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Technology assessment in developing countries

A proposed methodology

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Abbreviations

AI	Artificial intelligence
AvH	Alexander von Humboldt Stiftung
BIBB	Bundesinstitut für Berufsbildung
BMZ	German Federal Ministry for Economic Cooperation and Development
CGIAR	Consultative Group for International Agricultural Research
CIM	Centrum für Internationale Migration und Entwicklung
DAAD	Deutscher Akademischer Austauschdienst
ESIA	Economic and social impact assessment
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMOs	Genetically modified organisms
IEEE	Institute of Electrical and Electronic Engineers
HST	Hypersonic spaceflight technology
LMOs	Living modified organisms
MoEF&CC	Ministry of Environment, Forestry and Climate Change
NGOs	Non-governmental organizations
NIS	National innovation system
TA	Technology assessment
TAB	Technology Assessment Bureau
SDG	Sustainable Development Goal
STI	Science, technology and innovation
PUB	Public understanding of biotechnology
UNCTAD	United Nations Conference on Trade and Development

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1. Introduction

Technology assessment (TA) is a well-established interdisciplinary methodology for assessing opportunities and risks of new technologies, mainly in developed countries. In many countries, its emergence was embedded in a somewhat sceptical or concerned attitude towards technologies, with possibly far-reaching impacts, such as the use of nuclear energy to generate electricity. However, new technologies also have huge potential to help reconcile economic, social and environmental development goals. Technological innovations can contribute to many of the United Nations Sustainable Development Goals (SDGs). One example is mini-grids fed by renewable energies; these can help provide quality electricity to the rural population in parts of Africa, contributing to SDG 7 (Affordable and clean energy) and also to SDG 13 (Climate action). Another example is precision agriculture, enabled by uncrewed aerial vehicles (drones) and artificial intelligence (AI), which can help stabilize yields of food crops in the context of climate change while reducing the environmental impacts of intensive farming. This contributes to SDG 2 (Zero hunger), SDG 6 (Clean water and sanitation) and SDG 15 (Life on land).

In many cases, innovation outcomes may have both positive and negative consequences. For example, AI in agriculture can enable the precise application of fertilizers and other chemical inputs. However, it can also lead to a loss of jobs due to advancements in agricultural robotics (as discussed in box 2). In some cases, the picture remains opaque regarding how exactly a technology will develop and the economic, social and environmental impacts its implementation may have in each country. One example is Cas,[1] a new technology for genome editing in agriculture and medicine with potentially positive effects on food security, but which raises a number of questions on risks and ethical issues (Stamm, 2021). One prominent and current case is "green hydrogen", which many see as a fundamental element of a global strategy for climate protection and socioeconomic development. However, it is unclear where and under what conditions green hydrogen will be produced and whether developing countries (often well-endowed with renewable energy sources) can benefit from it.

In all these cases, TA is a crucial tool that helps assess the pros and cons of a given technological development; informs policymakers; induces public dialogues and debates; and helps frame supportive policies and instruments. Developing countries need to know in advance about the features of new technologies and their possible impacts. However, in a globalized economy, the decision of whether a new technology should be employed widely is not purely in the hands of national actors. For instance, if a multinational company decides to automate harvesting activities in a host country, national regulation can usually do little to prevent this. However, by being informed as early as possible, governments and other actors can take appropriate measures to minimize risks and maximize benefits. In many cases, these accompanying measures will not have an immediate effect and may need years before they bear fruit. One example is the building up of human resources (e.g. vocational training, higher education) required to deal appropriately with a new technology.

It should be noted that TA, as described in this document, can be used to assess a selected technology very early in the innovation cycle when it is not yet fully adopted in a country. On the other hand, a standard impact assessment methodology is more suitable once a concrete implementation has already taken place in a given socio-environmental context. In either case, attention needs to be paid to mobilizing the local, indigenous and often tacit knowledge of the population groups that might benefit from a technology or suffer from its direct or indirect consequences (see section 7).

[1] Clustered regularly interspaced short palindromic repeats (CRISPR) associated protein (Cas).

This document summarizes the existing knowledge about TA processes and good practices and reflects on these in the context of the current conditions in African and other developing countries. The following observations are considered crucial to delimit the subject area:

- First, there is great diversity among developing countries' exposure to new technologies. This occurs mainly through acquiring technological goods and services (e.g. mobile phones, machinery and equipment, e-commerce), foreign direct investment, or integration in global value chains. In addition, international agreements – for instance, related to climate change mitigation and adaptation – also demand the implementation of new technologies (e.g. solar photovoltaics, wind turbines, and in the future, probably green hydrogen). This is true for most low- and lower-middle-income countries. In most cases, building up technological knowledge and capabilities is limited to a degree necessary for mastering the operation and maintenance of equipment and systems ("know-how") but does not help better understand the technologies and the science behind them ("know why"). In many upper-middle-income countries, the national innovation systems (NISs) host a relatively large number of scientific and technical experts who are able to assess the opportunities and risks that new technologies and innovations create. However, the NISs are not sufficiently advanced to offer such expertise in many developing countries.
- Second, in many high-income countries, deliberations about new technologies and (disruptive) innovations and their potential impacts on society are driven by the research and expert communities, other stakeholders (e.g. business organizations, trade unions, non-governmental organizations (NGOs)) and even the informed public (e.g. newspapers, journals, other media). In many developed countries, discussing the pros and cons of technologies is an essential part of the academic curricula at most vocational schools and universities. In most high-income countries, social conflicts relating to the assessment processes are possible. However, they are embedded in democratic traditions and participatory processes that allow all stakeholders to express their views and opinions without risk of repression or negative consequences. In parts of the developing world, this is not the case, whereby opposing the interests of dominant interest groups may be encountered with sanctions and even violence.

This paper proposes a step-by-step approach to TA. There is little experience with TA implementation in the context of sub-Saharan Africa and in developing countries in general. Therefore, the document is supported largely with analogies and experiences from other regions, especially Europe and North America. The approach will be tested, verified and possibly modified within the United Nations Conference on Trade and Development (UNCTAD)–United Nations Commission on Science and Technology for Development project. This TA project aims to assist countries in sub-Saharan Africa and other developing countries to achieve three objectives: (1) to focus on the issue of recent and emerging technologies that could be crucial for them; (2) to encourage discussion of economic, social and environmental impacts of the selected technologies; (3) to support the national public-sector efforts to access and master some priority technologies for the country. The paper is, therefore, to be understood as a living document. Researchers and practitioners in TA and closely related science, technology and innovation (STI) disciplines, especially from African and other developing countries, are welcome to contribute to future developments of the document by providing comments and documenting experiences. Even if there are overlaps between TA and some other concepts, TA should not be equated with "other methodological approaches or tools of technology management such as technology forecasting, technology foresight, technology needs assessment, and technology roadmaps" (UNCTAD, 2021 p.6ff):

- TA can be seen as "a form of policy research that examines short- and long-term consequences (e.g. societal, economic, ethical, legal) of the application of technology" (Banta, 2009 p.7).

Impacts of TA are expected to be threefold (Hahn and Ladikas, 2019 p.6): raising knowledge, forming opinion among policymakers, and initializing actions by them.

- **Technology forecasting** is often used to predict the future characteristics of useful technological machines, procedures or techniques. Thus, it applies to all purposeful and systematic attempts to anticipate and understand technological change's potential direction, rate, characteristics, and effects, especially invention, innovation, adoption and use (Firat et al., 2008). However, its aim is mainly to inform decision makers at the level of companies and other organizations, thus not concentrating on the broader societal effects of technological advancements and innovation. It is based mainly on quantitative techniques for prediction of the future.
- **Technology foresight** combines creative thinking, expert views and alternative scenarios to contribute to strategic planning. It represents a systematic exercise looking into the longer-term future of STI to make better-informed policy decisions (Pietrobelli and Puppato, 2016). Foresight is broader in focus than TA and applies foresight tools to STI policy (including research, technology and innovation) or other policy areas. Foresight is a long-term strategic planning tool that aims to inform and steer policy in directions that help move towards desirable future outcomes rather than purely an assessment tool.
- **Technology needs assessment** methodology has been developed since 2001 to identify, evaluate and prioritize technological means for achieving sustainable development in developing countries, increasing resilience to climate change, and avoiding dangerous anthropogenic climate change. Technology needs assessments are a set of country-driven activities that identify the technology priorities of partner countries and work towards producing a pipeline of investment projects (Haselip et al., 2019).
- **Technology roadmaps** combine foresight, horizon-scanning techniques and long-term strategic planning to develop future product development plans that include specific technological solutions. They traditionally represent a structured business planning approach to STI developments, originally used by industry and geared towards developing specific products (Phaal et al., 2004). Roadmaps have been adopted for use more widely, including by governments. The term "roadmap", rather than "technology roadmap", is also used and incorporates a broader focus that can include STI policy in a general sense. In addition, roadmaps can cover other areas, such as health, energy, agriculture, or the environment. Roadmaps generally set out an implementation plan to reach specified future objectives that have been selected for a product, for STI policy[2] or a specific sector or industry.
- **Responsible research and innovation** is an approach that anticipates and assesses potential implications and societal expectations concerning research and innovation, intending to foster inclusive and sustainable research and innovation design. In practice, the responsible research and innovation approach is implemented as a package that includes multi-actor and public engagement in research and innovation, enabling easier access to scientific results, the take-up of the gender perspective and ethics in the research and innovation content and process, and formal and informal science education (European Union, 2014). The approach builds its methodology toolbox from participatory TA as its societal aims overlap with those of TA, while it is not geared towards technology policy options development.

Common ground among these various concepts is that all exercises try to anticipate the speed and direction of technological change and the likelihood that specific technology paths will occur to inform the target groups and assist informed decision-making. Furthermore, all concepts stress the need to do such forward-looking exercises involving policymakers (representing line ministries) and scientific and

[2] For example, the United Nations has an initiative to introduce the practice of preparing STI roadmaps as an STI policy tool to promote countries reaching the SDGs through the use of STI policy. See https://sdgs.un.org/partnerships.

technical experts, as well as other stakeholders and the informed public, to ensure the best possible knowledge management and contribute to the acceptance of technology choices. The main difference between the concepts is the target groups and aims of the various exercises, spanning across the management of businesses, industrial policymakers, international climate cooperation and the general public. TA has a long tradition as an STI policy tool with a particular technology focus, an interdisciplinary approach, a broad societal representation and the development of short- to medium-range policy options unique among the relevant disciplines (Hahn and Ladikas, 2019 p.3).

