: research (i.e. scientific), participation (i.e. interactive), and impact (i.e. communicative). Every approach to TA, regardless of the context in which it is to be found, should reflect these three aspects. This refers to formal structures in TA, since types of "informal TA" are also widely practised. These are practises that involve exclusively the public sphere and the public debate on STI, not focusing on scientific research, but rather on bottom-up grassroots public participation. As van Est and Hennen point out in this volume, these types of TA require further reflection about the extent to which there is an international or even global public sphere or debate.

Having this caveat in mind, we have attempted to summarise the ideas developed in this book, in a typology of global TA that can take different key forms. We suggest four possible models that TA can follow in order to achieve a global presence. Each model includes a set of challenges and opportunities, as discussed in the contributions to this book.

Model 1: Internal Globalisation of Existing National TA Capacity

This concerns countries with existing TA capacity but limited to the specific context. Like the nation-state and national public spheres, national TA has become a site of globalisation. The observable development of national TA capacities and projects being increasingly concerned with issues of global reach, can be called internal globalisation. Based on the all-affected principle, globalisation forces national TA to broaden its field of view. Internal globalisation can affect the scientific and technological developments to be studied, and the inclusion of groups world-wide which are affected by those developments.

Such a model represents perhaps the easiest and most straightforward possibility to implement a global approach to TA issues, as it can build on existing institutional infrastructures. National TA capacities increase their awareness of the global nature of issues they are dealing with and thus increase their capacities and motivation for transnational TA cooperation. The argumentation for the need for global TA details the existing interdependencies and global effects of STI developments (see Hennen et al., introductory chapter, this volume). As such, there is an inherent need to perform TA studies that go beyond the national state-of-the-art, even if they are only targeting national audiences. This might in turn necessitate input from transnational sources and implementation of methodologies at international level. This type of TA can be described as "global" in the sense that it has a global perspective. It should be noted that in the case of the European Union, the interdependencies between Members States run so deep that it is virtually impossible to perform a "national" TA study without integrating the full aspect of multilateral governance represented by the EU, a factor reflected in the foundation of EPTA in the 1990s.

Moreover, there is clear evidence that a sizeable part of the young generation consider themselves to be citizens of the world, in a trend that is characterised as an "internal globalisation of the public sphere" (see van Est & Hennen, this volume). This trend alone would necessitate the development of a globalised national TA, simply to make it relevant to the main preoccupations of the national citizenry. Perhaps the most prominent example of such TA is the issue of climate change. It is a truly global issue that is very salient for most people around the world, and requires concerted national analysis and action. A TA study on STI-based resolutions to climate change, will inevitably be global in scope.

Model 2: Strengthening National TA Capacities Across the World

This concerns countries with weak or non-existent TA capacity. Global TA can grow by strengthening the TA capacity of developing countries across the world. Moreover, although TA has been typically developed in democratic countries, strengthening TA capacity in authoritarian states is also a route towards global TA.

This model represents an implicit acceptance of deep structural differences between developed and developing countries in terms of STI development and public debates on related issues. Such a view should be taken with caution; although we can see clear gaps in STI education and output (see Ladikas and Stamm, this volume), we tend to overlook the potential of distinctive systems of local STI development and debate such as those involved in "frugal innovation" (see Srinivas and van Est, this volume). It is therefore advisable to approach the issue of capacity building from a mutual-learning perspective. There is no doubt that many (but not all) developed countries have considerable experience in TA implementation, covering the whole spectrum of methodologies, from the standard expert-based analysis to fully participatory scrutiny. There is scope in providing information and training to countries that do not have such experiences, in addition to providing advice on the possible institutional location of TA. On the other hand, the typical TA in industrialised countries is not geared to incorporating parameters that describe developing country constraints. For instance, severe funding restrictions, policy dependencies from external actors, or the role of international organisations and expert expatriate communities, are not normally accounted for in TA. Such an expansion would require "reverse" capacity building from developing to developed countries.

Another aspect that this model brings to the fore is that of political system differences amongst the various TA collaborating countries. This is an issue that has been discussed extensively within global TA (see Hahn & Ladikas, 2019). A short answer would argue for prescribed limitations on how "non-democratic" the country requesting the implementation of TA is. What has been called the "TA Habitat" is a vital feature for the development of any type of TA (Hennen & Nierling, 2015). It is without doubt true that the concept of TA as it developed in the Western world "has politics", in the sense that its mission and self-understanding is closely tied to the democratic values of scientific independence and open and inclusive public deliberation of policy issues (Hennen & Ladikas, 2019). This encompasses the necessary preconditions for the implementation of TA, one of which is the possibility for an open dialogue on STI issues. Regardless of the perceptions that exist for any regime around the world, if it allows for a public dialogue, then TA can in principle grow in it. Restrictions on the dialogue might exist, and they might even be related to the standard norms of behaviour in the country (e.g. strong hierarchies), but as long as they allow for the expression of honest views on the subject, they can be acceptable. As such, the political limitations for the development of TA are demarcated, in the sense that TA would at least develop niches of open debates within the public sphere.

Model 3: Institutional Networks Across Borders

To stimulate the internationalisation of TA, existing national TA institutes may collaborate across borders on various TA-related topics. This so-called Institutional Network option aims to establish an expert-and-participatory TA capability by connecting an appropriate set of independent, non-partisan and non-profit organisations into an international network. Examples of existing networks are EPTA and the globalTA Network. Cooperation between institutes may vary from bilateral cooperation to cooperation on a global scale, like for example in the World Wide Views on Global Warming[4] (WWViews) project.

This model represents the existing "status quo" of global TA. EPTA is a loose network of established parliamentary TA institutes, mainly from Europe but recently also accepting non-European countries as associated members to the network. It functions as an information exchange, by e.g. providing a searchable database with TA reports developed by members, and also organizes an annual conference for members, under the auspices of a rotating presidency of the network. EPTA is therefore a good example of how similar TA institutes can form an international network, but this does not translate into common projects or standardisation of TA approaches. So far, there has been only a limited number of TA projects under the auspices of EPTA, since the network does not have its own research funds. However there have been many European TA projects in recent decades (mainly funded by the European Commission) which would not have been established without the strong ties of exchange that have been developed in the EPTA network (EuropTA, TAMI, GEST, PACITA).[5]

A similar structure is to be found in the globalTA Network. It is also a loose network of TA institutes, with the difference that it intentionally covers the whole world. It also requires that members formally accept a mission statement that clearly describes TA as[6]:

- dealing with technology and socio-technical developments
- interdisciplinary and multi-perspective
- policy-oriented (targeting political and societal addressees) and problem-oriented (addressing real-world issues)

[4] See http://wwviews.org.

[5] See https://eptanetwork.org/database/projects?start=0.

[6] For details, see https://globalta.technology-assessment.info/about-us.

- neutral and independent (non-partisan, not funded by interest groups).

The mission statement also describes the aims of the network and the obligations of its members. This represents a step towards the creation of a permanent structure of engagement in the area of TA, but is still far from achieving it. As with EPTA, the globalTA Network does not have its own funds to initiate TA projects at global level, and it does not have a legal entity to apply for funds. There is no doubt that the achievement of global TA via such networks will necessitate these steps. But one should not underestimate the impact that EPTA and the globalTA network have on promoting TA on the international stage. Without the existence of such international networks, TA would not normally have the chance to transform its functions from the national to the international level of analysis and policy advisory.

Model 4: Global TA Linked to a Global Decision-Making Body

National parliamentary TA organisations are often linked to a decision-making body, like the parliament. This decision-making body option can also be implemented on the global level, in particular with regard to UN institutes. In the field of global warming, the IPCC is an example of this model.

This model of global TA represents a truly global structure with a global outreach. It is the most ambitious of the four models and also the most challenging. We have seen throughout this book that TA linked to a global decision-making body is not an uncommon vision for the future of global TA. Two chapters have specifically used the example of the IPCC as a case study for global TA (see Ashworth and Clarke, Ladikas and Stamm, this volume). There are very good reasons for approaching a possible structure of global TA from this perspective. Global TA deals with global STI challenges and it is natural that it should be located as a global decision-making body. But simultaneously, TA practitioners should represent as many countries as possible in order to allow for a fair and globally effective strategy or intervention. It is hard to think of any other institutional structure that accommodates global representation than the typical UN paradigm.

The challenges identified for such a possibility are many and significant. One that is shared with any other institutional TA arrangement across the world, is its relationship to policymaking. We are witnessing a great variety of policy locations in existing TA institutions, from internal bureaus in the national legislative branch that are run by policymakers and funded directly by public funds, to external STI advisories that are self-regulated and self-funded. There are major pros and cons associated with each institutional location, which have been extensively discussed (Decker & Ladikas, 2004). IPCC's location is to be found between the two sides, whereby the strategy and funding are a combination of governmental needs and scientific self-regulation. An institution performing global TA could not be differently located than IPCC. TA is by definition a consultative process to the policy making but should also have certain freedom of action in order to provide independent analysis and advice. Such freedom of action is not found elsewhere in the typical UN institutional system. As such, IPCC offers indeed a pragmatic possibility.

Another challenge is to be found in the scientific representation of a global decision-making body. Here, a global TA would be faced with the inevitable imbalance that exists between developed and developing countries in terms of scientific education and output. A TA that is based on concrete peer-reviewed science is a TA that would take the bulk of its input from very specific STI-intensive economies. There are ways to influence this input imbalance, from activating expatriate scientific communities to funding specific projects in countries with weak STI systems. These are long-term processes that cannot be effective in creating immediate input, but only a global institutional arrangement can deal with such challenges in the long term.

Furthermore, a main challenge for such a model would be the manner in which TA methodologies are implemented in different cultural contexts. This refers mainly to participatory and interactive methods that are well-established in most Western countries but have not yet been tried extensively in other cultures. Although it is clear that public debates on STI issues are evident across the globe (see van Est & Hennen, this volume), it is far from clear that participatory methodologies can be applied equally well in every country. Cultural specificities, norms of behaviour and political context, are some key elements that global TA must take into consideration. This is particularly important for a TA that is closely located to a centralised global decision-making structure. If TA is to provide the ground for consensual decision-making, everyone must be content with the way it is applied in their national context. This is a challenge, but also a unique opportunity to initiate global debates which are both based on and promote global citizenship. Some of the (little) experience that TA has accumulated in this area (see World Wide Views, above) is very promising for the potential of globally implemented participatory methodologies.

