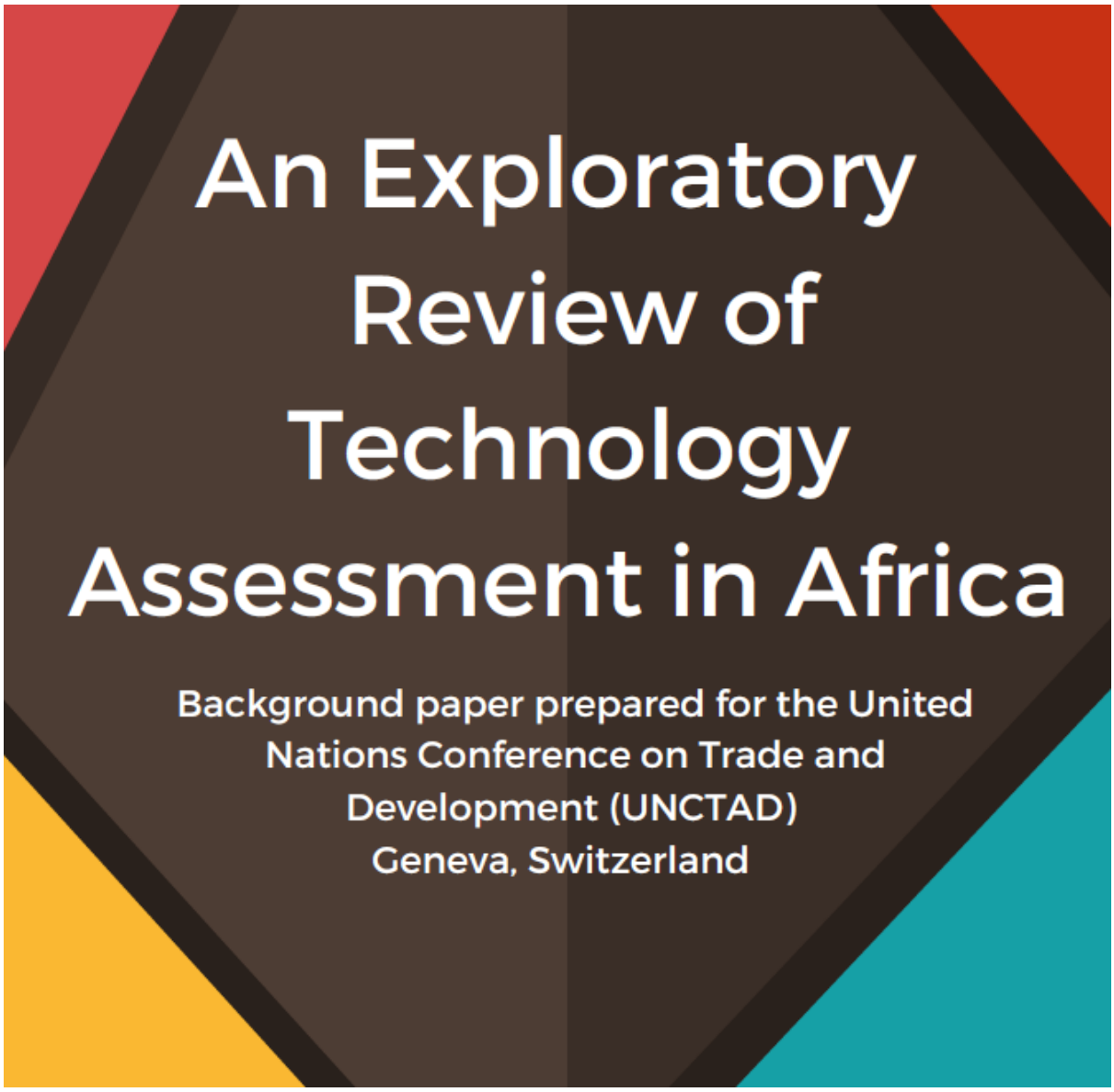
United Nations Conference on Trade and Development