As conceptualized in this paper, TA is expected to help policymakers make better-informed decisions in areas relevant to the application of a particular technology and the framework conditions under which they are implemented and further developed. This includes the active implementation of a technology by national actors and – in a globalized world – the governance of technologies brought into the country by external actors such as transnational corporations. Technological development, in many cases, is not neutral. It affects various social groups differently and can lead to winners and losers. The TA process must consider this and ensure that the interests of vulnerable groups are fully addressed. This is more the case in polarized societies where the economically disadvantaged often have fewer resources to articulate their interests. Technologies must be evaluated against the normative background of the common good. The gender dimension has to be mainstreamed in the TA process.

2. Participatory and multi-stakeholder processes in a developing country: Important considerations

This section examines several critical factors to consider when planning a TA exercise. It further suggests three essential objectives to guide the selection of stakeholders and actors to be involved in the TA exercise.

The existing evidence from TA processes indicates that it is critical to involve disciplinary experts from a specific technology field and stakeholders representing other societal groups. A participatory approach is essential to bundle dispersed knowledge, develop socially sustainable solutions, and strengthen the democratic process. However, governing a complex multi-stakeholder consultation process is a significant challenge, particularly in societies that do not yet have fully developed democratic structures or have little experience with participatory processes (Monteiro et al., 2020). Three objectives should guide the selection of stakeholders to be involved, the roles they will play in the process and the rules applied for the TA project:

- It is expected that a TA process will uncover differing assessments of the technology under review regarding the opportunities and risks its application might create. Therefore, it must be ensured that no inappropriate considerations shape the TA process. This risk may arise from various angles, e.g. political lobbying whereby stakeholders who claim to represent the common good or benefit may influence the discussion to back or oppose the government; or business interests that might feel that a specific emerging technology threatens their investments.
- The process should not be obstructed or excessively delayed by existing conflict lines between different societal groups, potentially overshadowing the discussions. Depending on the situation in each country, these conflict lines may be related to political parties and fractions, ethnicity or religious groups. The task here is to find a reasonable balance between inclusiveness of the process and possible extraneous conflicts, which may lead to a stalemate situation not directly related to the TA exercise. Therefore, it is vital to have clear and transparent criteria for selecting the actors involved and creating clear rules governing the process.
- All stakeholders should feel free to express their well-founded opinions on the issues at stake, even if this implies arguing against a government policy or a significant project. Any form of sanctioning should be excluded. One possibility to achieve this might be to hold the sessions of the TA process under the "Chatham House" rule[3] so that it would be difficult to trace the expressed arguments back to a specific individual. Minutes of the meetings and the TA report would be drafted accordingly. In countries where certain expressions of opinion may endanger the lives or livelihoods of individuals, additional methods may need to be found to bring their views into the process without disclosing the sources.

Even if relatively few participatory processes assess new and emerging technologies in developing countries, some cases can illustrate how this has been done in the past or is done today (see boxes 1, 3, 4 and 6 and figure).

[3] See https://www.chathamhouse.org/about-us/chatham-house-rule.

Box 1. Nationwide technology consultation in South Africa – the Public Understanding of Biotechnology programme

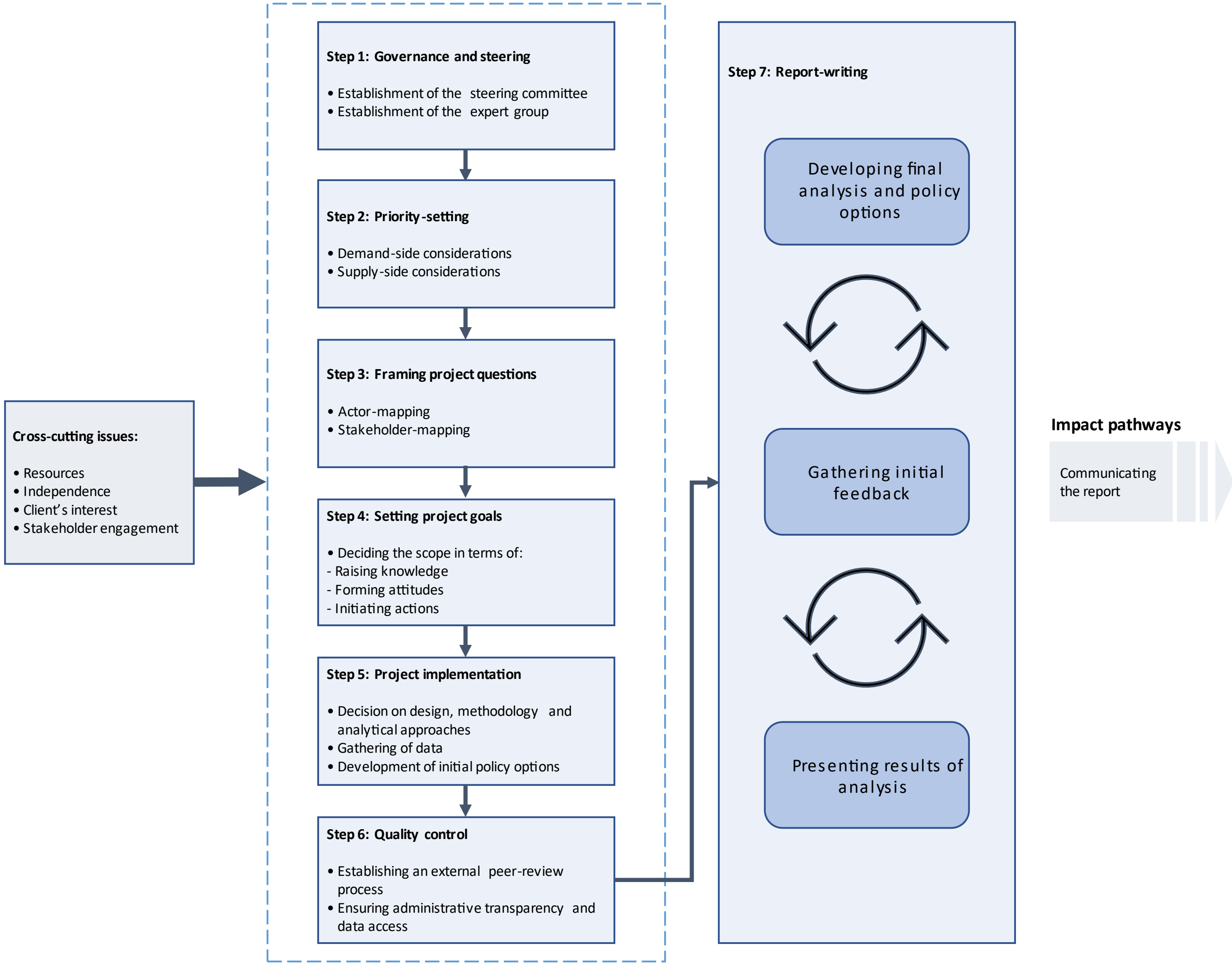
The Public Understanding of Biotechnology (PUB) programme was launched in 2003 by the Department of Science and Technology with two complementing objectives. The first objective was to increase public awareness and understanding of the scientific principles and potential of biotechnology. The second was to instigate public debates on biotechnology and its applications to enable informed decision-making.

The programme consists of a series of public perception surveys on controversial biotechnology applications (such as genetically modified foods and crops) and public engagement activities including all facets of society, emphasizing consumers, educators and learners. In this manner, PUB creates a single multi-stakeholder national vision of biotechnology and develops expertise in science communication. In addition, PUB falls under the Ministry of Higher Education, Science and Technology's "Science Engagement Strategy" that attempts to promote a knowledge-intensive economy by involving the broader public in STI debates and decision-making.

Both the PUB and the overall governmental programme build upon the participatory tradition of TA and environmental decision-making by employing methodologies such as consensus conferences and scenario workshops.

Source: https://www.pub.ac.za.

Figure: Summary of key steps of TA project design



Source: UNCTAD.

3. TA step 1: Governance and steering process

This section discusses the importance of putting in place a sound and inclusive governance structure to plan and implement a good TA exercise. The proposed structure is to be built around two entities: a steering committee and an expert group.

In developing countries, TA processes are complex knowledge-based endeavours that have to be carried out in a limited time and most often with limited resources. Under these restrictions and at the beginning of any TA process, it is recommended to set up a steering committee that will oversee the project implementation. The steering committee should consist of representatives of the project's sponsor (e.g. relevant line ministry or prime minister's office) and independent external TA experts. The steering committee will deal with administrative issues and ensure a smooth and timely process. Adequate representation of women on the steering committee is indispensable.[4] In addition, depending on the technology to be assessed, it could be recommended that specific societal groups (e.g. youth or specific ethnic groups) have a voice on the steering committee. This follows the normative concepts of equity and a favourable shared orientation.

The steering committee will decide the constitution of an independent expert group, which will be responsible for implementing the TA process and developing a TA report by providing timely and high-quality information. The expert group should be an interdisciplinary team of experts who will prepare and accompany the analytical process from the beginning to the end. Even regarding a rather technical process, it is crucial to assure, as far as possible, a variety of perspectives and avoid a narrow approach to evidence-seeking. This is especially the case when a technology is in a rather infant stage and fluid, raising uncertainty about possible risks, rewards and benefits or adverse side effects, including indirect consequences and externalities. This is why the expert group must be independent and interdisciplinary. Furthermore, in the expert group women should be adequately represented.

Identifying experts for the expert group is not a minor issue in many developing countries. Therefore, it is recommended to involve actors from the following (indicative and non-exhaustive) list:

- University and non-university researchers and experts in disciplines directly relevant to the respective technology (including social sciences). These categories of actors may be able to assess technological impacts in general and on specific social groups. In many cases, it can be recommended to involve retired researchers and experts as they carry explicit and implicit knowledge gained over their professional life. In addition, as they are not burdened with research and teaching duties, they might find it easier to invest time in a TA exercise than experts still involved in day-to-day work;
- Members of the knowledge diaspora, e.g. nationals who live abroad for postgraduate or doctoral studies or who work as researchers in relevant disciplines. They may have relatively easy access to world-class knowledge related to the respective technology and its possible impact;
- Private-sector experts (active and retired, see above) with experience in relevant technologies and sectors, as long as there is no conflict of interest;
- Representatives of trade unions and NGOs, or think tanks related to them;
- Non-national international researchers with long-standing relations and cooperation with the home country and, thus, an excellent knowledge about the specific local conditions;

[4] A specialist trained in the assessment of gender impact (e.g. gender studies) and/or other socially disadvantaged groups, resulting from technological change, should be considered for the steering committee. This person would then have the mandate to oversee the implementation of this dimension in the TA project.