4 Next Steps for the GlobalTA Network

Having discussed the various models that the global TA could follow, we provide some insights as to the development of the network itself. Irrespective of the manner in which TA can embrace multilateralism, there are certain steps inherent in its development. Notwithstanding the achievement of having created a global network, the next steps should involve:

The development of global projects; the practise of global TA can only be attained by actually running TA projects which encompass at least the majority of the Network membership. This means agreeing on common methodological approaches, timelines and frameworks for results comparison. This is a very complex and expensive process that so far has not been realised due to funding constraints. An alternative could be a more modest comparative approach, using existing institutional funds. But without this step, there can of course be no global TA approach.

Information exchange; a network is foremost a structure of information exchange. Like EPTA, that lacks extensive project implementation but offers a platform for extensive exchange of national project results, global TA could also develop its own information exchange platforms. Although a less demanding step than the common project one above, it will still require dedicated staff for this purpose, and internal funds.

Legal institutionalisation; as we have seen, there are different ways in which TA has been institutionalised in different countries. The globalTA Network will require a legal entity if it is to develop in a coherent TA practise group. This is far from simple, as multilateral institutions require backing by national authorities in order to become legal entities. But this is necessary in order for the Network to acquire the capacity to bid for project funds, pay staff and be represented on the global stage.

Long-term funding; this is of course another necessary aspect for the globalTA Network. One possibility is to follow the IPCC model and require an annual fee from the institutes and scientists that comprise the network. In this manner, the network can safeguard its independence and acquire a secretariat to ensure basic functions.

The role of the UN; as we have seen, UNCTAD is the UN organisation with a remit to perform TA and outreach to the whole globe. It is evident that the globalTA Network has a lot to gain by working with UNCTAD while the opposite is also true. Such mutually beneficial relationships can be formalised with a Memorandum of Understanding (MoU) that establishes a working relationship whereby the network can run TA projects on behalf of UNCTAD.

Overall, there is significant potential for development in the globalTA Network. How far this development can go depends not least on the necessity to have such a network on the global STI stage. We believe that this is indeed the case. This book is another step in developing the globalTA network, as it provides the conceptual structure upon which the practise of global TA will be built. It is now time to make the leap from theory to practise.

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Appendix
Technology Assessment Activities in Australia, Brazil, Central Europe, Chile, China, India, Russia, South Africa, South Korea, and the USA

Australia

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Australia: Specific Context

As in the rest of the world, the nature of Australian society, industry, and environment are shaped by how we develop and apply science and technology. In Australia, there is a clear commitment by the national government to finding science and technology solutions for complex challenges, and as a key driver of innovation and economic prosperity (Lacey et al., 2019). Formal processes of technology assessment (TA) are currently applied in the Australian Government's health system to ensure the safety and efficacy of health technologies for market regulation and to assess the safety, clinical- and cost-effectiveness of various health technologies. National agencies have also applied TA processes to examine and compare cost estimates for electricity generation technologies. More recently, these energy technology assessments have shifted toward energy security assessments, so that risks to adequacy, reliability, and affordability of energy in Australia can be used to better plan for future energy needs. Australia has long embraced technological solutions to enhance the production of its primary industries and resources sectors.

For the most part, the consideration of science and technology applications by government in Australia has been managed by sector, through either formal processes (e.g., Health TA), regulatory agencies (e.g., Office of Gene Technology Regulator), or national standards (e.g., Food Standards Australia New Zealand). However, private industry and multinational companies also develop and drive how technologies are being taken up and shape Australian society. Developments such as the collection and

L. Hennen et al. (eds.), *Technology Assessment in a Globalized World*,
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use of significant datasets mean that technologies are increasingly reaching further into our daily lives for a variety of purposes. Some developments in technologies and their applications are also posing potential new societal and ethical challenges. Such areas of future science and technology and their impacts have become the subject of increasing attention in Australia.

Australia: Developing a National Research Capability in Responsible Innovation

New science and technologies provide significant opportunities to generate public and private benefits in our lives. Such benefits may be realized through the evolution of tailored healthcare systems, in improvements to security and crime prevention systems to protect our privacy, in realizing more sustainable energy solutions for the future, or in demonstrating new ways to protect significant environmental assets such as the Great Barrier Reef. However, new science and technologies can also pose ethical, social, and regulatory challenges, which if left unresolved, may hinder the progress and innovation that can be delivered to society and future generations. In the recognition that advances in science and technology are increasingly, and in some instances purposefully, intended to be disruptive, there has been heightened attention leveled at what constitutes responsible research and innovation in Australia (Ashworth et al., 2019).

While the concept of responsible innovation (RI) has been used extensively in Europe, and to some extent in the United States, for over a decade, its adoption in the Australian context is a comparatively recent phenomenon. RI was first expressed in a programmatic way within Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The CSIRO is the largest of the publicly funded research agencies in Australia, with a mission to solve the greatest challenges through innovative science and technology and catalyze collaborations that will boost Australia's innovation performance. In 2016, CSIRO launched a new research program of Future Science Platforms, which represents one of the largest investments in future-facing scientific research currently underway. Over time, this investment has grown to represent a diverse research portfolio that includes future manufacturing, synthetic biology applications, quantum computing, and development in health and medical technologies, among others (CSIRO, 2021). Many of these fields draw on the increased computational power of digital data and machine learning to drive new predictions and industry developments in all aspects of our lives.

Such transformational research intends to produce disruptive technologies, which in turn precipitate societal change and uncertainty. Given the intentionally disruptive nature of the research portfolio, it was recognized that assessing the risks, benefits, and uncertainties of these areas of science and technology development was required in order to ensure that responsible science and technology was being designed and delivered for all Australians. This also required an ability to design for and be responsive to the social context and the end users of the research. Comprehensively assessing the benefits, risks, and uncertainties that new and disruptive science and technologies present for society has emerged as a challenge around the world.

Since 2019, RI has been adopted in the national science agency as an approach to this challenge. RI is funded as a Future Science Platform in its own right as opposed to being embedded as a cross-cutting capability. In this way, ensuring responsible science and technology development is itself considered to be a critical long-term scientific pursuit, with the requirement to demonstrate how it can be advanced through applied scientific research and experimentation, which is also subject to scientific peer review. The development of the Australian RI program drew heavily on the work of European colleagues. For example, the development of the program's ten-year impact pathway for delivering RI for Australian science and technology development was refined with the input of experienced colleagues in Germany, Finland, Norway, and the United Kingdom, along with those in the Australian research and innovation sector. The advantage of drawing on the lessons of global colleagues allowed ideas that had been trialed and challenges that had been experienced in other contexts to inform the design of the Australian research program. The most significant design decision as a result of this consultation was to launch a research program that would support experimentation across different portfolios of science to identify what worked and what did not. This required identifying collaborators who were equally open to and motivated by RI outcomes, and it replaced the original model of designing a top-down RI framework and seeking to apply it across the entire organization.

The funding within the national science agency was also used to establish new collaborations on RI with three Australian universities. This approach not only embeds a broader reach for RI research across Australia but also demonstrates the willingness of universities to invest their own funds in building a stronger base in RI capability. The collaborations are based on 50:50 matched funding arrangements and host jointly funded early career researchers who are provided with the experience of working across both applied and academic research environments. The intent is to seed and strengthen collaborative networks among the early career researchers and their host organizations that will test and validate RI research and its application over many years to come.

Australia: Specific Challenges and Outlook

The development of an applied research capability in RI and its application to diverse technologies represents one recent and formal cross-sectoral approach to advancing TA in Australia. However, the results of this experimentation with developing new, applied approaches to RI through 'blue sky' research investment are not yet conclusive. The main challenge currently relates to drawing together initial research findings across a diverse range of projects and portfolio applications to identify what has worked and why, and what is most likely to translate to an applied approach to

RI that can be taken up and used by a range of stakeholders or end users within and beyond the research sector. The effort to date has largely been focused on stakeholder engagement and constructive TA approaches.

In the immediate term, there is evidence of the importance of drawing on global lessons and trends for Australian-specific application. Recent research combining Indigenous Knowledge and artificial intelligence (AI) to improve environmental management outcomes in Northern Australia has been a case in point and has shown how approaching TA at the regional and community scale will always be of critical importance (McDonald et al., in press). However, these developments do not happen independently of global research and technology trends. In the broad domain area of digital agriculture for example, the Australian research on responsible digital agricultural systems has been developed in the context of Australian agriculture, but has been highly influenced and remains closely connected to international scholarship, industry, and governance practices (Fleming et al., 2021).

In Australia, it is recognized that there is also a need to manage the tension between creating a research capability in RI, which is used within research settings by and for researchers, and how and what might be translated into professional and policy settings by other stakeholders charged with managing innovation processes. While this research program in Australia is still early in its delivery, it emphasizes the importance and positive influence of being part of a global and connected network of researchers and practitioners working with the changing nature and impact of technologies (such as the globalTA network). This was evident in the design of this national research program in RI research. However, there are lessons and experiences that continue to remain transferable and instructive across contexts. The importance of adopting a global approach also allows us to examine the increasingly globalized role of technologies in our lives.

Brazil

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Brazil: Specific Context

Brazil is Latin America's largest country, and the region's most relevant economy. Likewise, it has the region's most developed science, technology and innovation (STI) ecosystem, despite all the gaps and challenges science and technology are facing in the country. In 2016, for example, Gross Expenditure on Research and Development (GERD) totaled USD 37,705 million, with a GERD/GDP ratio of

1.24% (Reyes-Galindo & Monteiro, 2018). This is much less than the levels exhibited by highly developed nations and regional leaders like China, but well above Latin American averages. Research is still concentrated in public institutions, especially universities and public research institutes, and a longstanding challenge has been to escape the 'middle-income trap' and spark more virtuous cycles of innovation and investment associated with sustainable economic growth (Albuquerque, 2019; Andreoni & Tregenna, 2020). Around 61% of government research and development (R&D) spending goes to higher education, with 10% of spending going to agricultural and non-oriented research, respectively, 6% to industrial technology, 5% to infrastructure, 1% to defense, and other objectives such as environmental control, civilian space science, energy, exploration, and social development capturing less than 1% (Reyes-Galindo & Monteiro, 2018).