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Abbreviations

CGIAR	Consultative Group on International Agricultural Research
CNRS	Centre national de la recherche Scientifique
DPME	Department of Performance Monitoring and Evaluation
EIA	Environmental Impact Assessment
EU	European Union
GOA	Government Accountability Office
HTA	Health Technology Assessment
IAIA	International Association for Impact Assessment
IDSI	International Decision Support Initiative
IRENA	International Renewable Energy Agency
ISPOR	International Society for Pharmacoeconomics and Outcomes Research
NIH	National Institutes of Health
NRF	National Research Foundation
NSF	National Science Foundation
NSFC	National Science Foundation of China
OTA	Office of Technology Assessment
POST	Parliamentary Office of Science and Technology
SANEDI	South African National Energy Development Institute
SSA	Sub Sahara Africa
TA	Technology Assessment
UNCTAD	United Nations Conference on Trade and Development
USAID	United States Agency for International Development
UN	United Nations
SIA	**S**ocial impact assessment
WoS	Web of Science

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Introduction

Technology assessment (TA) is gaining currency as a powerful toolbox for making strategic choices on the procurement, development, introduction, and governance of new technologies. It is about critical and participatory assessment of social, economic and environmental benefits and risks of a particular technology. TA has a relatively long history, going back to at least in the early 1970s with the establishment of the Office of Technology Assessment (OTA) in the United States of America (USA).[1] It has evolved and been adopted in the European Union (EU) and Asian countries as a tool or mechanism for making technology policy and/or informing decision-making on the development, procurement, introduction and governance of new technologies.

Technology assessment (TA) is still in its infancy in Africa. Its application as a vital tool for technology policymaking is just starting to attract the attention of academics, technocrats and policymakers as well as legislatures on the continent. However, there have been various TA-like initiatives in health, energy, water, agriculture, and some TA on specific technologies such as biotechnology and nanotechnology in Africa.

Demand for TA is likely to grow in Africa for at least three reasons. First, African countries are increasingly put emphasis on the role of new technologies in sustainable development. This is reflected in the kinds of national science, technology and innovation (STI) policy frameworks that many countries in the continent are adopting. Second, countries are exposed to a large and growing pool of technologies and technological options making it critical for them to adopt specific tools and approaches for making wise technology choices. In this regard, TA is recognized as a vital 'methodological toolbox' for guiding the choice of specific innovations from the large global pool of technologies.

The capacity of African countries to design and use TA largely determines the quality of their policies and programmes for technology and innovation in a wide range of sectors such as health, energy, agriculture, mining, fisheries, security and transport. It is critical in policymaking on Foreign Direct Investment (FDI), technology transfer and acquisition, domestic investment in research and innovation (R&I), technology prospecting and procurement, environmental regulation, and many aspects of sustainable development. TA capacity is more critical and urgently required during times of crisis and uncertainty such the current COVID-19 pandemic and related systemic socio-economic crises. Government, private sector and even civil society organizations are expected to make decisions urgently on what technologies (particularly medical or health ones) to procure and deploy in health and economic systems that are fragile or under constant pressure.

The COVID-19 pandemic is vividly exposing the unpreparedness or preparedness of countries to harness existing technological knowledge and innovations to respond to health, economic and social challenges. For many African countries, TA capacity or at least components of it are scattered across the institutional terrain, with weak coordination. Take the case of personal protective equipment (PPE), TA mandates and capacity components may be in ministries of

[1] Some studies trace TA to the First Industrial Revolution when civic bodies got engaged in questioning and agitating for democratization of technology choices in energy, defense and health sectors. See for example Winner, L., ed., 1992, *Democracy in a Technological Society*, Kluwer Academic Publishers. However, more formal institutionalization of TA is associated with OTA in the USA.

health, trade and industry, standards bureaus, universities and even in defense agencies. Configuring the institutional setup to efficiently mobilize and use existing TA capacity is an issue of policy attention.