- Experts from international agencies, for example, the CGIAR (initially the Consultative Group for International Agricultural Research) centres for agricultural research, or the International Energy Agency and International Renewable Energy Agency in the energy field;
- Experts from other countries facing similar challenges who have gained experience in the relevant technologies.

> **Memo item 1**
> As a first step, two entities are created. The steering committee will oversee the process and hold discussions. The expert group will implement the TA process by providing timely and high-quality information and knowledge. Both bodies together assure effective and efficient governance of the TA process. The expert group should represent various scientific and technical disciplines and involve, whenever possible, non-national experts or the diaspora, which may have easier access to world-class knowledge. An adequate representation of women in both bodies is imperative. Furthermore, other groups that could possibly be affected should be encouraged to participate in this exercise.

The steering committee will act as a project management team, while the expert group will be responsible for implementation of the TA process (i.e. analysis and production of the final report). The two groups will work in close cooperation for a considerable time. Differences in opinions are to be expected within as well as between the groups. Regular (e.g. monthly) meetings are usually envisaged to ensure adequate opportunities for information exchange and consensus-building. In case of significant conflicts, the services of an independent mediator might be required, and additional meetings might be necessary. It should be noted that the expert group functions as an external implementation body with guaranteed independence but is still under contractual obligation to perform a detailed plan of action. An expert group member would need to be replaced if there is a breach of contract, inability to perform or unwillingness to follow the project design.

Ideally, the project requires a full-time project manager with expertise in the general field of inquiry, and a project assistant to deal with administrative issues. The project manager will be responsible for the smooth running of the steering committee and the expert group. The project manager will liaise regularly with participants in both groups regarding the project's research content and compile their inputs into the final report with support from the expert group. The project assistant will be responsible for planning meetings, workshops and participatory exercises; keeping protocols and organizing logistics and payments.

Expected outcomes

What can be achieved in TA step 1?

First, a **steering committee** will be formed to lead the overall TA exercise and take care of the general project management to ensure a smooth and timely TA process.

An external and independent **expert group** will then be chosen by the steering committee to implement the TA project.

The two groups are expected to be supported by a project manager and a project assistant.

4. TA step 2: Priority-setting

This section explores how to select a limited number of technology areas to be put on the TA agenda. It further discusses how agenda and priority-setting can be based on demand-side considerations.

The standard TA process ties up considerable human and financial resources. Therefore, a critical step is to determine which specific technologies are sufficiently relevant for the country and its sustainable development to be put on the agenda and prioritized. The exact definition of what shall be the object of the TA process is essential. Disruptive innovations often lead to a host of follow-on innovations, as shown with the example of AI in agriculture (see box 2). Where experiences with TA are scarce, it is suggested to focus on specific technological developments and ensure that lessons learned are obtained for analysing related technologies later. Ideally, for in-depth analysis, the focus of the study should be on a single technological development with considerable applications in a crucial economic field (e.g. genome editing in agriculture). Alternatively, two or three relevant technological developments can be analysed and compared in terms of their effect in the field (e.g. green biotechnology applications in agriculture). In order to allow for in-depth scrutiny and the development of realistic policy options, it is not recommended to attempt an analysis of several technologies in a single study as it would be more complex.

The steering committee will play a central role in priority-setting. However, activities during this step should also involve other stakeholders, including firms and entrepreneurs. The caveats discussed in section 1 regarding participatory and multi-stakeholder processes apply. The agenda and priority-setting can be based on demand-side considerations or driven by the technology supply side, or a combination of both.

Demand-side considerations start with an analysis of social, economic or environmental challenges to which technological solutions should respond either as a stand-alone solution or, more frequently, as an element of a comprehensive package of policy measures. In many countries these challenges have been analysed and written down in national development plans or specific sector plans, e.g. energy, rural development, food security or poverty reduction. In addition, many countries have signed international commitments that call for technological innovations to be rolled out. The nationally determined contributions that countries have submitted under the umbrella of the Paris Agreement to reduce national emissions and adapt to the impacts of climate change are particularly important in this context. Related to these contributions, many countries (more than 60) have conducted technology needs assessments, often supported by international organizations such as the Global Environment Facility or the United Nations Environment Programme. In these cases, lists of relevant technologies may have been put on the agenda, often in the fields of energy generation and usage (climate change mitigation) and agriculture (climate change adaptation).

Memo item 2

Technology assessment ties up considerable human and financial resources. Thus, decisions are taken by the steering committee on which technologies will be in the focus of the TA process and whether to concentrate on new technologies in a specific application or on those disruptive innovations that will trigger a broad spectrum of new technologies. These decisions should examine the demand-side considerations: which technologies might be functional for solving economic, social or environmental development challenges in the country? Otherwise, they could also be based on supply-side considerations: which technologies/innovations are emerging in other parts of the world that may affect, positively or negatively, the efforts of the respective country to achieve the SDGs?

Supply-side considerations stem from innovations that happen anywhere on the planet and either offer radically new opportunities or pose significant new threats to the home country's sustainable economic and social development. Disruptive innovations such as new technologies can dramatically change markets and threaten the survival of incumbents that may have dominated a sector for many years. In developing countries, disruptive technological innovations may provide completely new opportunities to satisfy given societal needs. This happens either because solutions become technically feasible or because radical cost reductions make their application possible. A combination of these factors explains fundamental opportunities for change. The issue is discussed with digital agriculture as an example in box 2.

Box 2. Disruptive agricultural technologies – opportunities and risks in developing countries

Artificial intelligence is undoubtedly one of the most important innovations of this time. A series of possible applications exist in agriculture. For example, sensor-equipped uncrewed aerial vehicles (drones) became a feasible option only after both core elements (the carrier and the sensors) became technically mature, and their prices radically declined. Combined with AI for the real-time and detailed assessment of the nutrient demand of agricultural land, this raises vast opportunities for precision farming (UNCTAD, 2017), allowing a significant reduction of external inputs (e.g. synthetic fertilizer) to the benefit of farmers and the environment. AI in agriculture may also provide threats for the producing countries and their labour forces. While harvesting machines have, to date, mainly played a role in the production of agriculture commodities, AI-driven robotics may result in automated harvesting of high-value and sensitive goods, as the robot sensor systems learn to choose the best picking time. Shamshiri et al. (2018), for instance, describe the first fully automated harvesting platform for sweet pepper. As the harvesting of agricultural products plays an essential role in the livelihood of many low- to semi-skilled workers in developing countries, AI constitutes a possible threat if implemented on a wide scale for harvesting.

The examples show how important it can be for policymakers and implementers in developing countries to be informed as early as possible about advancements in digital agriculture and AI, innovations primarily driven by developed countries. Early knowledge of such trends could allow governments to take measures to maximize benefits and minimize risks. For instance, smallholders may be put in conditions to apply precision farming if collective ownership of sensor-equipped drones is made possible and data management regulated. In addition, diversification of agricultural cash crops may reduce the risks of losing jobs due to the advancement of agricultural robots.

There is no strict rule as to how many technological developments could be the focus of the project. However, depending on the national context and its needs it is recommended that the exercise should focus on a single or a small number of technological developments. Early-stage innovations have many possible technology applications in a specific field of economic activity. Therefore, they can offer a broader inquiry spectrum in the analytic approach (e.g. AI applications in agriculture, genomic applications in health care, assistive technologies in the aging population). At the same time, specific developments might need particular attention in terms of their widespread effect on society and the environment (e.g. value stream kinematics, genome editing, synthetic fuel production, organic lithium-ion batteries). In a developing-country setting with certain limitations in advanced technologies expertise, one can assume that a broader spectrum would be a more appropriate focus of the project. In any case, the stage of technology development should be early enough to create a detailed planned introduction and adoption of a roadmap in the specific national context.

Expected outcomes

What can be achieved in TA step 2?

It is possible to start by analysing **social, economic or environmental challenges** to which technological solutions should respond either as a stand-alone solution or, more frequently, as an element of a comprehensive package of policy measures. These challenges can be identified by reviewing national development plans or other key policy documents for specific sectors. This could be supplemented with **a review of relevant innovations** that happen anywhere on the planet and either offer radically new opportunities or pose significant new threats to the home country's sustainable economic and social development. At the end of this step, it is important to identify **a shortlist of technologies or technological developments for assessment**.

5. TA step 3: Framing project questions

Step 3 is about analysing the societal, political and scientific domains related to the selected list of technologies in order to define an exact problem to be targeted by the TA exercise and to identify a suitable project design. The section also discusses how the mapping of relevant actors and stakeholders as well as an analysis of the NIS can help achieve this objective.

After deciding which technologies are to be put on the agenda for the TA study, the next step is to assess the context in which the issue at stake develops. This refers specifically to the societal, political and scientific domains of analysis. During this step, any relevant background knowledge is gathered and analysed to identify an exact problem to be studied and to choose the most effective project design for this purpose. Again, the expert group leads this step with the support of the project manager and guidance from the steering committee.

Step 3 should start with mapping of:

(a) Actors directly involved in developing, regulating, and governing a specific technology: ministries and State agencies, universities and research centres, and international cooperation agencies;

(b) Stakeholders affected by the implementation of a new technology or lobbies for everyday goods, e.g. business groups (producers, processors, traders, exporters), trade unions, farmers' organizations (in the case of agricultural technologies) and civic organizations. Also, consumer protection organizations might be relevant in specific technology fields.

Empirical evidence shows that both actors and stakeholders carry explicit or implicit knowledge about the issues at stake, which should be mobilized in the TA process. They also stimulate the public debate about the technology, which should be seen as one desirable impact of a TA process (see table 1).

A second sub-step of step 3 analyses the discourses and debates around the focus technologies within the society. It is essential to understand at an early stage which main arguments and which conflicts of interests and opinions have been formulated and whether consensus or agreements are possible and in which topics. Concerning innovations that are new to the country,[5] there might be little empirical evidence to draw on. In this case it might make sense to draw on analogies – e.g. previous discourses and debates about innovations in a specific sector, such as agriculture or energy – in other countries with similar characteristics. For instance, one can analyse discussions carried out in other developing countries that have been previously exposed to the technology and draw concrete conclusions. In both cases, the primary purpose is to understand the various interests that might be affected and the potential arguments driven by economic, ethical or normative considerations.

Memo item 3

Once the priorities have been defined, the national context in which the technology will develop will be assessed. Actor and stakeholder mapping will lead to in-depth knowledge about the individuals and organizations that will have to be involved in the subsequent phases of the project. Knowledge is gathered, allowing informed decisions to be made about the project design and irrelevant analyses or the employment of ineffective methods to be avoided. The role of the NIS will also be analysed.