Some of the main actors in the Brazilian ecosystem for STI include:

- Executive branch: Ministry for Science, Technology, Innovation and Communications, and related Ministries; regulatory agencies such as the National Petroleum Agency, The Natural Gas and Biofuels Agency, and the National Electric Energy Agency; state and municipal secretariats;
- Society: Brazilian Academy of Sciences (ABC); Brazilian Society for the Progress of Science (SBPC);
- Funding Agencies: National Council for Scientific and Technological Development (CNPq); Coordination for the Improvement of Higher Education Personnel (CAPES); Funding Authority for Studies and Projects (FINEP); Brazilian Development Bank (BNDES); Brazilian Enterprise for Research and Industrial Innovation (EMBRAPII);
- STI 'operators': universities, federal and state STI institutes; science and technology institutions like the mixed public–private company Embrapa; technological parks.

Two major challenges are pressuring science and technology in Brazil currently, which also affect the Brazilian TA landscape: Dramatic funding cuts have been underway since 2015; and there is a crisis in the social contract between science and society, wherein a growing trend of denialism and attacks from extreme right-wing politicians and authorities flows into an already problematic context of separation between science and society. While the lack of funding, which has continued for years, threatens local capacity to develop and assess technologies properly, the crisis in the relationship between experts and society also threatens established mechanisms of assessment.

The crisis in funding has been happening since the 2015 recession, which was also combined with a severe political crisis around the impeachment of then President Dilma Roussef. The economic downturn was met with severe cuts in many areas, with science and technology being especially hard-hit. Scholarships for graduate students, a major motor in Brazilian science and technology, for example, have been at risk and unstable for years, causing both material damage and a subjective uncertainty which affect longer term outlooks for the country's technology and innovation activities (Andrade, 2019). Not even the COVID-19 crisis turned the tide, and cuts have been ongoing in all areas, causing a growing outcry from scientists. The combination of budget cuts and negationism has been called out internationally (Hallal, 2021), but this trend has persisted. From 2015 to 2021, the budget for the Ministry of Science and Technology went from USD 1.2 billion to about USD 400 million. This is the lowest level in history when the size of the research community is taken into account, which will certainly have as yet unknown longer term effects (Escobar, 2021).

Brazil: The Politics of Expertise

Health Technology Assessment (HTA) can be pointed out as both a good practice for the Brazilian case, but also an example of the challenges mentioned above. On January 17, 2021, Brazil's Health Regulatory Agency, ANVISA, granted approval to two COVID-19 vaccines for emergency use. One of these is the so-called CoronaVac, a partnership between Brazil's Butantan Institute and the Chinese company Sinovac Biotech. The other is the AstraZeneca-Oxford vaccine, being produced locally at the Fiocruz Institute through a technology transfer deal. Both vaccines were approved under intense scrutiny and surrounded by political disputes. On April 26, 2021, ANVISA barred requests for the importation of the Sputnik V vaccine, produced by the Russian Gamaleya National Center of Epidemiology and Microbiology. Touted as the 'world's first registered vaccine' for COVID-19,[1] it has also been at the center of various disputes involving state governors and the federal government, again with ANVISA at the center of controversies.

ANVISA is part of a system of institutions which help regulate and assess technologies for health, and it enjoys a positive reputation in the country. Alongside ANVISA, Brazil's universal health system (SUS) has also transformed the health technology landscape. SUS is a decentralized, universal access health system, mobilizing great resources and fomenting investment in medical technologies and HTA activities. SUS has provided universal health coverage and mass vaccination programs (Paim et al., 2011; Teixeira et al., 2018), which is very important in a very unequal country. Under the complex and decentralized SUS framework, the Ministry of Health established an HTA protocol (Brasil, 2016), which supports the activities of CONITEC (National Commission for the Incorporation of Technologies into SUS) which complements the role of ANVISA as well as other instances of HTA. This system, which mobilizes several highly respected experts and permanent technical personnel, has come under strain both due to the emergency situation posed by COVID-19, but also by the political challenges posed by President Bolsonaro and his supporters inside and outside government.

The Coronavac vaccine has been at the center of a dispute between the Federal government and the state government of São Paulo; former allies, and now bitter enemies. This involved questioning the Chinese origin of the vaccine and questions

[1] https://sputnikvaccine.com/about-vaccine/.

regarding its efficacy, feeding into conspiracy theories, boosting anti-vaccine movements and misinformation groups which have been very active since the 2018 election (Gramacho & Turgeon, 2021).

The controversy around Sputnik V also involved political disputes. The first negotiation took place in mid-2020 between the government of the state of Paraná, in Southern Brazil, and the Russian Direct Investment Fund (RDIF), but did not go forward due to the complexities in the technology transfer agreement. Later, the vaccine became the focus of initiatives by states in Brazil's Northeast, a poorer region of the country whose governors are overwhelmingly political foes of Bolsonaro.[2] The regulatory process for this vaccine has been unusually controversial, with Gamaleya publicly criticizing ANVISA, and governors pressuring for faster approval given the pandemic emergency (Moutinho & Wadman, 2021). Albeit receiving a limited green light to import doses, pressures and critique continue, this time coming from politicians mostly associated with the left, or seen as opponents of Bolsonaro.

Brazil: Specific Challenges and Outlook

As discussed above, Brazil faces a crisis regarding the social place of science and technology in society, which affects the place of and possibilities for TA in the country. This expresses itself in two interrelated trends: severe budget cuts affecting the continuity and resilience of research in the country; and the growing trends of denialism and critique of science and experts by political ideologies currently in power. This trend has been detected and commented on previously (Reyes-Galindo & Monteiro, 2018) and has been associated with the problematic distancing between science and society: Hierarchical and technocratic forms of governing science and technology have roots in the modern origins of Brazilian STI systems (which grew tremendously during the military dictatorship of 1964–1988), but have come under strain recently. Calls for opening up science and technology policy therefore mean a revision of the social contract of research and society in order to increase engagement and legitimacy.

In our current uncertain times, it is very unclear how such calls will resonate in the population and with policymakers. COVID-19 has forced a debate on the place of local technological capacity, for example when traditional institutes like Butantan and Fiocruz were able to produce COVID-19 vaccines locally and start developing their own technologies. But these examples remain the exception in a landscape of great instability and loss of future prospects. Our hope is that the ongoing struggle to consolidate the democratic gains of Brazilian post-1988 society will not let current instabilities threaten the major strides made since our new constitution.

[2] https://www.reuters.com/article/health-coronavirus-brazil-sputnik-idUSL2N2NQ1JG.

Central Europe (Poland, Czechia, Slovakia)

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Central Europe: Specific Context

Of the three Central European countries in this section, Poland has advanced Technology Assessment (TA) activities the most and succeeded in establishing a parliamentary TA office. Czechia (Czech Republic) and Slovakia actively participate in (mostly European) TA projects, but are struggling to establish solid TA institutions formally recognized by national government (either executive or legislative branch).

Historically, the scientific community interested in the problems of TA began to form in **Poland** as early as the 1970s. For instance, the works of Prof. Lech Zacher, a precursor of research and publications in this field, became relevant. After the first period of functioning as a loose group of scientists, this community found its institutional framework. Currently, the two leading institutions dealing with the issues of technical assistance in Poland are:

- The ***Bureau of Research of the Polish Parliament*** (*Biuro Analiz Sejmowych*, BAS[3]), established in 1991. BAS is the leading national institution specializing in legislative aspects of TA. It is the organizational unit of the Chancellery of the Polish Parliament (*Sejm*) which provides research and analytical support to the lower chamber of the *Sejm*. The main task of BAS is to draft legal opinions, prepare independent reports, and work out analyses upon request from individual MPs and parliamentary committees. Activities of BAS cover a broad spectrum of constitutional and legal matters, EU legislation, social and economic issues, and TA. BAS is also the associated member of the EPTA network.
- The ***Polish Association for Technology Assessment*** (*Polskie Towarzystwo Oceny Technologii*, PTOT[4]), registered in 2015. PTOT deals with TA from a scientific perspective. This organization aims to develop and popularize TA as a form of interdisciplinary scientific advice for broadly understood public policy. Members of PTOT are developing novel concepts for TA and improving research methods and tools used in TA. They are working to integrate scientific communities around

[3] http://www.bas.sejm.gov.pl/about_us.php.
[4] http://www.ptot.pl/.

the idea of TA, and integration of competencies dispersed in various scientific disciplines. A recent brainchild of this activity is the Center for Science and Technology Assessment (*Centrum Oceny Nauki i Techniki,* CONT), which has been established at the John Paul II Catholic University of Lublin, and which will be dedicated to the axiological dimension of science and technology in Polish society and internationally.

Czechia does not have an established institution dedicated solely to TA. Czech research teams were actively involved in European TA projects (e.g., TAMI and INES[5]) for the first time in 2002. The ***Technology Centre of the Czech Academy of Sciences*** (TC CAS[6]), which is a leading national institution specializing in analytical and conceptual activities oriented at the area of STI, can be regarded as the 'TA institution' in Czechia. The TC Department of Strategic Studies (STRAST[7]) systematically develops methodologies for strategic studies and utilizes the latest findings in this field to prepare conceptual background materials for the public administration on the European, national and regional levels. STRAST identifies research priorities and/or evaluates results and impacts of implemented policies. STRAST also develops methodologies used for its activities, such as evaluation, technology and impact assessment, foresight, or public engagement. In this context, TC CAS has been involved in UNIDO, ETAG, globalTA, as well as the Europe's People's Forum (EPF) networks and has become an observer in EPTA.