Post COVID-19 recovery and the transition to global Sustainable Development Goals (SDGs) in Africa will need more organized and deliberate TA as part and parcel of public policymaking. Many African countries are going to engage more in the search for measures that stimulate economic recovery and growth through manufacturing, industrialization, FDI and trade. Addressing challenges of food and energy insecurities will also demand greater engagement with TA in order to ensure that sustainability considerations are not comprised.

Therefore, understanding how African countries conceptualize and use TA in public policy is a matter of urgency. It is important in informing any programmes for building TA capacity on the continent. This is an exploratory study reviewing the status and capacity needs on TA in Africa. It focuses on how different countries and regional bodies such as the African Union (AU) are conceptualizing and institutionalizing TA as a tool for STI policy and technology governance in general. In section one, the study provides a brief review of literature on what constitutes TA, and why it is a critical tool for policymaking and technology governance. It then discusses some of the global trends in TA. Section two of the report focuses on TA in Africa, identifies some of the initiatives at national and regional or continental levels, and then discusses policy and institutional arrangements governing TA activities in the countries. In the third section a tentative survey or identification of TA capacity needs is provided, and the last section makes a number of recommendations on building TA capacity in Africa.

1. Technology assessment: An overview

1.1 Technology assessment as a critical technology and innovation policy tool

Technology assessment (TA) emerged in the 1960s, mainly in the United States of America, out of concerns about social, economic, environmental and ethical implications of new technologies in transport, energy, agriculture and health.[2] The USA's Congress Subcommittee on Science, Research, and Development of the House Science and Astronautics Committee was the first to use the concept of TA in its reports. According to Banta (2009), "[t]he Subcommittee, in a series of hearings and reports, examined issues surrounding technology and proposed technology assessment as an approach to problems surrounding technology, its development and use."[3] Technology assessment (TA) has evolved to become a more specialized policy research and analysis area. It is "a form of policy research that examines short- and long-term consequences (for example, societal, economic, ethical, legal) of the application of technology."[4] Other scholars (for example Coates 1980)[5] have defined TA more broadly as the assessment of the effects of technological change (defined as the introduction, diffusion, modification and application of technology) on society.

It is important to note that often TA is mistakenly equated or reduced to other methodological approaches or tools of technology management such technology forecasting, technology

[2] Banta, D. What is technology assessment? *International Journal of Technology Assessment in Health Care*, 25: Supplement 1 (2009), 7–9. Cambridge University Press. Printed in the U.S.A. doi:10.1017/S026646230909033
[3] Banta, D., 2009, op. cit. p. 7.
[4] Banta, D., 2009, op. cit. p. 7.
[5] Coates, J.F., 1980,

foresight, technology needs assessment, and technology roadmaps. These other methodological tools are mainly do not necessarily focus on assessing societal effects of specific technologies. For example, technology forecasting and technology foresights are largely about identifying and analysing certain technological pathways or trajectories, not their social, environmental and economic underpinnings or risks. Technology forecasting is about analysing and evaluating trends, performance and changes in particular technologies while technology foresight is "a process involved in systematically attempting to look into the longer-term future of science, technology and society with the aim of identifying areas of strategic research and the emergence of generic technologies likely to yield the greatest economic and social benefit." [6] Both technology forecasting and foresight are analytical tools for decision-making on R&D, used by academic, industry and governments.

On the other hand, TA is largely a part of a policy process as much as it is a tool in (or for) technology policymaking. It is supposed to be a multidisciplinary (increasing transdisciplinary) non-technocratic, inclusive, interactive and communicative process that helps to form public and political opinions about risks and benefits of technology. TA is important or critical for at least two reasons. First, it is a useful source of evidence and information on various policy options or alternatives that decision-makers and the public can use to make informed technology choices. Based on TA, decision-makers and investors are able to make wisely choose specific technologies to develop and areas of research and development (R&D) in which to invest. As Danielle Bütschi and Mara Almeida (2016) argue, TA is an important tool for science, technology and innovation policy making " by integrating any available knowledge on possible side effects, by supporting the evaluation of technologies according to societal values and ethical principles, by elaborating strategies to deal with inevitable uncertainties, and by contributing to constructive solutions of societal conflicts around science and technology."[7]