In countries with little experience settling conflicts in democratic or at least non-violent ways, it should be considered whether conflicts about technology-related processes have led to violent outcomes in the past. If such a possibility exists, the design of the process has to be adapted to avoid an escalation that often harms the disadvantaged groups in society, for instance by limiting the participatory events of the process while ensuring broader group representation in the expert group.

The role of the NIS will also be analysed. For example:

- How efficient is the NIS at informing policymakers and informing the societal debate around new or advanced technologies?
- Does the NIS have access to international state-of-the-art knowledge and research in the specific field, e.g. via formal research partnerships, informal networks or exchange of researchers?
- Are there linkages between knowledge-generating and knowledge-applying elements of the NIS, e.g. between the university and non-university research on the one hand and private or public companies demanding knowledge inputs, e.g. specialized hospitals and utilities, on the other?

Expected outcomes

What can be achieved in TA step 3?

The outcomes of step 3 are twofold. First, actor and stakeholder mapping will lead to in-depth knowledge about the individuals and organizations to be involved in the subsequent steps of the project. Second, knowledge is gathered, which allows informed decisions to be made about the project design and irrelevant analyses or the employment of ineffective methods to be avoided. For instance, a highly technical STI development at an early stage might not benefit from focusing on a more comprehensive participatory process that would generally necessitate extensive (and expensive) public involvement. The opposite could be valid for a highly politicized and debated issue that has already resulted in broad arguments encompassing societal norms and behaviours.

[5] Innovation research distinguishes new-to-the-firm, new-to-the-country/market and new-to-the world innovations (Organization for Economic Cooperation and Development and Eurostat, 2018). New technologies that reach a developing country might have been applied in developed countries and are thus not new to the world but new to the country.

6. TA step 4: Setting project goals

Step 4 is about clarifying which primary and secondary goals need to be pursued during the TA exercise.

Technology assessment had its origins in the 1970s as a research field with the primary purpose of assessing new and emerging technologies and identifying risks associated with them. Advising policymaking and legislation was the predominant purpose of TA in its early stages. In most countries, TA offices were (and still are) institutionally located in the parliaments. However, TA has considerably evolved in terms of goals, disciplines involved, procedures, and methods during the past five decades. TA has developed as a discipline from one that originally followed one primary objective (policy advice) based on analytical methods from the natural and social sciences and engineering, to one that now encompasses a broader field pursuing multiple goals and applying a diverse set of methods, including communication and dialogue techniques. As a result, TA functions today as a service providing policy options to govern technological development paths and instigating public debates based on the analysis of values and the inclusion of a wide array of stakeholder input. Thus, the core of much of modern TA concerns the development of interactive processes that bring together STI, society and policy. Table 1 provides an overview of the various goals that may be pursued in a TA project.

Table 1. List of TA goals in terms of activity spheres

Impact dimension issues	*Three goal dimensions*		
	Goal 1 *Raising knowledge*	*Goal 2* *Forming attitudes or opinions*	*Goal 3* *Initializing actions*
Technological and scientific aspects	Science and technology assessment *Expected outcomes and impacts:* • Technical options assessed and made visible • A comprehensive overview of consequences given	Priority setting *Expected outcomes and impacts:* • The public debate related to the new technology has been initialized/intensified • Priorities have been set • Visions and scenarios on possible impacts and accompanying policy measures are introduced	Reframing of debate *Expected outcomes and impacts:* • New action plans or initiatives to further scrutinize the problem at stake • New orientation in policies established
Societal aspects	Social mapping *Expected outcomes and impacts:* • Structure of conflicts made transparently	Mediation *Expected outcomes and impacts:* • Self-reflection among actors has been initialized • Bridges between stakeholders with divergent interests and opinions are established (wherever possible) • Discussion blockades removed (wherever possible)	New decision-making processes *Expected outcomes and impacts:* • New ways of governance introduced • Initiative to intensify and broaden the public debate taken
Policy aspects	Policy analysis *Expected outcomes and impacts:* • Policy objectives explored • Existing policies assessed	Restructuring policy debate *Expected outcomes and impacts:* • Comprehensiveness in policies increased • Policies evaluated through debate • Democratic legitimization perceived	Decision taken *Expected outcomes and impacts:* • Policy alternatives filtered • Accompanying measures taken to maximize benefits and minimize risks of a new technology (see example in box 2) • New legislation and/or regulation is passed, modifications in national and sector plans achieved

Source: Authors' elaboration based on Hennen et al. (2004).

Three different goal dimensions and expected impacts can be distinguished (see Table 1):[6] impact in raising knowledge; impact in forming opinions and attitudes of actors involved in policymaking and the debate; impact in initializing actions taken by policymakers or other actors. Various goals and impacts are prioritized under step 4. For example, in developing countries with relatively little experience in societal deliberations on technology and innovation there might be little scope for activities listed in goal 2 (forming attitudes or opinions) in Table 1. However, as some innovations (e.g. in the field of digitalization) can have a profound and lasting impact on economic and social structures in developing countries, initializing debates around potentials, risks and needs for their governance are of high importance.

> Memo item 4
> Technology assessment can pursue various goals. Concrete goals are defined under step 4. The three goals of this step are "raising knowledge", "forming attitudes", and "initializing actions". With advice from the expert group, the steering committee decides the relative weight of these three goals and how they are combined.

The first goal of raising knowledge represents the classical type of TA. It assumes the existence of discrepancies among the different stakeholders in their knowledge of the scientific facts relating to the specific STI development. The resulting knowledge gaps are considered the leading cause of uncertainty and social conflict.[7] In developed countries, especially in European countries, the TA tradition stresses the need to analyse potential risks of new technologies, which might only be apparent in the long run or in case of accidents. In some cases, the need to analyse residual risks of technologies has to do with the severity of negative consequences in the case of accidents, in terms of geographical scope and the time dimension. An evident example is nuclear energy. However, the potential of innovation in the context of the SDGs should be assessed to inform action (goal 3 in Table 1) to minimize risks and maximize benefits.

6.1. Goal 1: Raising knowledge

Knowledge gaps about new technologies and their risks and potentials will usually be more significant in developing countries than developed countries with established NISs. Knowledge gaps may relate to the scientific and technological, social or policy dimensions of the technology in question. Such gaps can be filled through analysis of scientific knowledge on paths of technology development, risks, chances, and unintended consequences (risk assessment), analysis of interests or perspectives of relevant actors (social mapping) and analysis of policymaking options (policy analysis).

6.2. Goal 2: Forming attitudes or opinions

The second goal of forming attitudes or opinions provides another perspective of modern TA. It views TA as a process that goes beyond scientific assessment to fill knowledge gaps that also aims to transform attitudes or opinions. Relevant processes focus on triggering thematically concrete policy and public debates concerning new scientific perspectives (agenda-setting). These can seek to resolve policy or

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[6] The goal dimensions in the table are provided along with the expected impacts and do not presuppose or favour one methodology over another. Regardless of the main "aspect" category (science, society, policy), the methodology followed will always include analysis of the technological development(s) under consideration in terms of societal, economic and environmental effects.

[7] Knowledge gaps should not be equated with a "deficit model" that denotes a belief that the more the public's knowledge of science increases, the more positive its attitude to science. This paradigm is outdated as it ignores the role of values, norms and worldviews in attitude formation (Pfotenhauser et al., 2019).

social conflicts via inclusive deliberation practices (mediation or contributing to conflict resolution). Alternatively, these can offer policymaking options based on a more comprehensive value analysis while providing new perspectives in policymaking procedures (restructuring the policy debate).

Box 3. Participatory assessment – citizens' jury on genetically modified organisms (GMOs) in Mali

A citizens' jury on GMOs was organized by the local 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 (e.g. government, civil society, research, farmer organizations, the International Institute for Environment and Development) was responsible for the design, organization 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 risk and advantages of GMOs, confront different viewpoints in favour and against GMOs, and formulate recommendations for policies on GMOs and the future of farming in Mali.

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

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

6.3. Goal 3: Initializing actions

Finally, the third goal, initializing actions, reflects TA's most tangible goal and impact perspective. It describes how the TA process influences the outcome of the policymaking process. In case of success, it leads to new or adapted STI or sector (e.g. energy, agriculture) policies and strategies that provide roadmaps for the direction of the specific technology at stake. The TA cycle will be closed, in the best case, with the implementation of new regulations, guidelines and codes of conduct. Accompanying measures will be implemented to maximize benefits and minimize risks for the society and economy as a whole or for the most vulnerable groups. Some examples concerning digital agriculture are offered in box 2.

How ambitious the TA process can be (especially concerning goal 3) will depend mainly on the remit and institutional setting of the processes and the available resources. For example, initializing action via regulation is easier where TA is directly linked to the legislative, and the parliaments are open to evidence-based policymaking. Nevertheless, the conscious choice and prioritization of the goals and impacts of the TA process should not be underestimated, and this is one core task of the steering committee's decision-making process (see section 2 of this paper on step 1 of the TA process):

- Choosing too many and overly ambitious goals raises the costs and time horizon for successful project implementation and will likely face significant challenges. One common criticism of TA is the length of time it takes to deliver project results. The time dimension will become more critical in times of rapid global changes when time losses not justified by the subject matter are considered less acceptable than ever.
- However, under-ambitious goals can also be seen in terms of truncated processes; for example, if a process concentrates on goals 1 and 2 and does not follow the targets and expected impacts under goal 3. The tangible benefits of a TA depend a lot on the concrete actions initialized. For example, companies might need clear framework conditions to implement a new technology

essential for competitiveness in a globalized economy. Alternatively, the benefits of relevant stakeholder groups may depend on early accompanying actions, as illustrated in an example with smallholder farmers and precision agriculture in box 2.

Box 4. New participatory methodologies – socioeconomic consideration of living modified organisms in India

A comprehensive consultation exercise on socioeconomic considerations of living modified organisms (LMOs), funded by the United Nations Environment Programme and the Global Environment Facility, was run by the Research and Information Systems for Developing Countries and overseen by the Ministry of Environment, Forestry and Climate Change (MoEF&CC), Government of India, covering the regions of Tamil Nadu, Gujarat, Telangana, Haryana, Punjab and Karnataka.

The project aimed to develop guidelines and methodologies for socioeconomic assessment for LMOs (under article 26.1 of the Cartagena Protocol on Biosafety to the Convention on Biological Diversity). It involved the creation of a steering committee with experts from the Indian Council for Agricultural Research and some state agricultural universities. The consultation exercise employed a survey and workshop methodologies, involving small and medium farmers from across the country, on several crop and trait examples.