Similarly, to Czechia, there is no proper TA institution in **Slovakia**. There has been some positive development regarding Health Technology Assessment (HTA), which can be regarded as a TA sister discipline, with the establishment of a national HTA organization at the Ministry of Health,[8] but there is no similar development on the front of TA as such. Still, the ***Slovak Academy of Sciences*** (*Slovenská akadémia vied*, SAV[9]) can be considered as an aspiring TA institution in Slovakia. In 2013, some of the first openly TA activities were in place, as the SAV Institute for Research in Social Communication started working on two projects dedicated to nuclear energy and human enhancement technologies. Furthermore, based on the guidelines of the European Academies Science Advisory Council (EASAC): Good Practice in the Dialogue between Science Academies and Policy Communities, SAV established a Science Advisory Platform in April 2016, became an observer in the EPTA network in the same year, and later also joined the globalTA network at the 4th European Technology Assessment Conference organized in Bratislava in 2019.[10] Generally, SAV is mostly involved in joint projects with other European TA institution, e.g., within the EU Framework Programme. Stemming from the support of the international network of partners, SAV is continuously working to advocate for TA activities in Slovakia,

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[5] http://salinitygradientpower.eu/what-is-the-ines-project-about/.

[6] https://www.tc.cz/en.

[7] https://www.strast.cz/en.

[8] Tesar et al. (2017).

[9] https://www.sav.sk/?lang=en.

[10] https://bratislava2019.technology-assessment.info/.

yet it lacks adequate resources both in human capital and funding in order to build an institutionally stable TA institution.

Central Europe: Highlights of TA Activities

A typical TA activity in the region of Central Europe is an international project involving citizen engagement (such as PACITA[11] and CIMULACT[12]). Secondly, there is good practice of science-policy interface regarding TA topics, with different levels of institutionalization among countries.

In **Poland**, BAS and PTOT both participated in European projects such as PACITA, actively testing various participatory TA methods for STI knowledge-based policymaking. Currently, there are national and international research projects dedicated to:

- ***Educational needs of TA from the Polish perspective***. This research aims to investigate the implications of the paradigm of TA at universities of technology. While pedagogical thinking in research has traditionally emphasized the issues of teaching about technology, reviewing it in the light of current empirical developments shows a niche in theories concerning TA in education.
- **Future-oriented TA as a support tool for Responsible Research and Innovation (RRI)**. As part of the research, the methods and techniques used in enterprises will be analyzed to reflect on the possible consequences of developing a given innovation at the design stage and generate practical, ethically acceptable, and socially acceptable desirable results.
- **The social perception of 5G technology**. The project aims to show how people perceive modern technologies, especially 5G technology, in the context of social security and opportunities and risks in social development. The theoretical model of the project refers to such theoretical positions in general sociology and TA, as well as in sociological research, which situate humans in the broader technological context of the information age or more broadly postulated Society 5.0.

In **Czechia**, TC CAS has participated in European Framework Program projects such as PACITA, CIMULACT, and GoNano.[13] Currently, it also works on NMP newcomers' better involvement within a TA-like participatory project FIT-4-NMP.[14] TC CAS actively contributes to EPF activities for the Conference on the Future of Europe. Recently, TC CAS has finished a national project called RedPot[15] (Reduction of Food Waste in Catering), where part of the project was to discuss and assess emerging technologies in catering for food waste reduction. Results have been further

[11] http://www.pacitaproject.eu/.
[12] http://www.cimulact.eu/.
[13] http://gonano-project.eu/.
[14] https://www.fit-4-nmp.eu/.
[15] https://redpot.strast.cz/en/documents.

used not only by the relevant ministries (of agriculture and environment), but also by some active fast food and catering chains like Hellman´s, Compass Group and Subway, as a practical guide for their employees all over Europe.

Several projects that SAV implemented in **Slovakia** dealt with citizen engagement activities. European Framework Program projects include PLATENSO[16] (citizen consultation on nuclear energy), CIMULACT (citizen consultation on research funding), and Human Brain Project[17] (citizen consultation on artificial intelligence (AI)). Some SAV projects also dealt with ethical dimensions of TA in relation to citizen engagement. Slovak Research and Development Agency funded a project (NBICET), which tackled ethical aspects of nanotechnology, biotechnology, information technology, and cognitive sciences. Within the SUPER MoRRI[18] project, an analysis of RRI elements, including citizen engagement, has been made.

To encourage public debate in **Poland**, BAS produces a few publications covering subjects related to current and forthcoming legislation and other matters of public concern. The Bureau publishes a series of short briefing notes ('Infos') containing concise 4-page analyses of current social and economic issues. Research reports are published in the quarterly '*Studia BAS*.' BAS assists the *Sejm* and its committees by organizing seminars and conferences on a wide range of topics. Another role of the Bureau is to monitor the consequences of current and future trends in technology development.

In **Czechia**, TC CAS involvement in European TA projects has brought a significant change in the way society and policymakers perceive TA, participation, and public engagement, as these methods and principles are more and more visible in the basic STI/RDI policy strategies and programs. In line with this, TC CAS hosted the 1st European Technology Assessment Conference in Prague in 2013.

Since 2016 in **Slovakia**, SAV has been involved in the Science meets Parliaments initiative organized by the Joint Research Centre of the European Commission. Due to a fruitful cooperation with the Parliamentary Committee for Education, three panel discussions have been organized in the Parliament so far, on topics such as quality of education, institutionalization of TA, transnational labor mobility, and industry 4.0. As continuation of these activities, together with the Parliamentary Committee for Education, SAV organized the 4th European TA Conference titled 'Value-driven Technologies: Methods, Limits, and Prospects for Governing Innovations' in Bratislava in 2019. At this conference, the globalTA network was launched and its 1st annual meeting took place.

[16] https://cordis.europa.eu/project/id/605140.

[17] https://www.humanbrainproject.eu/en/.

[18] https://super-morri.eu/.

Central Europe: Specific Challenges and Outlook

Typical for these three Central European countries is that, even though there are several institutions which carry out foresight activities, create scenarios, evaluate risks, and assess impacts on the environment and society, etc., these activities are often not coordinated, and the individual institutions rarely cooperate with each other. The best circumstances are in Poland, where, besides the Bureau of Research of the Polish Parliament, TA is actively developed primarily in academic fields, and PTOT is an organization that tries to unify all these different initiatives. In Czechia and Slovakia, the problem lies in the fact that TA activities are mainly carried out within individual (and mostly international) projects, and there are limited provisions for their continuity. Even though TA is actively used as a concept and tool for knowledge-based policymaking in both countries, TA is still not institutionalized in one organization within the government (neither for the executive nor legislative branch) which could support TA both in organizational and financial aspects. This can be considered as a challenge in order to reach a common understanding of the use of TA for policymaking on a regular basis and not only as an ad hoc tool. This also means that the international network of partners is crucial, especially for these two countries. Initiatives and platforms such as the globalTA network provide a ground for TA in Central Europe, even though nationally its roots are not very deep in some countries. This global connection can be used as leverage in advocating for more TA activities in the region.

Chile

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Chile: Specific Context

Chile, located in eastern South America (19 million population; US$ 14,986 GDP per capita[19]), is a country under a presidential regime, where legislative power is vested in the National Congress.

Congress is a bicameral legislature, composed of the Chamber of Deputies and the Senate, and integrated by a common service to both chambers, the Library (*Biblioteca*

[19] World Bank Data. (2019). Population, total [Data file]. Retrieved from https://data.worldbank.org/indicator/SP.POP.TOTL and "GDP per capita (current US$)" [Data file]. Retrieved from https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=CL.

del Congreso Nacional de Chile, BCN).[20] Created in 1883, the Library's mission is 'to support the parliamentary community in the exercise of its functions, generating information, knowledge, and specialized advisory, as well as to promote ties between National Congress and the citizenry, by making available to everyone the bibliographic, documentary, legal, and political-legislative history of the country.'

In order to fulfill the Library's mission to provide specialized advisory functions, in 2007 the Parliamentary Technical Advisory Service (*Asesoría Técnica Parlamentaria*, ATP-BCN) was created. Currently, it is made up of forty researchers/advisors, specialized in different areas of knowledge, such as economics and law, but also psychology, architecture, communications, biology, political sciences, and engineering, among others.

ATP-BCN advisors assist legislative committees on a permanent basis, preferentially providing information on bills under debate during the legislative process, as well as on issues of interest to committees and members of the parliamentary community. Most of the reports elaborated by ATP-BCN are produced on demand, and a large part of them contain analyses of comparative law, descriptions of comparative public policies, and explanations of technical aspects subject to regulation and their relation to society.

Over the last six years, researchers/advisors within ATP-BCN have been studying advisory models that are closer to Technology Assessment (TA), to incorporate more technical and scientific information into its reports. And for the last two years, ATP-BCN has been progressively delivering documents in line with an evidence-informed advisory service. The COVID-19 pandemic accelerated efforts oriented toward the adoption of concrete and more efficient evidence-informed advisory methodologies, strengthening the use of this type of documents at the request of the Chilean parliamentary community.

As a result of this renewed interest for science in public debate, ATP-BCN has developed networks and working protocols with the scientific community, in support of a fluent and constant collaboration between expert sources and decision-makers. Particular attention has been paid to limit possible biases arising in this process, as well as to inherent difficulties in the contemporary relationship between science and politics. All of the above activities are taking place in the midst of the current drafting of a new Chilean constitution, and more than a decade of water droughts that have severely impacted the country's territory.

Chile: Highlights of TA Activities

Responding to inquiries from members of Congress is one of ATP-BCN's main activities, whether through comparative law documents or legislative/public policy reports from a sectoral point of view. Also, ATP-BCN researchers/advisors respond

[20] Biblioteca del Congreso Nacional de Chile. Available at https://www.bcn.cl/portal/.

to technical questions on a wide array of matters, such as connectivity, health, agriculture, fisheries, defense, labor market, family, education, and international relations. These responses are sent via documents, emails, presentations before committees, or even by phone. Notwithstanding the delivery support mechanism, any information provided by BCN-ATP must always comply with the same standards: quality, impartiality/neutrality, and opportunity.