Second, TA can be a vital mechanism or process for securing democratic governance of technology and democratizing technology policy.[8] It enables the building of public confidence in technology policy, critical to unlocking social, economic and ethical barriers to innovation in general and the spread of beneficial technologies. As a tool for governing technology, TA can steer investments towards responsible research and innovation, and help to attain social inclusion, environmental sustainability and economic development.

Methodologies for TA are evolving rapidly since the 1970s from more linear reductionist reactionary to systemic anticipatory approaches, and from technocratic expert intra-disciplinary exclusive events to inclusive transdisciplinary multi-stakeholder processes. Adrian Ely, Patrick Van Zwanenberg and Andrew Stirling (2011)[9] provide a succinct analysis of evolving 'models' and methodologies for TA. According to their study, TA has evolved from an exclusive experts' or technocratic exercise to democratic pluralistic inclusive techno-political processes that harness public opinion and expert knowledge to inform policy.

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[6] Cho, Y., and Daim, T., 2013, Technology Forecasting Methods, p. 67-112 in Tugrul U. Daim, Terry Oliver and Jisun Kim (2013*) Research and Technology Management in the Electricity Industry: Methods, Tools and Case Studies*. Springer Publishers.

[7] Bütschi, D., and Almeida, M., 'Technology Assessment for Parliaments – Towards Reflexive Governance of Innovation', p.65 in Klüver, Lars, Rasmus Øjvind Nielsen, and Marie Louise Jørgensen, eds. *Policy-Oriented Technology Assessment Across Europe: Expanding Capacities*. Basingstoke: Palgrave Macmillan, 2016. doi: 10.1057/9781137561725.0013.

[8]Borgman, A., 'A Moral Assessment of Technology', p.207-213 in Winner, L., 1992, *Democracy in a Technological Society*. Kluwer Academic Publishers.

[9] Ely, A., Van Zwanenberg, P. and Stirling, A., 2011, New Models of Technology Assessment for Development, STEPS Working Paper 45, Brighton: STEPS Centre.

The classical top-down non-participatory TA approach is where government or funding agencies establish experts' committees to assess risks or impacts of a technology or technologies. The experts committees, may or not, hold consultations with various non-expert stakeholders, prepare technical reports that are submitted to government or funding agency. This approach prevails in many countries around.

Participatory inclusive non-technocratic TA approaches are taking root since the 1990s, particularly in individual European Union (EU) countries and at the Union level.[10] These approaches are guided by certain basic principles of good governance and policymaking. Such principles are participation, transparency and accountability in STI policymaking. Baark (1991)[11] classified TA into four types: (a) *promotional TA* the approach that focuses on the development of technological innovation in the interest of national competitiveness or development, (b) *regulatory TA aimed at* assisting governments or the state to exert control, in a reactive sense, over actual or projected impacts of technology, (c) *constructive TA***,** this form of TA does not accept that the course of technological development is deterministic and it seeks to tune the relevant development according to social and political priorities, and (d) *participative TA*, this is an extension of the constructive approach with a wide spectrum of parties at interest participating in testing technological alternatives and/or performing social experiments to improve the design of the innovation. Baark's classification helps to examine the evolution of TA. For example, OTA in the USA was mainly conducting mainly regulatory TA and to a smaller extent promotional TA. European TA offices focus more on constructive TA.

Overall, TA is becoming a powerful toolbox for STI policy. Its usage or application is gaining currency around the world as countries and regions (e.g. the European Union) intensify or increase their focus on STI as key assets in securing the global Sustainable Development Goals (SDGs). Key institutions such as ministries of STI, national and local parliaments, research funding agencies, environmental protection agencies, health and medicines regulatory agencies, technical standards agencies, investment banks and related regulatory agencies, and citizens' movements are starting to be involved in various aspects (and forms) of TA either directly or indirectly.