Based on an analysis of farmers' needs and the expert community's opinions, the project has developed a socioeconomic assessment methodology, presented to the MoEF&CC. At the same time, the moratorium on genetically modified crops in India (active since 2010) continues. Furthermore, the guidelines and methodologies in decision-making on GMOs are discussed at the Ad Hoc Technical Expert Group under the Cartagena Protocol on Biosafety. Such an approach represents a robust empirical TA research toward the effort to find consensus on what factors and elements should be taken into account for socioeconomic considerations of LMOs.

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

The choice of the number and level of ambition of the goals depends on various contextual factors, the urgency of the issue in question and other external factors such as relevant policy papers and roadmaps in the pipeline. In addition, the level of institutional learning should be considered. Therefore, it is advisable for institutions establishing TA for the first time to work with a limited number of ambitious yet realistic goals.

Another critical factor is the available resources and the presence or absence of international support. In technologies related to energy and agriculture, international support may be within reach in the context of international funds for preparing countries for climate action. Many international development organizations are focusing on both these sectors.

Expected outcomes

What can be achieved in TA step 4?

While the development of interactive processes that bring together STI, society and policy are at the heart of a modern TA exercise, it is important to find a clear combination of possible goals and objectives to guide the exercise.

Concrete goals are to be defined under step 4. These goals can be defined according to three main objectives: raising knowledge, forming attitudes, and initializing action. With advice from the expert group, the steering committee decides the relative weight of these three goals and how they are combined.

7. TA step 5: Project implementation

The section discusses how evidence about selected technologies is to be collected, analysed and synthesized.

In the sense of the UNCTAD project and this paper, TA is yet to be become established in STI or sector policymaking in African countries. Consequently, empirical evidence on good practices cannot directly be derived from experiences from other countries in Africa. Nevertheless, the following guidance has been developed based on several decades of learning processes in developing countries. In addition, some lessons can be learned from related processes such as STI roadmapping or technology needs assessment.

In a developing country context, gathering, analysing and synthesizing evidence about the technology in question, its core features, risks and opportunities in the local context, will play a significant role in any TA process around new and emerging technologies. The involvement of stakeholders, mapping of their interests, assessments against given social norms and values is an important second step. There is a plurality of methods and tools that are available and are employed in TA projects, reflecting the diversity of the disciplines involved in TA. TA engages methods based equally on natural and engineering sciences as well as on social sciences and humanities.

It should be noted that TA assesses technologies in the early stages of development when they have not yet been fully implemented in the country, but may be considered as necessary to reach the SDGs (demand side) or have already been implemented in other parts of the world and are expected to reach the country, e.g. through action by foreign direct investment or the involvement of local actors in global value chains (supply side, see step 2). When a technology is close to being implemented in a specific region, it is increasingly often the case that economic and social impact assessments (ESIA; see, for example, International Union for the Conservation of Nature and Natural Resouces, 2020) are conducted. Both TA and ESIA include participatory approaches but address different stages of the innovation cycle and focus on various core groups and methods.

Depending on the issue and the development stage, there are various methods to mobilize local, indigenous and often tacit knowledge of the population in a specific region that will possibly be affected. Qualitative interviews are the most frequently used instrument in qualitative social research. They are often semi-standardized, allowing the collection of comparable data among the interviewees while giving them time to speak out on additional important issues. Under resource constraints (number of researchers, time), they allow an in-depth understanding of issues to be developed but can only cover a limited number of individuals. Moderated focus group discussions can help mobilize local and often not codified knowledge about factual circumstances in a given region or population groups, but also about perceptions, expectations and fears, e.g. related to a specific technology. Field experiments combined with participatory observation have been used, for instance, to analyse the challenges of population groups in dealing with a new technological item (e.g. improved cooking stoves).

7.1. Step 5.1: Gathering and synthesizing evidence

The starting point and a central element of the analysis is the review of core scientific and technical literature from natural, engineering and social sciences, science and technology studies, innovation system research, and the sociology of knowledge. In most cases, drawing on international knowledge and experience is an important step to acquire the essential information and develop an understanding of the possible effects an innovation might have. In addition, however, there is a need to embed the knowledge into specific social, political, economic and environmental conditions of the country in question. As this cannot be seen as evident in every country, the impact of technologies on women should be made explicit in the analyses, and every progress report should have a particular section or chapter on it.

> Memo item 5
> Step 5 is the core element of the TA process and the most significant in terms of time and resources. There are two sub-steps. The first one is about gathering and synthesizing evidence based on the existing literature and data and harnessing additional analytical tools to embed the knowledge into the local context. The second one is about stakeholder involvement based on interactive methods to ensure broad participation. Because of the complexity of the two sub-steps, it might be necessary to build up relevant capacities through some form of international cooperation.

In TA processes, a number of analytical techniques can help to localize the process. Some of these methods have been listed in table 2. Drawing on advice from the expert group, the steering committee has to select which techniques are most promising and realistic under the specific local conditions. Some of these techniques are well established and frequently applied across the developed and developing world. Their application, however, requires an institution capable of steering complex knowledge-based processes: choice of the most convenient methods, considering timeframes and available resources, sequencing of instruments, selection of experts for interviews, Delphi exercises to guarantee expertise and non-biased outcomes.

These functions should be taken over by the steering committee with the assistance of the expert group. Where possible, the steering of the TA process should be transferred to an existing think tank or a specialized university or institute. In case no such institute exists with acceptable standards of STI expertise, alternative options should be explored to strengthen TA steering capabilities via partnerships with international TA institutes. This could take the form of funding a national TA institution via external contributions. International donors may be willing to support this, as the importance of the capacity to explore adapted technological solutions to global challenges is increasingly recognized.

Most of the methods mentioned, in addition, require a thorough understanding of the technology itself, the scientific and engineering fundamentals, history of applications, successes and failures, and possible hazards and side effects. This is necessary to develop the required instruments and models, surveys, focus groups or Delphi. It is important that the steering committee takes important decisions about the process of evidence-seeking in a timely manner and whenever possible based on a consensus among the members of the committee and considering the available resources in terms of time, finance and human effectives. Some of the questions to be dealt with include:

- How is “technology” delineated as the core subject of assessments, and what analogies can be used when sufficient expertise and experience are not yet available at the national level?
- Which techniques of evidence-seeking are the most appropriate?
- How much time can be allocated to this step of the analysis, and what support can be called upon from outside, if necessary?

This, again, emphasizes the importance of the composition of this committee and the qualifications of its members (see step 3).

Table 2. Methods for gathering local knowledge of and attitudes towards the selected technology

Technique	*Description*	*Reference*
Interviews	One-to-one structured discussions designed to elicit information from the interviewee on a specific topic of analysis	Bauer M and Gaskell G, eds. (2000). *Qualitative Researching with Text, Image and Sound. A Practical Handbook*. Sage. London
Surveys/ questionnaires	A list of questions to guide collecting information from a group of people regarding their attitudes, knowledge, perceptions	Groves RM, Fowler Jr FJ, Couper MP, Lepkowski JM, Singer E and Tourangeau R (2009). *Survey Methodology.* 2nd edition. Wiley.
Delphi studies	These were developed as an instrument to forecast an unknown future. Experts answer questionnaires in two or more rounds. After each round, a facilitator provides an anonymized summary of the forecasts from the previous round, as well as the reasons provided for their judgments. Experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process, the range of the answers will decrease, and the group will converge towards the "correct" answer.	Linstone HA and Turoff M, eds. (1975). *The Delphi Method: Techniques and Applications*. Addison-Wesley. Reading, Massachusetts.
Focus groups	Focus groups involve people who are asked about their perceptions, attitudes, opinions, beliefs and views regarding a specific topic. They use group interaction to explore and clarify the beliefs, opinions and views of participants.	Morgan DL (1997). *Focus Groups as Qualitative Research*. Sage. London. https://www.kth.se/social/upload/6566/morgan.pdf.
Risk assessment	The analysis of events that may negatively affect individuals, society or the environment in terms of influencing factors and the level of systemic acceptance	Rausand M and Haugen S (2020). *Risk Assessment: Theory, Methods, and Applications*. 2nd edition. Wiley.
Life-cycle assessment	A technique to assess environmental impacts associated with all the stages of a product's life, from raw material extraction through materials processing, manufacture, distribution, and use	United States Environmental Protection Agency (2006). Life cycle assessment: Principles and practice. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=155087.
Modelling or simulation	Modelling and simulation are used to predict the final properties of manufacturing parts, ICT systems, or transport plans via reproductions at a smaller scale or mathematical models.	Padilla JJ, Diallo SY and Tolk A (2011). Do we need M&S science? *SCS M&S Magazine* 4(8):161–166.
Scenario development	A narrative illustration is used as a policy analysis tool to describe possible sets of future conditions.	Gill R (2010). The role of scenarios in strategic foresight. *Technological Forecasting and Social Change* 77(9):1493–1498.
Discourse analysis	Uncovering the content and quality of different types of argumentation in any type of written or spoken texts	Schiffrin D, Tannen D and Hamilton HE, eds. (2005). *The Handbook of Discourse Analysis*. Blackwell. Malden, Massachusetts.
Ethical matrix analysis	Analysis of ethical concerns embedded in the decision-making process	Mepham B (2000). A framework for the ethical analysis of novel foods: The ethical matrix. *Journal of Agricultural and Environmental Ethics* 12:165–176.
Resilience analysis	Analysis of the recovering capabilities within the design of a particular system	Woods DD and Wreathall J (2003). Managing risk proactively: The emergence of resilience engineering. Ohio State University.
Heat map analysis	A statistical data visualization technique is used for complex network analysis.	Wilkinson L and Friendly M (2009). The history of the cluster heat map. *The American Statistician* 63(2):179–184.

Source: Authors' elaboration.

7.2. Step 5.2: Stakeholder involvement based on interactive methods

For all three goals detailed in table 1 to be achieved, TA cannot effectively be done by the isolated analyses of experts, even though they bring in knowledge from different disciplines and fields of speciality and combine scientific and experience-based expertise. An important lesson from decades of TA exercises in industrialized countries is that interaction with stakeholder groups, (potentially) affected societal groups and the interested public, in general, improves the quality of the outcomes considerably and contributes to anchoring them in social and political discourses, which is a necessary condition for achieving goals 2 and 3.

Interactive methods involve exchanges between stakeholders in a structured setting. The type and number of invited stakeholders are of utmost importance in the choice of the method, as this will directly impact the quality of the exercise and, hence, the quality of the recommendations.