To improve our internal processes, ATP-BCN has been working on several strategies to enhance certain skills, through: (1) internal workshops on evidence-informed legislation, (2) international networking with international parliamentary advisory organizations (EPTA Network, globalTA, and INGSA) as well as with local scholars, universities, and the national scientific community, (3) design and implementation of original documents with new and replicable advisory methodologies, and (4) strengthening assistance and support to specialized congressional committees on science and technology matters.

Current global challenges, like climate change, radical and accelerated advances in technology, and the need to comply with the UN Sustainable Development Goals (SDGs), have shown the urgency of incorporating new support channels for decision-makers through frontier evidence-based documents. These documents inform Congress members on related changes and potential effects for Chile, many of which, due to their novelty, are not yet widely regulated around the world.

As in other countries with parliamentary advisory experience, in Chile, as previously mentioned, ATP-BCN has worked under the concept of 'Technology Assessment,' by building instruments, practices, and networks that, as a whole, represent a concrete advance in how to integrate scientific knowledge into the deliberative process of new legislation.

Technical manuals and scientific articles recommending best practices, from institutions like the U.S. Government Accountability Office (U.S. GAO)[21] and others, have recently been published. However, there is still no agreement among scientific advisory organizations on which methodologies, products, and processes are most effective to achieve the goal of providing the best information to parliaments. Hence, at ATP-BCN we have decided to develop our own path regarding TA-related documents, complementary to its traditional advisory services.

In 2020, a new task force was created to promote TA methodologies and products among ATP-BCN researchers/advisors, called 'Scientific Legislative Advisory' (*Asesoría Científica Legislativa*, ACL). These are:

- **Frontier Reports**: Six-eight page reports based on scientific, technical, and legislative sources, developed to answer questions from Congress committees on new technologies, climate change and other social and legislative issues not yet regulated in the world, or where actual local norms are being challenged (v.gr.

[21] Available at https://www.gao.gov/.

'neurorights'[22]). This document is structured in four main parts: technical definitions, real world examples, concerns from the parliamentary community, and potential solutions provided by science and/or foreign public policy/legislation. Most importantly, these kinds of reports are not only subject to internal review, but also by well-renowned external experts in their field of research.

- **Expert consultation**: Based on the Delphi methodology, this report provides consolidated answers, from 10 to 15 experts, on a specific legislative issue. The experts' participation is anonymous, that is, only the ATP-BCN research/advisor in charge knows the identity of participants, and the responses are not associated to their names. However, the said experts can authorize the publication of their names at the end of the report, and an informed consent clause indicates how the information from their responses will be used. The questions are specific to the subject matter, and the selection of such experts must meet a gender parity criteria, diversity of viewpoints, and academic excellence or demonstrated experience in case of participants from outside the scientific community.

Also, effective networking with the members of the scientific community has proven crucial to the attainment of ATP-BCN's goals on the provision of evidence-informed advisory services. Recent collaboration agreements have been celebrated with the government's National Agency of Research and Development (*Agencia Nacional de Investigación y Desarrollo*, ANID), and with a Chilean universities consortium (Vincula). Plus, there have been informal but constant collaborations with other TA organizations from different countries (both extra- and intra-parliamentary offices), such as globalTA, the Parliamentary Office of Science and Technology (POST) at the UK Parliament, 'Ciencia al Parlamento' (a Spanish organization promoting the recently created scientific advisory office at the Congress of Deputies of Spain), and the Mexican chapter of the International Network for Government Science Advice (INGSA), and Universidad Austral of Argentina.

Likewise, engagement with the parliamentary community is a permanent objective within any legislative advisory service. ATP-BCN has a long and well-established working relationship with committees and congressional staff. This has allowed ATP-BCN researchers/advisors to follow and actively participate in the legislative process, while maintaining a technical standing as an intra-parliamentary office.

In this context, ATP-BCN is working closely with the 'Future, Sciences, Technology, Knowledge and Innovation Committee' at the Chamber of Deputies, providing support on requirements regarding scientific-based information on four specific issues: telemedicine, distance learning education, carbon neutrality, and democracy and social networks. For each of these issues, an ATP-BCN researcher/advisor and a deputy member of committee is in charge, supported by the ACL task force for methodologies, identification of specialists, and evidence check-up process.

[22] Roberts, Raimundo (2019). Neurotechnologies: Connecting Human Brains to Computers and Related Ethical Challenges. ATP-BCN. Retrieved from https://obtienearchivo.bcn.cl/obtienearchivo?id=repositorio/10221/28289/1/If01_Neurotechnologies_BCN_eng.pdf.

Chile: Specific Challenges and Outlook

We recognize that bringing expert knowledge into the legislative decision-making process requires professional and specifically designed advisory work. Bridging the gap between Congress members and experts, by conveying the latter's knowledge in a way that makes sense in terms of legislative requirements, is as relevant as detecting possible biases in this process.

With this objective in mind, it is key to develop an institutional culture of evidence-informed advisory, by strengthening the ACL task group activities within our service, mainly by introducing, training, and supporting the use of the described methodologies in the elaboration of evidence-based documents. It is, and will continue to be, a learning process, improved by internal feedback and formal and informal development of new skills.

All of the above examples have the sole aim of reinforcing the use of scientific evidence in decision-making at the Chilean National Congress. In the end, it is about making better legislation for a world in constant and accelerated change, where international collaboration is essential to find local solutions that bring expert knowledge closer to the public. Hence, the main challenge is the construction of a culture of evidence-informed policy decisions, where networks such as globalTA are a lighthouse; a node where national experiences converge. In the path of developing this culture of evidence-informed policy decisions, the institutionalization of the described mechanisms can help to democratize knowledge and, hopefully, improve citizens' quality of life.

China

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China: Specific Context

Governance in the field of science, technology, and innovation (STI) has long been regarded as a critical area of STI policy research in China. However, there are still few explicit technology assessment (TA) publications from China. RRI (Responsible Research and Innovation), a relevant research term for TA, has been a rapidly growing research domain in China. Chinese researchers have developed RRI as a research concept of governance in terms of China's development in science, technology, innovation, and society (Zhao & Liao, 2017).

Currently, more Chinese researchers are concentrating their efforts on the governance of STI. Chinese researchers are also trying to apply methodologies of governance that include TA, RRI, sustainability research (SR), etc. For instance, the research team from Chinese Academy of Science and Technology for Development (CASTED) participated in the *ERC Horizon 2020* research project *'Responsible Research & Innovation in practice'* to introduce RRI as a governance research concept to case studies in China.[23] The concepts of TA, RRI, and SR have been incorporated into governance research on topics such as research ethics, open science, artificial intelligence (AI), the digital economy, and sustainability (Mei et al., 2017).

China: Highlights of TA Activities

Research ethics is a critical component of RRI research in China. With the rapid development of science and technology in China, research ethics and integrity have become major issues for a variety of stakeholders, including scientists, the public, business, and government. Research concepts from RRI open up new avenues of inquiry for Chinese researchers and policymakers. To address the uncertainties inherent in the development of STI, public administration, university, and research institutes are employing RRI concepts such as open access, public engagement, and reflexivity. For instance, NSFC and CAS have already released open access policies.[24]

In China, the concept of open science has grown in popularity in recent years. Scientific research institutions, researchers, and government have participated in discussions about open science issues such as open access, open data, and open peer review (Huang et al., 2020). Additionally, Chinese researchers have a more favorable view of open data and open access. Numerous studies have demonstrated that combining open science concepts and RRI improves communication and trust among a diverse range of stakeholders, including the public, industry, universities, research institutions, and government. Open science practice and development will contribute to the improvement of China's scientific research environment and the further transparency of scientific research.

According to related research, RRI has been considered among the most significant motivating factors in advancing the use of AI in industry policymaking, privacy protection, education, and innovation. China's AI-relevant technologies and application scenarios have experienced a significant increase in innovation. Both policymakers and researchers note that AI technology presents potential risks for society (Guo & Liu, 2019). RRI and TA concepts have been applied to China's AI research and development (R&D) process (Li & Chen, 2020). The concept of responsible AI

[23] https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bd55b2b4&appId=PPGMS, access at: 2021/06/13.

[24] http://www.unesco.org/new/en/communication-and-information/portals-and-platforms/goap/access-by-region/asia-and-the-pacific/china/, access at:2021/07/12.

with a research ethics perspective has been employed in national level policy.[25] RRI offers a new ethics research perspective into China's AI development.

The digital economy is a significant domain of China's economy. Responsibility has been taken into consideration in both research policy and practice as an essential motivation for the digital economy. Although RRI is still a research concept, it offers the dynamic process of revealing the 'black box' of digital technologies by providing the perspective of reflexivity. Meanwhile, RRI contributes to the development of the digital economy by increasing transparency and protecting personal privacy. When it comes to the digital economy, an online platform is a conduit for social responsibility. To achieve responsible innovation for platform governance, it is critical to have open and transparent communication for multi-stakeholders. Meanwhile, an online platform provides a collaborative interface for a variety of stakeholders (Huang et al., 2019).

Sustainable development has also been introduced into China's practice of public policy, as well as industrial policy. China's *Fourteenth Five-Year Plan (2021–2025)* emphasizes the importance of sustainability. As stated in *China's Government Work Report (2021)*, the country's primary goal is to achieve carbon neutrality by 2060, with a target of reaching a CO2 emissions peak before 2030.[26] In China, SR has introduced a positive trend in interdisciplinary research. SR covers multiple disciplines such as environmental science, ecology, economics, management, sociology, and policy science.