1.2 Global trends in Technology Assessment: Institutions and practices

One of the first TA efforts was undertaken by the USA National Science Foundation through a programme led by Joe Coates in the 1970s. Coates defined TA as "the systematic study of the effects on society, that may occur when a technology is introduced, extended, or modified, with emphasis on the impacts that are unintended, indirect, or delayed."[12] This initiative or programme may have stimulated the institutionalization of TA when the Office of Technology Assessment (OTA) was established in 1972 in the USA. OTA was established to provide Congressional members and committees with objective and authoritative analysis of the complex scientific and technical issues. The OTA operated until 1995 and produced approximately 750 full assessments, background papers, technical memoranda, case studies, and workshop proceedings spanning a wide range of topics. It was closed or disbanded, but

[10] Ely, A., Van Zwanenberg, P. and Stirling, A., 201, op. cit.
[11] Baark, E. 1991**.** "Development Technology Assessment-Some theoretical and methodological issues." Paper presented at the United Nations/Office of Technology Assessment Workshop on Technology Assessment for Developing Countries, Washington DC, November [UN Branch for Science and Technology for Development].
[12] Coates, J.F. 1976**.** "Technology assessment-A tool kit." Chemtech (June): 372-383

different departments of state (e.g. agriculture, energy, health and defence) continued to undertake TA on sectoral and ad hoc basis with no direct authorization by Congress.

In 2002, Congress directed the Government Accountability Office (GAO) to bolster its technology assessment capabilities. Between 2002 and 2019, GAO conducted 16 TAs, and in 2019 established an office, Science, Technology Assessment, and Analytics (STAA), dedicated to TA. The GAO is building STAA into a fully-fledged centre of excellence in TA with expertise to conduct comprehensive participatory TAs so to advice Congress and other decision-making bodies on various technology policy issues.

In many countries in Europe TA is being, increasingly, institutionalized in various forms and agencies since the 1980s. Nentwich (2016) provides a good analysis of European TA institutions and practices.[13] Drawing lessons from the USA's OTA, France (1983), the Netherlands (1986), Denmark (1986), the United Kingdom (1989), and Germany (1990) established programmes and/or offices for TA. These countries established different configurations of TA offices in their parliaments.[14] France was perhaps the first country in Europe to institutionalize parliamentary TA with the creation of the Parliamentary Office for Evaluation of Scientific and Technological Options (OPECST) in 1983. In Germany, the Office of Technology Assessment at the German Bundestag (TAB) is an independent office established in 1990 but is administered by the Institute for Technology Assessment and Systems Analysis (ITAS).[15] The ITAS is one of the institutes of the Karlsruhe Institute of Technology (KIT). Together with the Institute of Futures Studies and Technology Assessment (IZT), KIT mobilizes and provides to TAB the best available expertise and infrastructure for TA in the country.

In the United Kingdom (UK), the Parliamentary Office of Science and Technology (POST) was established in 1989 inspired by the USA OTA model and experience. However, the UK POST has a broader customer base than the OTA in the sense that unlike the OTA, it provides TA to both houses of parliament not to specific committees. It has a more flexible remit and provides independent policy analysis to the UK Parliament. POST has an independent Board that develops its work programme and governs its operations.

Today, most countries in Europe has offices or institutes dedicated to TA either linked to legislatures or to executive branches of government, or even to both state organs. Such 23 offices or institutes established or constituted the European Parliamentary Technology Assessment (EPTA) in 1990. The EPTA is a network and its members (the 23 offices or institutes) advise parliaments on social, environmental and economic impacts of new technologies and related scientific developments. It has become a good mechanism for sharing expertise, information and experiences in TA in Europe and around the World.[16] In 2011, the European Commission launched the PACITA project to support EU member states in institutionalizing TA.