There have been many interactive methods employed in TA in the past four decades (by some counts, more than 100). Many of them were introduced as experiments in enhancing the democratic credentials of the TA process or as local adaptations to a more conventional approach. In the current state of TA methodological thinking, there are standard sets of interactive methods. These have to be adapted to the specific needs and opportunities in a developing countries context:

- Consensus conference (highly structured information exchange between experts and laypersons to reach clear consensus);
- Deliberative opinion poll (open expert debate in front of a considerable number of lay participants involving the running of opinion polls);
- Citizens' dialogue (large scale, highly structured debate with laypersons to identify future STI challenges and policy agendas);
- Citizens' jury (panel of laypersons that hear expert arguments and judge technology qualities; see box 3);
- STI café (informal, non-academic setting to discuss the merits of particular developments);
- Future workshops (participation of local people, designed to deal with local challenges and solutions);
- Fishbowl planning (highly concentrated and mobile discussions, involving an inner and an outer circle of participants);
- Vision assessment (analysis of dominant future visions of technological developments and their constituent parts);
- Social experimentation (analysis of people's reactions to certain events).

As implementation of TA projects and, even more, institutionalizing TA in a relevant institution, is a complex process, capacity-building is an essential cross-cutting topic with particular relevance for step 5. Cooperation in building up knowledge capacities is an integral part of programmes offered by international organizations, for example UNCTAD and the United Nations Industrial Development Organization related to the economic dimensions of TA, the World Health Organization for health issues, the Food and Agriculture Organization for agriculture, or the International Telecommunication Union for telecommunication. European and many bilateral development donors have related programmes. To specify what might be expected from bilateral cooperation offices, box 5 offers a brief overview of relevant cooperation organizations operating in Germany.

Box 5. Opportunities for knowledge cooperation related to TA: examples from Germany

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
With more than 23,000 employees, GIZ is by far the largest service provider for development services in Germany. Almost 70 per cent of employees are national staff in developing countries. The main commissioning party is the German Federal Ministry for Economic Cooperation and Development (BMZ). The range of topics covered by GIZ is manifold. In most cases, the topics of bilateral cooperation are periodically negotiated between BMZ and the partner countries.
See www.giz.de.

The German government's competence centre for international labour mobility
The Centrum für Internationale Migration und Entwicklung (CIM) facilitates the transfer of knowledge from individuals to developing countries and emerging economies. CIM places skilled personnel and experienced managers from the German and European labour markets. All such experts working with local companies or institutions in a developing country receive a salary top-up from federal government funds.
See www.cimonline.de.

Federal Institute for Vocational Education and Training
The Bundesinstitut für Berufsbildung's (BIBB) mandated tasks include conducting research on and developing vocational education and training, and serving in an advisory capacity and providing services. BIBB also offers cooperation in the field of technical and vocational education and training.
See www.bibb.de.

German Academic Exchange Services
The Deutscher Akademischer Austauschdienst (DAAD) is the world's largest funding organization for the international exchange of students and researchers. In 2020, DAAD funded more than 110,000 German and international scholars worldwide. The funding offers range from a year abroad for undergraduates to doctoral programmes, from internships to visiting lectureships, and from information-gathering visits to assisting with the establishment of new universities abroad.
See www.daad.de.

Alexander von Humboldt Stiftung (AvH)
AvH promotes academic cooperation between excellent scientists and scholars from abroad and from Germany, mainly with research fellowships and awards.
See www.humboldt-foundation.de.

Expected outcomes

What can be achieved in TA step 5?

This step can be started with a review of core scientific and technical literature from natural, engineering and social sciences, science and technology studies, innovation system research, and knowledge sociology. In most cases, drawing on international knowledge and experience is an important step to acquire the essential information and develop an understanding of the possible effects an innovation might have. Drawing on advice from the expert group, the steering committee will select which techniques will be used to develop required instruments and models, e.g. surveys, focus groups or Delphi. Finally, by utilizing a variety of interactive methods, this exercise aims to validate these findings and collect recommendations in relation to the selected technologies.

8. TA step 6: Quality control

The section proposes a range of measures that can help ensure that the process achieves results of high quality.

Regardless of the methods or the mix of methods employed in the TA process, a complete design must include a quality control element. TA is a complex undertaking involving several analytical tools used in a coordinated way to produce relevant and implementable policy proposals. This is not an easy task, but it is an essential requirement of an adequate system. The complexity of the process implies higher risks of suboptimal outcomes or mistakes. Thus, feedback loops have to be built into the process to assure quality. Quality control should conclude each of the steps 1 through 4. Even if these steps are intended to be sequential, it may be advisable to take a step back at certain points in time. For instance, after concluding step 2 (priority-setting) and step 3 (framing TA questions), it can be recommended to reconsider the governance framework (step 1), as it might make sense to recruit additional members to the expert group. Thus, while the quality issue is a cross-cutting one, after concluding sub-steps 5.1 and 5.2, step 6 is essential to consolidate and validate the outcomes of the core analytical processes. Have the analyses of the empirical evidence and gathering of additional (often qualitative) data been carried out with state-of-the-art methods and interpretations free from biases?

> Memo item 6
> Quality control should be part of every single step in the TA process. However, step 6 is recommended to check the scientific and process quality systematically. The scientific quality of the process is verified following procedures close to those of peer reviewing in academic research, but has to be transdisciplinary due to the very character of the TA process. Process quality must ensure the achievement of its main goals from every stakeholder's perspective.

8.1. Scientific quality

The evidence, in particular scientific evidence,[8] collected and analysed throughout the TA process is the most vital aspect of a successful conclusion. Inadequate or false evidence will inevitably lead to bad advice and eventually poor policymaking that increases the likelihood of social disruption or other negative impacts. How TA can control the quality of the knowledge input is similar to the standard academic review process but with two caveats. First, not all pieces of knowledge considered have to be necessarily the outcome of a formal research process, but can be explicit or implicit knowledge of practitioners and lay people, which is often the case when local environmental and social systems are affected by technology. Second, controlling the quality of TA processes should follow the established and proven methods of academic peer reviewing to avoid risks of subjective or biased interpretation of the evidence.

In addition, since TA is an interdisciplinary process, any review arrangement must consider this in its design. Even if the project focuses on disciplinary topics, no single disciplinary review will suffice for

[8] We use the terms "science" and "scientific" in a broad sense as a process that builds and organizes knowledge in the form of testable explanations and predictions about the world. It is often done in dedicated subsectors of the society conducting research and development activities. Modern approaches to science include knowledge generated outside this system, e.g. experience-based indigenous knowledge, passed on by word of mouth about the environment or medicinal plants (Cámara-Leret and Bascompte, 2021). This is not, strictly speaking, scientific knowledge, but it has to be considered in TA or ESIA (see section 6), especially whenever effects of an innovation may impact local ecosystems and societies.

proper quality control. The practitioner should constantly consider transdisciplinary knowledge creation with an overwhelming advisory goal, referring to analysis created for non-experts. Whether a policymaker or any other interested party, the reader is certainly not an expert in every relevant discipline. The analysis must be simple enough to be understood but not so simple as to miss the acknowledgement of the expert community. The quality of the input is nevertheless a matter for the comprehensive review, which includes:

- Multidisciplinary peer review: Peer review is still the most widely established and available quality assurance process in academic and policy research. In the case of TA processes in a developing country with a limited NIS, the peer-review process could draw on support by international experts, e.g. from the global TA network.[9] This can ensure an unbiased peer review by people with a solid understanding of the TA process and its objectives.
- External expert discussions: An alternative to the standard peer-review process, particularly helpful in cases where evidence is still uncertain or lacking, is to open the whole TA process to external expertise.

8.2. Process quality

This type of quality assessment is akin to the standard term of "external validity". By that we mean that the TA process must ensure the achievement of its main goals from every stakeholder's perspective. Therefore, it should not only be based on solid scientific evidence. Furthermore, it should be transparent, balanced and fair in its practice.

Transparency entails detailed documentation of the process (e.g. minutes, recording) and the documentation upon which the evidence and participant opinions are based. It should also entail a strict view on conflict of interest. Every participant in the project must declare any conflicts in terms of business interests, personal or academic relationships, or anything else that might influence their judgment. These should form part of the project's official documentation that external reviewers (or even the public at large) should be given access to. If the project analyses highly controversial issues where vital stakeholder interests may be affected, the caveat of section 1 (Chatham House rule) applies. The documentation of the TA process and its outcomes can be published on a dedicated website hosted by the implementing agency or the relevant line ministry. This is a step to enhance transparency further.

Balance refers to the number and representational quality of the views and inputs to the project. Regardless of the project focus, there are always contrary views and arguments that merit representation. In a highly complex topic, these might be views of competing researchers or research labs, in addition to varying statements by interested parties.

Procedural fairness refers to the rules of engagement that the project participants must adhere to. It is common in a TA project to have diverse participants in terms of disciplinary background and social status. It is essential to devise rules that do not disadvantage any participant.

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

Expected outcomes

What can be achieved in TA step 6?

Step 6 ensures that the overall results achieved under each TA exercise are of high scientific quality. The measures can include a multidisciplinary peer review or an external expert discussion. Similarly, additional measures are to be put in place so that the TA process attempts to achieve its goals from every stakeholder's perspective. Furthermore, these measures help to make sure the TA exercise is transparent, balanced and fair in its practice.

The documentation of the TA process and its outcomes can be published on a dedicated website hosted by the implementing agency or the relevant line ministry. Balance refers to the number and representational quality of the views and inputs to the project. Regardless of the project focus, there are always contrary views and arguments that merit representation.

Furthermore, the TA rules of engagement are defined in a way that does not disadvantage any participant.

9. TA step 7: Reporting

The section discusses what should be included in a good TA report. Furthermore, the section examines the importance of legitimization of the final report and ways to achieve this.

The output of TA covers a broad spectrum, from short information booklets aiming at raising awareness on particular STI issues to complete analysis of technological fields in terms of state of the art and applications in various areas of economic activity, and finally to the development of policy options. The information booklets might necessitate no more than 3–4 weeks of analytical work, while a full-blown analysis could take anything up to 2 years for completion, as international experience indicates. Between these two extremes, there are many more possibilities that depend on various influencing factors such as the level of political debate, the timing of the legislative agenda, the level of technological development and its relationship to the national economic structures.

> Memo item 7
> The TA report is important to inform policymakers and implementing agencies about the process, the outcomes and the recommendations of the TA process. In addition, it assures core information is safeguarded and stored for the future. It should include the rationale for decisions taken by the steering committee, e.g. the priorities set in step 2. The main findings that led to the policy recommendations and the recommendations themselves are also part of the report.

A standard TA report should include a number of critical aspects of the TA process covering its inception, contextual background, methodology, analysis and policy options. As policymakers often have limitations of time and scientific knowledge that are required to read exhaustive analyses of complex STI issues, executive summaries or policy briefs are usually produced alongside the full report for broader dissemination. These highlight the policy challenges and the policy options that the TA process has developed.