China: Specific Challenges and Outlook

In order to keep up with China's rapid development of science and technology, TA as a research concept still needs to be developed. There are still fewer empirical studies of quantitative and qualitative analysis in China's current RRI research. The governance of emerging technologies has been considered as a grand societal challenge for China's development because of its potential impact on society. Collaboration and knowledge exchange between China and other countries are required for emerging research topics in the TA domain. Chinese researchers are trying to develop RRI research that is based on the comparison of best practices from different countries and areas. The globalTA network could be a knowledge exchange platform for Chinese research. However, for Chinese researchers, there are still fewer international peer-reviewed journals to present the best practice from China in the domain of RRI, TA, and SR. Grand societal challenges necessitate the development of a new governance research paradigm in order to achieve policy practices that are sufficient, efficient, and appropriate.

[25] http://fi.china-embassy.org/eng/kxjs/P020171025789108009001.pdf, access at: 2021/07/12.

[26] http://www.xinhuanet.com/english/2021-03/16/c_139814792.htm, access at:2021/06/13.

India

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India: Specific Context

The Technology Information, Forecasting and Assessment Council (TIFAC), under the Department of Science and Technology, is the primary TA organization in India. TIFAC has been doing important work like developing the 'Technology Vision 2035' or supporting mission mode programs and innovation-related programs with regard to intellectual property rights, micro-, small-, and medium enterprises, technology development, and commercialization. However, there are other organizations that are working on TA, broadly defined, and recently Health Technology Assessment (HTA) has gained prominence. TA practices in India are varied, but there is no central agency that co-ordinates TA activities. Many agencies claim that they are doing TA, although there is no clarity on methodologies.

As India embarks upon harnessing emerging technologies like quantum technologies, artificial intelligence (AI), and genome editing, there is an urgent need to pay attention to TA. The Technology Policy Statement of 1983 defined TA as mechanisms consisting of 'competent groups (which) will render advice in all cases of technology import relating to highly sophisticated technology, large investments and national security,' and this later resulted in the formation of TIFAC. However, as Pandey and Sharma (2020) have pointed out the visions relating to science, technology and innovation (STI) in India from official agencies have often been based on the deficit model of Public Understanding of Science (PUS). As a result, TA is limited to such an approach rather than becoming rooted through participatory TA or constructive TA. The only initiative that has resembled participatory TA was on Bt Brinjal (a genetically engineered variety of aubergine), which resulted in the government declaring a moratorium on Bt Brinjal.

Given the range of government ministries and departments that deal with STI in India, from space to industrial/applied research, atomic energy to agriculture, it would be obvious that there should be some sort of assessment of technology/innovation that is part of the planning process or policymaking mechanism, although it might not be called 'Technology Assessment'. But in reality, there is none that could be classified as 'Technology Assessment' as normally understood.

Given the fact that programs are evaluated and assessed, and outcomes are often compared with similar ones elsewhere, it is obvious that there are mechanisms to evaluate, assess, or study the impacts and examine the outcomes vis-à-vis the costs and the estimated benefits. However, these are in almost all cases mechanisms that are internal and function as part of the respective ministries/departments, while external evaluation by agencies like the Comptroller and Auditor General of India is limited to regulatory frameworks and administrative functioning (e.g., see CAG, 2016). On the other hand, academic institutions and universities do not have adequate competences in doing TA, nor are mandated to do that. While some civil society groups are active in STI policy, or on technologies related to some sectors like biotechnology or pharmaceuticals, TA is certainly not their 'cup of tea'.

India: Highlights of TA Activities

'Technology evaluation', 'impact assessment', and 'techno-economic study/assessment' are some of the terms that are used in various documents and mandates of various institutions/programs, but these do not constitute TA. For example, the Indian Council of Agricultural Research (ICAR) evaluates the outcomes of various programs and initiatives for varietal development, but this is not TA. Instead, the varieties are assessed on the basis of yield, cost and benefit, and economic gain to the farmer but, again, this is not a comprehensive assessment of either the technology or the varieties. The Department of Agricultural Research and Education (DARE), under which ICAR functions, differentiates between technology intervention, and technology assessment and refinement in its activities. According to the Annual Report of DARE for 2017/18, there were 3,446 technology interventions in 3,340 locations, with 26,029 trials conducted in the farmers' fields, while in the livestock sector, 580 technology interventions were made in 584 locations, and 6,160 trials on animals were conducted (DARE, 2019: 107–108). The report lists the criteria used to assess and refine. From this, it seems that thematic areas in assessment and refinement were focused on using one or two criteria to evaluate, rather than to assess as is done in typical TA exercises. The report also mentions participatory technology development and participatory plant breeding, but these are not significant in terms of numbers.

Health Technology Assessment (HTA) has received support from the Government of India and is emerging as an important component in decision-making on technologies and treatments in India. In 2017, the Government of India proposed setting up a Medical Technology Assessment Board (MTAB). Later, this idea was replaced with HTA in India (HTAIn). HTAIn comprises three organizations, HTAIn Secretariat, HTAIn Technical Appraisal Committee (TAC), and HTAIn Board. The HTAIn Secretariat collaborates with specific technical partners (TPs) and regional resource hubs (RRHs). The requests for HTA studies can emanate from health departments in central and state governments. The HTA study has to be comprehensive, including systematic literature reviews, economic evaluations, cost–benefit analyses, measuring and valuing the health outcomes, and analyses on equity and access issues. Finally, a policy brief and HTA outcome report is sent to the department that requested the assessment. What is noteworthy, is that this has provisions for stakeholder consultations in two stages; the TA studies are expected to go beyond economic assessment and cost–benefit analysis, and thus to be comprehensive. For example, the outcome report, 'Health Technology Assessment of intraocular lenses for treatment of age-related cataracts in India,' published by the HTAIn Secretariat in July 2018, addresses equity issues through literature survey, compares different technological options and makes recommendations (Department of Health Research, 2018).

India: Specific Challenges and Outlook

The main challenge for TA in India is the lack of an agency to co-ordinate, standardize methodologies on TA, and to do capacity building. In addition, there is a lack of awareness of the importance of TA. The draft STI Policy mentions TA in passing in one sentence, although TA is very important in the case of emerging technologies (Department of S&T 2020). There is no specific policy or strategy on TA, and while HTA is gaining importance it is more like a standalone exercise than part of a national TA framework or strategy. The globalTA network could contribute to sensitizing on TA, create awareness on the importance of TA and support capacity building in TA. It can help in introducing new concepts and practices in TA and in contextualizing them for India.

Russia

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Russia: Specific Context

The process of institutionalization of TA in Russia should be considered in the wider historical context of a post-socialist society. On the one hand, during Soviet industrialization, TA-like activities were undertaken ad hoc in large-scale projects, such as urbanization of undeveloped areas, which had to co-ordinate the planning of production, housing, transport, and recreation systems, trying to compensate the side-effects for the environment, public safety, and health. On the other hand, the social and environmental assessment of technologies has been for a long-time specialized industry-wise and is still to some extent encapsulated within the different agencies, yet lacks public participation and openness. Nowadays, the great disparities between the de-industrialized and the hi-tech centers, and the complex problems of environment, infrastructures, and mobilities require systems analysis and coordinated action on a new level.

Russia: Highlights of TA Activities

The most notable aspect of the current institutional context for TA activities in Russia is the crucial role played by the largest technical universities. Historically, they have closely interacted with industry through the system of targeted (employer-sponsored) education, cooperating with scientific institutions, and actively networking on the national and international levels. The structure of programs in higher technical education allows relatively high representation of social sciences and humanities. Recently, the technical universities have accumulated even larger resources as the dominant centers of technological clusters (technoparks). A few have acquired the status of 'National Research Universities,' providing state support for innovative projects, and a higher degree of autonomy in developing educational standards.

An example of taking advantage of this opportunity is the development of the first complete cycle of TA education (a bachelor and a master program) in Bauman Moscow State Technical University (BMSTU). In the last five years, the undergraduate program, 'Sociology of Technology and Engineering' (https://bmstu.ru/bachelor/majors/sociologia-390301), was accredited and received state funding. Despite the necessity to fit into the existing disciplinary category and the general standards of sociological education, the program pursues the wider interdisciplinary approach of TA and Science and Technology Studies (STS). The long-term collaboration between BMSTU and the Institute of Technology Assessment and Systems Analysis at the Karlsruhe Institute of Technology, Germany (KIT-ITAS) enabled the organization of an orientation workshop 'Technology—Society—Innovation in TA and STS research perspectives' in 2019. Currently, the pilot master program, 'Social Analysis of Technological Innovations and Risks,' is being implemented in BMSTU, with a perspective of further internationalization. The faculty aims to provide practice-oriented training, including internships in industry, opinion poll centers, municipal and state agencies, and media, to enrich the field of knowledge regarding sociotechnical processes.

In addition, the faculties of Social Sciences and Humanities have accumulated an extensive knowledge in engineering studies. In recent years, many research projects were focused on engineering cultures and visions, professionalization, career strategies and mobility of engineers, methodologies of technical education, etc. This material is gradually implemented in the new courses within the engineering curriculum, such as 'Sociology of Technology and Engineering,' 'STS for Engineers,' 'Engineering Ethics,' and others. The coursework and individual projects have to include at least basic acquaintance with the TA problematic in the particular field as a criteria for evaluation. In this case, the technical universities can enable 'intervention from within' in technical thinking, and more active exchange between the socio-humanitarian and engineering communities.

On the basis of the network of the largest technical universities of Moscow, Saint Petersburg, Tomsk, Perm, and the other regions, BMSTU has initiated the organization of the association 'TA and STS in Russia,' going beyond the educational community and bringing together academic research institutions, enterprises, and the governmental analytical centers. The participants of the first organizational event in 2019 noted that the TA-like activities under different names are dispersed in institutional and regional aspects, and that international cooperation with the European, Chinese, and other actors in TA is currently more pronounced than coordination on the national level. In general, TA is still not institutionalized in Russia and remains a largely foreign experience. It is necessary to elaborate an optimal, context-specific model of expert support for science and technology policies, and to promote the public discussion of sociotechnical problems.