[13] Nentwich, M., 2016. Parliamentary Technology Assessment Institutions and Practices: A Systematic Comparison of 15 Members of the EPTA Network. Austrian Academy of Sciences www.epub.oeaw.ac.at/ita/ita-projektberichte/ITA-AIT-3.pdf

[14] Vig, N.J. (1992). "Parliamentary technology assessment in Europe: Comparative evolution" *Impact Assessment Bulletin 10* (4): 3-24.

[15] www.tab-beim-bundestag.de

[16] See Nentwich, M., 2016, op. cit.

In Asia, a number of countries have also established TA or TA-like institutes and programmes. In study on technology assessment in Japan and Europe, Antonio Moniz and Kumi Okuwada (2016)[17] map Japan's institutional landscape of TA and TA-like initiatives largely led or stimulated by the Research Institute of Science and Technology for Society, of the Japan Science and Technology Agency (JSTRISTEX). Another study by António Moniz, Go Yoshizawa and Michiel Van Oudheusden (2015) provides a good analysis of the evolution of and experiences in TA in East Asia.[18] They argue that institutionalization of TA is slow in East Asia despite rapid technological developments or advances in the region. Many countries in the region do not have parliamentary offices dedicated to TA or well-configured institutional mechanisms to link TA programmes to legislative processes. There are challenges or differences in how the countries conceptualize and practice TA. For example, in "Japan, TA has come into the spotlight several times since the 1970s, but serious misinterpretations have impeded its effective societal embedding over the last forty years…., technology and policy experts directed their attention to technology and to a limited range of technology's impact, as if TA were synonymous with an "evaluation of technology" or "technical assessment."[19]

Other Asian countries such as South Korea, Singapore, Malaysia and Taiwan have established programmes for TA and TA-like initiatives. South Kores established the National Assembly Futures Institute (NAFI) in the mid-1990s. The NAFI is an associate member if the EPTA and focuses on technology foresighting and monitoring governmental TA activities.

Many developing countries are adopting and starting to practice TA and TA-like activities after several years of hesitation that TA was being imposed on them to stall their development. There is now a surge of interest in TA in many developing countries, largely influenced by variety of factors. First, there has been significant raise in awareness of social, environmental and even risks that may be associated with some technologies or 'ungoverned' technological change. Since the 1980s with the adoption of United Nations conventions and protocols on biological diversity, biosafety, climate change and land degradation, there many developing countries have embraced TA and have been at the forefront of advocating for the transfer of environmentally sound technologies.

Second, some developing countries have witnessed massive failures of huge investment projects e.g. dams, telecommunications, and irrigation schemes because they did not make appropriate or wise technology choices. Social dislocation and environmental degradation have been outcomes of many big investments in transport, agriculture and energy in different parts of the world. There are also many cases of social resistance to new technologies because they introduced into communities or economies without appropriate adequate engagement with or of users. In *Innovation and its Enemies*, Calestous Juma (2016) offers a rich historical account of social tensions over new technologies.[20] He argues for governance of technology to be integrated into or be a core part of STI policies.

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[17] Moniz, A., and Okuwada, K. 2016. *Technology Assessment in Japan and Europe*. Karlsruhe Institute of Technology (KIT) Scientific Publishing.

[18] Moniz, A., Yoshizawa, G., and Van Oudheusden, M. 2015. Technology Assessment in East Asia Experience and New Approaches in *Varieties of Technology Assessment Practices*. Proceedings of International Conference file:///C:/Users/u04216482/Desktop/Technology%20Assessment/Technology%20Assessment%20Asia.Proceedings_Berlin_FINAL-2.0_144.pdf

[19] Moniz, A., Yoshizawa, G., and Van Oudheusden, M. 2015, op. cit. p. 291.

[20] Juma, C., 2016. *Innovation and Its Enemies: Why People Resist New Technologies*. Oxford University Press, USA.