For a country with no experience in TA, the reports can be shorter and summarize the core information necessary for informed decision-making. It must include the rationale behind the priority-setting (step 2) and the main findings that led to the policy recommendations. It should be drafted by the expert group, which might wish to select one or two key authors representing two different disciplines (e.g. biotechnology, and economics or social sciences), who will prepare the first draft versions. These will be reviewed by the whole expert group and submitted to the steering committee for approval. A possible structure for this report can be found in box 6.

Finally, the trajectories of technological developments are not easy to predict. Disruptive innovations may accelerate or significantly change the process and may call for adapted assessments and recommendations. Therefore, the TA report should conclude with a recommendation by the steering committee and expert group as to whether and when the main findings of the TA process should be revised. This is very important considering the rapid pace of technological change.

9.1. Political legitimization of the TA report

Political legitimization of the TA report is of utmost importance for its overall standing and eventual impact. This aspect is intrinsically related to the institutional setting in which TA functions in the country. If TA aims to advise policymakers, it must be located close enough to policymaking to allow for direct access to it and at a relative distance to assure independence and objectivity while avoiding any conflict of interest. This is not an easy task, but there is enough flexibility to allow for different institutional paradigms that a newly established TA can follow (Decker and Ladikas, 2004).

National parliaments and STI ministries have always been the main clients of TA, and it is where TA is usually located. There is widespread agreement in the TA community that the institutionalization of TA should ideally take place within the parliamentary system (Klüver et al., 2016). This is because national parliaments are the primary representation of the public and the main stage of policy debates on STI developments. At the same time, they usually contain a pluralistic depiction of social norms, values and opinions that does not leave any significant view or perspective out of the picture. In addition, parliaments are better suited to run TA offices as they are less likely to develop interdependencies with them, whether these relate to party politics or specific positions held by members of the parliaments. Such interdependencies can develop more easily within the government ministerial system. It thus allows for a more impartial office dedicated to TA research. In this manner, one can depict parliamentary TA as a balancing power between the legislative body's need to control the executive body's power to foster particular STI developments. This is crucial for any democratic system, within which TA can best flourish and be legitimized politically.

Whether or not attached to the parliamentary system, the ultimate political legitimization of the TA process derives from its official adoption by the policymaking community. There are various examples of how this can be done. For instance, in the pure committee model in Germany, TA reports are requested by the relevant parliamentary committee, executed by the parliamentary office, and officially approved and published as parliamentary reports. In the office system at the European Parliament, external consultants are given contracts to run TA studies, and the resulting reports are approved by the relevant panel and officially adopted as parliamentary publications. Finally, in the interactive system of the Dutch government, TA studies are outsourced to the Royal Academy institutes, and the resulting reports must be received and commented on by the relevant ministry or parliamentary committee. In any case, the political legitimization of the TA report must be built into the process, taking into account the country's institutional context.

Box 6. Indicative structure of a TA report in the context of Africa

1. Introduction: explaining the process and the composition of the steering committee and the expert group;
2. The rationale for priority-setting on the selected technology/technologies;
3. Fundamentals:
    - State of development/maturity and areas of application of the technology;
    - Core international experiences;
4. Potential ways how the technology might be implemented/become relevant in the country (foreign investments, national development plans, international commitments related to the SDGs and other agreements (climate change, biodiversity));
5. Opportunities of the technology in the national context:
    - General assessment;
    - Specific opportunities for women;
    - Specific opportunities for youth and other social groups;
6. Risks of the technology in the national context:
    - General assessment;
    - Specific risks for women;
    - Specific risks for youth and other social groups;
7. Policy recommendations related to:
    - The governance of the technology (regulations, promotion schemes, creation of multi-stakeholder technology platforms);
    - Policies and instruments for minimizing risks and maximizing benefits, in general, and for women, youth and other social groups;
    - Possible reforms to existing or creation of new technology institutes (in terms of vocational training, higher education, research and development);
    - International STI cooperation;
    - Monitoring of the further development of the technology on the national and international level;
8. Annexes:
    - List of members of the steering committee;
    - List of members of the expert group;
    - List of key informants;
    - List of references.

Source: Authors' elaboration.

Expected outcomes

What can be achieved in TA step 7?

Technology assessment report: A standard TA report is to be developed. It is expected to include a number of critical aspects of the TA process covering its inception, contextual background, methodology, analysis and policy options.

Policy briefs and/or executive summaries: These supplementary documents are usually produced alongside the full TA report for broader dissemination. Their aim is to highlight various policy challenges and the policy options that the TA process has produced.

TA recommendations: As the trajectories of technological developments are not easy to predict, the TA report should conclude with a recommendation by the steering committee and the expert group.

Political legitimization: The ultimate legitimization of the TA process derives from its official adoption by the policymaking community and must be built into the TA process, taking into account the country's institutional context.

10. Pathways to impact

Once finalized, the TA report is sent to decision makers. At this point, the formal TA process may be seen as successfully concluded in relation to goals 1 and 3 (see memo item 4). However, regarding goal 2 (forming attitudes or opinions), additional activities could be conceptualized. This may or may not be part of the TA report.

Experience indicates the usefulness of TA exercises to inform the public debate around technological innovations. TA has accumulated considerable know-how in communicating STI policy issues in a language and manner that non-experts or even laypersons can better understand. Standard communication methods, which have to be adapted to the national context in African countries, include:

- Opinion articles (TA experts write popular media articles on STI developments featuring project results);
- Science exhibitions (local public exhibitions dedicated to specific scientific areas or specific developments with high public interest);
- Open science days (days where the public can visit the TA institute, hear about its projects and inquire about the main issues under research);
- Science blogs (personal or group blogs following a specific TA issue);
- Interactive websites (websites dedicated to informal online dialogue over a TA issue or project);
- Newsletters and focus magazines (description of current topics of discussion and policymaking for the interested public);
- Art-science exhibitions (collaboration with artists to develop new forms of expression of ideas and opinions in STI debates).

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Annex – Examples of TA projects

Example of interactive TA: energy transformation

As part of its international obligations to reduce CO_2 emissions and its own decision to phase out nuclear energy in the country, the German government has initiated a far-reaching programme to transform its energy systems with the ultimate aim to become climate neutral by 2050. The transformation includes the integration of the German electricity, heat, and mobility sectors into a nationwide grid with both centralized and decentralized structural elements, which is fed by renewable energy sources. This is an immense undertaking incorporating the expansion of wind energy plants, the construction of large geothermal or biomass plants and the expansion of energy grids and associated changes in spatial structures. Citizens are required to both change their consumption patterns and accept new major energy structures in their localities. New regulatory frameworks must be developed to account for these changes.

The government, via the Helmholtz Association of Research Centres, has initiated the project "Energy transformation in dialogue" to allow for an overall societal understanding of the energy transition by providing and processing information, offering advice and further training, and bringing together very different actors from research and society in a participatory TA process. Transdisciplinary experts are required to initiate various participatory methods with the general public, civil society, NGOs, public administration, the energy sector, trade and industry, local authorities, teachers, energy consultants, students, and so-called early adopters.

These include:

- Informational and explanatory videos;
- A "sustainable energy" tour;
- Energy scenario workshops;
- Transdisciplinary project courses;
- A citizens' forum on energy transition;
- Real-world experiments.

It is an ongoing process that has already shown considerable promise in the willingness of stakeholders to take part in the process and the intense exchanges that have been documented. The results of the exchanges are projected to feed directly to regional and national policy debates on the design and location of the new energy systems. Despite this project's unusually long-term approach, it provides an excellent example of interactive TA methods to map and understand STI conflicts and build bridges amongst critical stakeholders.

Source: http://www.itas.kit.edu/projekte_stel18_endia.php.

Example of scientific TA: Sänger space transport system

In the 1990s a decision had to be taken on how to continue with a governmental research programme for hypersonic spaceflight technology (HST); the central part of it consisted of the development of a reusable space shuttle system (named "Sänger" after a German engineer and space flight technology pioneer). The Committee for Research, Technology and Technology Assessment of the German Parliament commissioned the parliamentary Technology Assessment Bureau (TAB) to conduct a study exploring ways to continue with the HST programme. TAB carried out an extensive analysis of the technical feasibility, the future demand and possible impacts of the Sänger technology with a systematic analysis of technical and economic aspects of the technologies under consideration (literature, interviews, expert workshops) and an interdisciplinary closed-circle group with the involvement of high-level experts from relevant disciplines (space technology, economics, transport, public administration, culture, environment).

The study concluded that a decision on the HST programme should involve a general decision on the extent of Germany's future engagement in space flight, providing three options for continuing the HST programme. Option III proposed to expand the scope of the HST programme to technical options alternative to the space shuttle technology, to base the programme on a systematic comparison of different reusable transport technologies, to intensify international cooperation and to reduce the activities related to the development of the Sänger technology. The Committee for Research, Technology and Technology Assessment unanimously forwarded a recommendation that the government should restructure the HTS programme according to option III of the TAB study and enter into consultation with the European partners on the scope and funding of future European engagement in space flight. The study was debated in the plenary, and the recommendation given by the committee was approved. The success of the TA process was attributed to the quality of the experts involved, the quality of the scientific argumentation, and the broad range of coverage, including economic, environmental and cultural analysis. The timing of the study was also significant as there was a widely recognized political need to clarify the future of the "Sänger" programme concerning its relation to ongoing plans for a European space flight programme and the immense financial challenges involved.

Source: TAMI project: https://www.itas.kit.edu/projekte_grun02_tami.php.

Example of communicative TA: World Wide Views

World Wide Views developed as a global information exchange and citizen consultation tool focusing on global challenges. It has already been used on the issues of global warming and biodiversity to coincide with the United Nations summits on climate change, and was developed by the Danish Board of Technology and other World Wide Views Alliance partners prior to COP15 in Copenhagen in 2009. Citizens from a number of countries are provided with written information material describing the issue under discussion with opposing arguments and facts. The material is reviewed by a scientific advisory board and by citizen focus groups in different parts of the world prior to being finalized.

The main event takes place on the same day around the world and follows exactly the same format. The day is divided into four or five thematic sessions. An information video introduces the thematic issue, and citizens are then presented with a set of questions (three to five) with pre-prepared answering options. Groups of five to eight citizens deliberate on the questions before them, assisted by a trained table moderator. Each session can last between 30 and 90 minutes. At the end of each session, citizens vote individually on the questions. Votes are then collected and reported to the World Wide Views website, where results can be compared as they arrive throughout the day – starting in Asia and finishing on the American West Coast. Comparisons can be made between countries, continents and different groupings, such as developing and developed countries.