Russia: Specific Challenges and Outlook

In our view, the major challenge for TA in Russia is the uneven development, which combines the problems of the developed and developing economies across the Russian regions. The rapid spread of high-tech innovations, such as e-medicine, platform businesses, and digitalized governmental services, is going on in parallel with a lack of access to the basic infrastructure, and the environmental effects of the extraction industries (oil, coal, iron, etc.). Potentially, this may stimulate TA to balance the predominant interest in the high technologies and disruptive innovations which is present both in public discourse and science and technology policy analysis, and to pay more attention to the low-cost technologies, grassroots, and frugal innovations, as well as maintenance and repair studies. The ethnic and cultural diversity of Russia raises the problems of public perception and attribution of meaning to technologies, requiring the comparative perspective and contextualization of technological solutions and risks. The lack of transparency of decision-making in the technical processes problematizes the distribution of knowledge and responsibility in society, and the ways technologies may aggravate, reproduce, or reduce the existing inequalities.

The globalTA network may have a large impact by demonstrating the precedents of successful institutionalization of TA worldwide, as well as the best practices of public engagement in technological solutions. It is already clear that international networking enables collaboration within the national expert community and helps to link the diverse agents (educational institutions, think tanks, enterprises, civil society organizations, etc.) that were institutionally demarcated.

South Africa

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South Africa: Specific Context and TA Activities

Technology assessment (TA) is in its infancy in Africa. It is not as common or practiced and institutionalized in Africa than in other parts of the world. So far, its conceptualization and application have been ad hoc and largely conducted by consultants as part of externally funded policy initiatives. TA has been often conceptualized around identification of unintended impacts, or as cost–benefit analysis of technologies and/or new infrastructure projects (e.g., roads, rail, and dams). Some aspects of TA have been embedded in environmental impact assessment (EIA) activities or programs that are now more institutionalized and legislated in many African countries. In EIAs, emphasis is often placed on environmental impacts of technologies or investment projects in general. Environmental protection agencies are the main institutional mechanisms for undertaking EIAs, and often there is less synergy or coordination between such processes and national STI policymaking processes.[27] The conduct and governance of EIAs tend to be increasingly participatory in most African countries because of the existence of legislation and citizen groups or activists for the protection of the environment. This is not the case for STI policy, where there are relatively small civil constituencies, budget deficits, and weak institutional (particularly) executive leadership.

TA has also been conceptualized as part of health technology and medicines regulatory or approval processes in some African countries. Domiciled in government ministries or departments of health, aspects of TA focus on assessing the side-effects or health risks of medicines, drugs, and other health technologies. Some of these efforts have been tagged or labeled 'health technology assessment'. However, this is misleading because such efforts or processes do not focus on societal effects but are narrowly aimed at health or medical aspects of technologies. Moreover, they are often not linked to or do not feed into national STI policymaking. This is mainly because health ministries or agencies and government agencies in general tend to work or operate in 'silos', with limited synergies to each. There is also a tendency to rigidly define STI policy as the exclusive mandate of ministries of STI. In addition, ministries or departments of STI tend to be less influential or powerful in the organizational structure of government, and thus are less resourced and capacitated

[27] Mugabe, J., 2019. Governance of Science, Technology and Innovation in Africa in Kameri-Mbote, P., et al. *Blazing the Trail*. University of Nairobi.

to mobilize other government agencies to engage in multi-sectoral ways in TA, which is multi-disciplinary and cross-sectoral.

Health TA has become a key part of public policy to respond to COVID-19 and related crises around the world. There is recognition that AI, digital innovations, and data science offer an array of opportunities to help effectively combat the pandemic and pre-empt and prevent future infectious disease epidemics in South Africa. They can enable health practitioners and policymakers to design and implement context-specific interventions to trace, test, and treat COVID-19 and other viral infections. AI, digital innovations, and data science are pervasive and converging in unprecedented ways, making it possible to search for and develop treatments, exploit available scientific information about the pandemic and related epidemics, assist enforcement of containment policies, and monitor the impact of the disease on patients as well as on socio-economic systems. A number of countries in Africa are harnessing the technological and scientific opportunities to confront and manage the COVID-19 pandemic and other infectious disease epidemics.[28]

Institutional actors in research on TA and TA-like activities in Africa are mainly public universities. They include the University of Pretoria, University of Cape Town, University of KwaZulu Natal, University of Witwatersrand, Stellenbosch University, University of Johannesburg and University of South Africa (UNISA) in South Africa, Cairo University in Egypt, and Mohammed V university of Rabat in Morocco, and research institutes such as the Council for Scientific and Industrial Research (CSIR) in South Africa.

South Africa has experimented with both expert-led top-down and multi-stakeholder participatory biotechnology assessment initiatives. In 2001, the then Department of Arts, Culture, Science and Technology (DACST) established an expert committee comprising of scientists from a variety of disciplines, including science and innovation policy, economics, and law, to provide an independent assessment of biotechnologies in agriculture, health, mining, and industrial applications of the biotechnologies, and propose to DACST and the country cabinet a national strategy for biotechnology. The committee had two international non-South Africa experts. It conducted risk and cost–benefit analysis and proposed a national strategy for modern biotechnology. Government adopted the National Biotechnology Strategy in 2001. The Department of Science and Innovation (DSI) reviewed the strategy and developed a National Bioeconomy Strategy in 2016.

Participatory TA has been tried through South Africa's Public Understanding of Biotechnology (PUB) program, launched in early 2003 by the South African Agency of Science and Technology Advancement (SAASTA), funded by the National Research Foundation. The overall aims of PUB (www.pub.ac.za) are to build public awareness and understanding of biotechnology, and to promote public dialogue and debate on socio-economic and environmental impacts of the technology. PUB has

[28] Mugabe, J. and Manyuchi, 2021. Unlocking systemic barriers to innovation to respond to COVID-19 in Africa. Working paper, University of Johannesburg, South Africa.

conducted several studies and surveys, including two assessments of public perceptions of biotechnology, its benefits, and risks.[29] In the early 2000s, PUB and the National Advisory Council on Innovation (NACI) organized public workshops and seminars at provincial and national levels to solicit public views on and inputs to biotechnology policies.

South Africa: Specific Challenges and Outlook

Overall, TA is in infancy, but there is high demand to institutionalize it, to be part of STI policy processes. As countries engage or focus on and address global and local challenges such COVID-19 and aim at attaining the SDGs, they need TA capacities in order to make appropriate technology choices. The countries are exposed to a large and growing body of scientific knowledge and related technological innovations through foreign direct investment (FDI), technology transfer, and a variety of other mechanisms. Again, TA capacity is needed for them to be able to wisely govern FDI and technology transfer for sustainable development. The study recommends that raising awareness, promoting sharing of information and experiences, mobilizing, and enhancing skills, establishing a pan-African network, strengthening institutional coordination and synergies, and improving policy and legislative frameworks are key as aspects of building TA capacity in Africa.

South Korea

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South Korea: Specific Context

In South Korea, technology assessment (TA) became mandatory due to the enactment of the Framework Act on Science and Technology in 2001 and has been performed from 2003. Since then, a total of 21 TA projects and studies were successfully completed on various topics, such as big data, 3D printing, genome editing, and social robots. The main goal of South Korea's TA is to find the right direction, which is to increase positive impacts of technological development, by evaluating newly developed S&T's impact on the economy, society, ethics, and the environment, and

[29] See for example DST, 2015, *Public Perceptions of Biotechnology in South Africa.* Department of Science and Technology, NRF, SAASTA and PUB www.pub.ac.za.

to use these results to advise related policy planning. One of the most important characteristics of South Korea's TA is that it is performed according to a legal basis. The other characteristic is that the government, represented in the Ministry of Science and ICT (MSIT), is responsible for the TA process. The role of MSIT in the TA process is to discuss the annual TA plan with the Korea Institute of S&T Evaluation and Planning (KISTEP), which then conducts the TA process and gathers opinions from related government ministries. The final TA results are reported to PACST (Presidential Advisory Council on Science & Technology). The report includes how government ministries reflected policy recommendations from the previous year's TA. This process of reporting to PACST enables the application of TA results in policy settings and budget planning.

South Korea: Highlights of TA Activities

In this system, a TA project for one technology is conducted every year. Technology candidates for TA are proposed by the Technology Selection Committee, which consists of experts from the humanities and social sciences, as well as S&T. These experts are from academia, industry, etc. The Ministry of Science and ICT then decides on the target technology by collecting opinions from other ministries on the proposed technologies. KISTEP then organizes the TA Committee and a Citizen Forum. TA is carried out by the TA Committee made up of experts and a Citizen Forum made up of general citizens. The TA Committee, composed of experts in the field of technology and social sciences, predicts the development of technology, analyzes ripple effects and issues on the economy, society, etc., and derives policy recommendations. The Citizen Forum discusses the impact of technology and makes recommendations through a citizen-participatory deliberation process. In addition, an online board is operated so that anyone can participate in TA (Fig. 1).

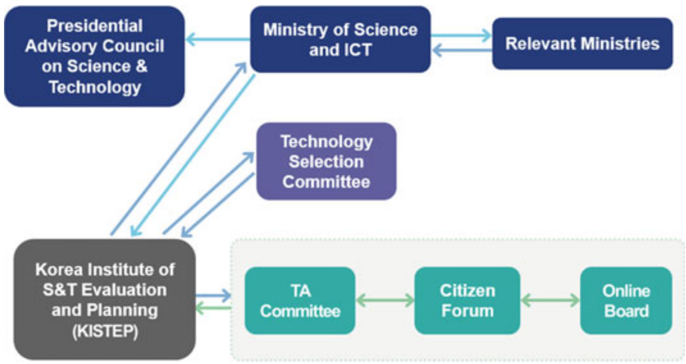

Fig. 1 TA implementation system in South Korea

An example was the TA on genome editing technology conducted in 2015. The results include the following issues: potential and safety for disease treatment, embryonic and reproductive cell application, and quality improvement and safety of agricultural and livestock products. When used to treat disease, genome editing technology can fundamentally treat genetic disorders, and also cure chronic disease like diabetes. From the TA results, it became clear that there are concerns about safety. For instance, worries about serious side-effects may occur if genetic scissors sever unintended DNA. There were mixed arguments for and against the application of genome editing technology to embryos and reproductive cells. The technology can treat genetic disorders but may lead to unexpected side-effects. Genome editing technology can improve the quality of agricultural and livestock products. However, it must verify whether gene-edited crops and meat are safe for humans, and also these products' impact on an ecosystem should be examined. The TA Committee came up with the following policy recommendations through sufficient discussions and joint meetings with the Citizen Forum. First, more in-depth research on the effectiveness of genome editing technology and verification on its impacts on the human body are needed. Second, a consensus is especially crucial concerning the application of genetic scissors to embryos and reproductive cells. In addition, it is necessary to review and enact relevant laws and regulations. Third, a new regulatory framework is needed to verify the safety of products created by genome editing technology. Fourth, risk communication needs to be strengthened, such as providing communication channels for various levels and transparent information disclosure. A discussion contest on genome editing technology was held for high school students in 2017, and a seminar was held in which stakeholders, citizens, and reporters related to this technology participated in 2019. It is understood that social discussions on this technology have become more active after the TA in 2015.

In general, before finalizing the TA results an open forum is held. In this open forum, which is conducted every year, not only the TA results but also South Korea's TA system is explained. Based on the results of the TA process, a booklet for the general public is also published. The booklet plays a role in raising interest in the TA system as well as the specific technology. In the case of genome editing technology, there was a discussion forum to review the results of TA five years later. In this forum, the TA results and policy recommendations were reviewed, and utilization of the technology and related regulations were discussed. It was discussed that the difference between genome editing technology and GMOs should be explained more to the public. The public should be more engaged in policymaking. And there was an opinion that the government should have been more active in policy-setting after the TA.

South Korea: Specific Challenges and Outlook

Based on the experience of TA in South Korea for the past 18 years, the direction of future development has begun to be considered. A possible development plan for TA is proposed in the following three aspects.

First, simplification of the TA process should be considered to evaluate multiple technologies each year. TA can be simplified by adjusting the scope of target technology or assessment, performing only expert committee evaluation, or operating only a Citizen Forum. As new technologies appear faster and the impacts of those technologies on society are getting bigger, it seems better to conduct TA for several technologies to achieve the role of TA.

The second is to raise the awareness of TA. Since TA has been carried out for nearly 20 years, the general public's awareness of TA has increased. As a result, the number of people who apply to participate in the Citizen Forum is increasing every year, although the number of applicants increases for more familiar technologies, such as artificial intelligence. However, various methods such as new media should be used to strengthen the publicity of the TA process and results.

Finally, it is necessary to consider ways to diversify the operational method of the Citizen Forum according to the characteristics of the target technology. The Citizen Forum is composed of about 15 citizens considering age, gender, and region. In the first meeting, citizens get to know the TA system and increase their awareness of the target technology. After that, through two rounds of discussion, recommendations are made by the citizens. In addition, mutual opinions are exchanged through a joint meeting with the Expert Committee. Regardless of the type of target technology, the Citizen Forum has always been operated according to this procedure. The result of the Citizens Forum ends with a citizen's report. However, it is also worth considering reducing the effort of citizens to write reports. Instead, it could be more useful for researchers to observe citizens' discussions and to write a report on the opinions of citizens.

Technological development does not only affect a specific region or country, but also the entire world. However, there may be differences in the degree to which a specific society, community, or individual feels the impact of a technology. Therefore, it is meaningful to promote a global TA for the same technology. A more desirable direction for technological development can be found by comparing policy recommendations among countries. In addition, the TA process of other countries will be a good reference when South Korea seeks a new TA process.

United States of America

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USA: Specific Context

The United States has now been without a centralized technology assessment organization for longer than it had one. The 1972 creation of the congressional Office of Technology Assessment (OTA) ushered in an era of legislative TA, during which it was sometimes said of the ill-defined intellectual field of technology assessment that TA was whatever OTA happened to be doing at the moment. While the memory of OTA's 1995 closure recedes into a past that is increasingly hazy and—in many ways—irrelevant in both political and technological ways to our contemporary and near-future world, the current TA landscape in the US is comparable to its pre-TA landscape: As Vary Coates, the grand dame of TA, found in her pre-OTA doctoral research, just because there is no national office for TA does not mean that TA does not exist (Sadowski & Guston, 2015).

TA has persisted in numerous guises over the more than two dozen years since OTA's closure. At the institutional level, a group of experts has maintained a TA capacity close to the centers of federal power in the Government Accountability Office (GAO; formerly the General Accounting Office). Less institutionalized has been an effort to reinvigorate a more participatory form of technology assessment, led by academics and others (and with which I have been closely associated) called ECAST—Expert and Citizen Assessment of Science and Technology. A third and still emerging effort, more akin to the social movement aspect of TA, is the effort by a group of philanthropists and universities in the US to create a new field of 'Public Interest Technology'—a field that sees TA as an important element of its potential contribution, and OTA as an ancestral practitioner.

USA: Highlights of TA Activities

Like the former OTA, GAO is one of a small set of professionalized offices serving primarily the US Congress. Led by the Comptroller General of the US, GAO has been regarded as more deeply expert than the Congressional Research Service and more generalized than the Congressional Budget Office, but nevertheless as expert in auditing and evaluation rather than scientific and technological issues (Bimber, 1996). Since the defunding of OTA, however, a small, focused, and well-regarded TA capacity has emerged at GAO, issuing a small number of reports per year across technological fields (recently including 5G, CRISPR, climate tech, and health). GAO consolidated this effort in 2019 into its Science, Technology Assessment, and Analytics (STAA) team that, as of November 2019, had 59 staff members with graduate degrees. GAO offers short and long formats for its studies and analysis, including its S&T outputs, which focus on more concise, more decision-focused information, and multi-media communication appropriate for the Web. Its S&T outputs represent perspectives of 'foresight,' 'oversight,' and 'insight,' with production times in each category ranging from days to two years (https://www.gao.gov/assets/gao-20-306t.pdf). In October 2020, the STAA team created the Polaris Council, a group of external expert advisors, and the Innovation Lab, to reflect the knowledge and skills of the fourth industrial revolution back onto GAO's central mission.

While GAO has maintained important connections to the broader S&T and TA communities in the US, it has remained mostly attached to the expert mode of practice that OTA also engaged in. Meanwhile, an informal group called ECAST (ecastnetwork.org) has taken up the mantle of participatory technology assessment (pTA). In 2008, the Center for Nanotechnology in Society at Arizona State University (CNS-ASU) conducted a multi-sited consensus conference after the Danish model on the topic of nanotechnology and human enhancement. Building on this experience, ECAST emerged as a partnership among ASU, the Boston Museum of Science, SciStarter (a citizen science group), the Loka Institute (a non-profit dedicated to democratic S&T), and the Woodrow Wilson International Center. With the practical knowledge generated by the CNS-ASU experience, ECAST began to work on other pTA opportunities, including the three World Wide Views programs coordinated by the Danish Board of Technology (DBT) and projects for US S&T agencies like NASA and the Department of the Interior, as well as privately funded pTAs on smart cars, geoengineering, and other topics. In partnership with Baylor College of Medicine and funded by the National Institutes of Health, the ASU team and its Museum of Science colleagues are joining the anticipatory governance approach pioneered at CNS-ASU with the more refined approaches to pTA developed by ECAST to examine public perspectives on human gene editing in the age of CRISPR. Especially with its global connections, this work has emerged as an important alternative to other public elicitation techniques such as deliberative polling.

Among the intellectual movements—like the TA movement—that began in the late 1960s was that of public interest law. Supported by the Ford Foundation, public interest law provided opportunities for law students to train and lawyers to practice in the public and non-profit sectors. Today, the Ford Foundation, New America, and others are attempting to create a new field of public interest technology (PIT). The impetus for PIT derived from many sources, but people who were tech savvy and politically active were increasingly asking whether tech—and particularly digital tech—was delivering social progress as well cool gadgets. Huge potential investments in digital infrastructures, e.g., smart cities, coupled with conflicts over regulation of digital platforms, e.g., the Facebook hearings, demonstrated a lack of tech expertise in government, while algorithmic bias and controversies over censorship and privacy punctuated the idea that private tech development was more about 'how can we innovate?' rather than 'how should we innovate?' Central to PIT is the

Public Interest Technology-University Network (PIT-UN; https://www.newamerica.org/pit-un/), now including more than 40-member institutions, and a small grants program that supports some projects that are oriented in TA-like directions. PIT is dominated by contemporary digital issues, but it embraces the full spectrum technologies in their relationship to creating public value. The PIT movement is also associated with explicit efforts to add technical expertise to government through its TechCongress program, which, like the Science and Technology Policy Fellows program of the AAAS, places technical experts in staff positions in the US Congress.

USA: Specific Challenges and Outlook

Since OTA was defunded in 1995, there have been numerous efforts to reinstitute it (Morgan & Peha, 2003), including in recent years with some surprisingly bipartisan support. Recreating OTA would, however, seemingly require some unique partisan alignment that has not appeared, nor does it appear imminent. While it is part of the genius of American democratic culture, identified as far back as Tocqueville, that organizations based in civil society rather than government can generate real contributions—and ECAST and the PIT movement are real such examples—there are substantial challenges to a system that generates such multi-centered expertise. Specifically, expertise in the current environment is often deeply attached to political interests, and social media both easily amplifies voices that purport to be expert while disguising their inexpertness or inauthenticity. This situation is not unique to the US, but it is perhaps accentuated there.

There are clear traces of global interactions benefiting US-based TA, specifically in the participatory register, as the Danish consensus conference model influenced early pTA in the US (Guston, 1999), and then ECAST, at length derived from that early US experience, collaborated with DBT on World Wide Views. With the PIT movement, the US has an opportunity to return the favor. While PIT is in many ways cognate with Responsible (Research and) Innovation (RI or RRI; see Stilgoe & Guston, 2017), it offers additional opportunities to work toward justice, equity, diversity, and inclusion than at least the European level of articulation of RI values has offered. As I write, the PIT-UN is also affirmatively deciding to expand associate membership to non-US institutions of higher education, potentially contributing to the further development of opportunities for global TA.

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