World Wide Views represents an innovative TA method that uses both physical meetings and interactive websites to inform the public, discuss pertinent issues and provide input in the policymaking process. The long-term plan of this method allows for continuous information exchange and awareness-raising amongst the general public in many countries.

Source: http://wwviews.org/the-world-wide-views-method/.

Example of a standard interdisciplinary TA study process: functional foods standards in Europe

The project was undertaken by the European Academy of Technology and Innovation Assessment's working group "Functional Foods", which worked from January 2001 to June 2003 in Rheinland-Pfalz (Germany). It was sponsored by the Foundation of Rheinland-Pfalz for Innovation, the Ministry of Science and Technology of Rheinland Pfalz and the German Aerospace Centre. It was developed according to the expert interdisciplinary TA process for two years. Based on an initial scoping exercise that undertook a basic literature review, the study aims were set to analyse the consequences of the emergence of functional foods on:

- Individual health (cardiovascular diseases, cancer);
- National health programmes (health care costs, productivity);
- Food industry (food manufacturing, retailing, pricing);
- Regulations (precautionary principle, health claims, labelling);
- Public perceptions (risk evaluations, attitudes);
- Ethical issues (stakeholder identification, accessibility, food naturalness).

The core expert group was established by the steering committee of the European Academy and consisted of experts in food ethics, food economics, food policy, food perceptions, nutritional physiology, food law, and probiotics. The expert group met monthly to exchange specific disciplinary information and develop the report on the principle of consensus. In addition, external input in the form of invited expert presentations was received at standard intervals (kick-off, mid-term, final project workshops) and at project group meetings when considered necessary by the expert group.

The expert group adopted the ethical matrix methodology as it was deemed helpful in comparing the impacts of future development, such as the introduction of functional foods, with the status quo. Moreover, the ethical matrix methodology is designed to offer a neutral approach to decision-making by identifying all the interest groups or stakeholders that will be affected by a new technology and applying principles drawn from different traditions of ethical thought.

The stakeholders were identified and the effects of the introduction of functional foods were analysed according to three main categories: utility (welfare, safety, risk, benefits), rights (choice, autonomy, regulations) and fairness (justice, access, policy). The list of stakeholders covered a broad spectrum from those affected directly by functional food developments (e.g. producers, distributors, consumers) to those implicated indirectly (e.g. professional and environmental groups).

The analysis covered five main areas of interest for public policy:

- Safety: Comparison of the assessment process of diet–health interaction; areas of health most affected by functional food consumption; appropriate biological markers to be used as assessment standards; the role of genetic predisposition to food effects on health; the desirable scientific standard of post-marketing surveillance for functional foods;
- Policy/legal: Definition of functional foods; categories of claims that can be included on the food label; sound scientific evidence for the regulatory acceptance of a claim; the role of substantial equivalence versus the precautionary principle;

- Economics: Market share of functional food products and future outlook; externalities influencing the market; required food industry changes to accommodate the new developments; effects of health-impact foods in national health budgets and social welfare plans; impact on food prices with consequences for lower socioeconomic groups and for developing countries;
- Public Perceptions: consumer acceptance, public trust, perceived risks and benefits, risk communication channels;
- Ethics: Food naturalness, informed choice, accessibility and affordability, global distribution, animal welfare, environmental sustainability.

The standard peer-review process was followed at mid-term and final draft report intervals, whereby external experts mirroring the expert group expertise provided comments and suggestions. Amendments were followed, and the final report was developed via consensus, presented to the sponsors, accepted officially by them and distributed widely to relevant policymaking entities. The report was also published as a co-authored book for the wider academic audience.

Source: Chadwick R, Henson S, Moseley B, Koenen G, Liakopoulos M, Midden C, Palou A, Rechkemmer G, Schroeder D and von Wright A (2003). *Functional Foods*. Springer-Verlag. Berlin Heidelberg.

Example of a short interdisciplinary TA study process: tackling deepfakes in European policy

The TA study, published in July 2021, was requested by the Panel for the Future of Science and Technology and managed by the Scientific Foresight Unit of the Directorate for Impact Assessment and European Added Value within the Directorate-General for Parliamentary Research Services of the Secretariat of the European Parliament. A specific call for proposals provided the study rationale and aims and the schedule (six months). The study was developed by an interdisciplinary expert consortium consisting of the Rathenau Institute (Netherlands), the Institute for Technology Assessment and Systems Analysis (Germany), the Fraunhofer Institute for Systems and Innovation Research (Germany) and the Technology Centre of the Czech Academy of Sciences (Czechia).

The project team followed four methodologies: literature review, policy analysis, expert interviews, and expert reviews.

- Literature review: The literature review covered academic sources and grey literature, employing a narrative literature study approach that fed into the expert interviews. The review included scanning journals in media studies, computational science (e.g. image processing), and political and legal sciences, in the databases Scopus, ISI Web of Science, Google Scholar, the Institute of Electrical and Electronic Engineers (IEEE) Explore and SSRN. The literature study also included reports from national and European Union institutes, such as the European Parliament, European Commission, European Regulators Group for Audiovisual Media Services, sector organizations in computer science (e.g. IEEE), media research agencies (Reuters, IPSOS, PEW Research, Brookings), social media platform companies (Facebook, Twitter, TikTok), cybersecurity (ENISA, Graphika, Sensity), relevant NGOs (AlgorithmWatch, Electronic Frontier Foundation, Climate Change Committee) and media relevant to deepfake developers (Reddit, MrDeepfakes Forums).
- Policy analysis: The study also included the analysis of the regulatory and policy landscape to ensure that the options developed could be accompanied by possible mechanisms for implementation. The European policy analysis included the following regulatory initiatives: AI legislative framework, General Data Protection Regulation, copyright law, image rights, eCommerce Directive, Digital Services Act, Audio Visual Media Directive, Code of Practice on Disinformation, Action Plan on Disinformation, Democracy Action Plan.
- Expert interviews: The outcomes of the literature review and policy analysis were supplemented by expert interviews. Nine experts were identified in the literature based on their expertise with regard to the technology and main impact areas. The interviews were conducted in a semi-structured fashion, based on a predefined list of questions.
- Expert reviews: The research team drafted a wide array of policy options based on the literature review and policy analysis combined with insights from the expert interviews. These policy options were then reviewed by three expert reviewers, which led to further refinement and improvement of the policy options.

The study was approved by the Panel for the Future of Science and Technology and was issued as an official European Parliament publication to be distributed to members of the European Parliament and discussed in relevant legislative committees.

Source: https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_STU(2021)690039.

Example of methodology for participatory TA: the consensus conference

Consensus conference is a standard participatory TA methodology that has been applied extensively in TA projects across Europe over the last four decades. It involves laypeople (i.e. citizens) who do not possess any specialized knowledge on the technology issue under consideration. They are required to draw upon their daily experience and express their views, visions, values and norms in their own manner. It is a form of common dialogue on technology developments with people with different backgrounds and qualifications who can freely express their views on aspects of the technology that scientific experts, policymakers, and other interested publics have overlooked. The purpose of the exercise is to enrich the TA project by allowing for additional input from society, where potentially controversial technologies have a direct effect on everyday lives, and thus develop a more comprehensive assessment.

Organizational structure

The project management team consists of a project manager, a project assistant, and a project secretary. The project management team is responsible for the practical implementation of the conference and acts as a coordinator concerning all parties involved.

The planning group consists of four to six critical experts appointed by the project management team. They represent a broad, balanced representation of interests, expert opinions and knowledge and must be acknowledged members of the scientific and stakeholder communities. The planning group meets with the project management team three to four times a year during the planning phase. The planning group's tasks are to prepare guidelines and ensure wide accessibility of the introductory material for the citizens' panel; comment on and approve the introductory material; approve the composition of the citizens' panel; contribute to the selection of experts to the expert conference panel; and to comment on and approve the conference programme.

The citizens' panel consists of 14 to 16 randomly selected citizens. Selection can be made by contacting a random number (ca 2,000) of citizens and asking them to apply for membership in the panel or advertising the conference in public media with a call for application. Then the project management team and the planning group choose the panellists, taking care of representativeness regarding age, gender, employment and geographical location. The panel's task is to put qualified questions to the expert panel and formulate the final document based on their answers.

The process consultant is an external person appointed by the project management team and is a professional facilitator with communication experience and experience of group process management. The consultant is specifically hired to manage the citizens' panel process at the conference. Together with the project manager, he or she is responsible for managing the panel's preparatory sessions as well as the actual conference. In addition, the consultant assists the members of the panel in expressing and communicating their attitudes and messages and facilitates the communication between citizens and experts, citizens and politicians, and between citizens and interested parties participating in the conference.

Procedure description

The standard procedure includes two preparatory weekend sessions and the conference itself, which lasts four days.

First, a science communicator with knowledge of the subject area prepares introductory material of no more than 40 pages for the citizens' panel. The material provides a comprehensive view of the most essential attitudes, conflicts, problems and development trends relating to technology development.

Second, based on this new knowledge and their abilities and inquisitiveness, the panel formulates a number of relevant questions to the different experts, who are requested to answer them. The questions must be designed to assess the given technology and lead to policy recommendations for the future development of the technology.

Finally, based on the experts' answers, the citizens' panel assesses the technical insight and the views it has been presented with. Their assessment and views are formulated in the final document that the panel develops by itself and is presented on the last day of the conference. The document is discussed with the politicians, decision makers, interested parties, the press and other conference participants.

The citizens' panel's preparatory weekends: The additional purpose of the weekends is to allow the panel to formulate significant themes and questions relating to the conference topic to be answered by the experts. The weekend programme uses a mixture of group work and plenum sessions to identify the themes the panel wishes to have elucidated and explained at the conference.

The conference itself: The conference usually runs on the weekend from Friday to Monday. The first day is dedicated to experts answering the questions posed in advance by the citizens’ panel. Up to 25 experts might make oral presentations that are also provided in written form to be used by the citizens' panel during their deliberations. The second day is dedicated to elaborations and clarifications requested by the expert panel, while the audience is also allowed to ask questions. The official part of the conference is concluded and the citizens’ panel begins discussing the expert presentations and the final report. The third day is dedicated to discussing and formulating the final document's content, which the panel must accept with consensus. The last day begins with the panel presenting its final report, while the experts are allowed to correct any possible factual mistakes, and all participants can comment on the document and put questions to the citizens' panel.

Following the conference, a report is developed by the management team containing the summary of the procedure with the citizens' panel's questions to the expert panel, the panel's final document and the experts' written answers to those questions. The report is sent to all conference participants, policymakers and other interested parties.

Source: http://www.tekno.dk/subpage.php3?article=468&toppic=kategori12&language=uk.