The 1980s an 1990s witnessed an institutional surge in TA and TA-like activities in energy, health and agriculture. At the international level, United Nations agencies and programmes and bodies such as the World Bank, the World Energy Council (WEC) and the Consultative Group on International Agricultural Research (CGIAR) have adopted TA in the investment policies and programmes. The former UN Centre on Science and Technology in New York used to produce UN Advanced Technology Assessment Series reports in the 1980s. UNCTAD has been a source of analytical studies on TA focusing on biotechnology, nanotechnology and other emerging technologies. The United Nations Environment Programme (UNEP) and the Global Environment Facility (GEF) have over the past two decades or so supported developing countries to institute biosafety—assessment and management of risks of biotechnology. The World Bank in collaboration with UN agencies supported the *International Assessment of Agricultural Knowledge, Science and Technology for Development 2003-2008*, a multi-stakeholder consultative or participatory TA process that assessed the impacts of new technologies in agriculture.

Bibliometric analysis also show that TA has gained currency as a research topic. There has been a significant rise of academic interest in research on TA since the early 2000s. Our bibliometric analysis show that between 2010 and 2019, 246417 research publications on TA were generated or produced globally. The most prolific countries were USA (25.6%); China (15.3%); England (7.7%); Germany (6.1%); and Italy (5.3%). The most prolific organisations were the University of California System (1.8%); Chinese Academy of Sciences (1.3%); University of London (1.1%); CNRS (1.0%); Harvard University (1.0) and US department of Energy (0.9%).

1.3 Policy instruments for technology assessment

There is a variety of international, regional and national policy instruments for TA. They can be categorized as explicit and implicit policy instruments. Explicit policy instruments are those that designed and applied to deliberately promote TA, while implicit ones are those that though not intended for, can be used to promote and guide TA. At the international level, policies for TA are deposited or provided for in international technology, trade, environmental and health conventions or treaties. The conventions include the 1992 Convention on Biological Diversity and its Cartagena Protocol on Biosafety, the SDGs, the 2015 Paris Agreement (on the implementation of the United Nations Framework Convention on Climate Change), and the World Trade Organization (WTO) agreements contain explicit and implicit policy provisions on TA. For example, Articles 10 and 11 of the Paris Agreement contain provisions requiring State parties to share information on specific technologies and associated climate risks and benefits. Articles 14 (Impact assessment and minimizing adverse impacts), Article 16 (Access to and transfer of technology), Article 18 (technical and scientific cooperation), and Article 19 (handling of biotechnology and distribution of its benefits) contain provisions that countries should invoke to institutionalize TA, and cooperate to building capacities for TA at national and regional levels. The challenge is there is limited awareness of the international policy instruments and their utility in facilitating TA.

At regional levels, implicit and explicit policy provisions for TA are found in regional economic and trade integration frameworks such as the Agreement Establishing the African Continental Free Trade Area (AfCFTA), the ASEAN Free Trade (AFTA) Agreement, Common Market for Eastern and Southern Africa (COMESA), and some of the regional STI protocols. For instance, Article 2 of the Protocol on Trade in Goods under the AfCFTA aims

at promoting inclusive and sustainable industrialization, Article 21 is about product standards and Article 26 contains provisions requiring that trade in goods does not cause environmental damage and ensures conservation of natural resources. These are implicit TA policy instruments.

1.4 Institutional configurations for technology assessment

Widespread literature about new models of TA suggest that the success of a TA mission depends on the extent to which diverse circles of actors are acknowledged and accommodated in the knowledge input and decision-making processes of technological change in a society. The prevailing institutional configurations and their associated concepts of participation, collaboration and feedback are discussed here.

The state plays a vital role in ensuring equitable participation and access to the various actors who will be impacted by technological change.[21] This can be characterised by support for skills development and capacity building. It can also be manifested in public awareness campaigns, topical conferences or national workshops. Government may also stimulate social dialogue through public debate in order to identify key areas that can contribute to forming political opinion and eventually a technological development. National institutions for TA include National Steering Committees to guide and establish the scope of the assessment or Sectoral Institutions from health, agriculture or energy and mining ministries.

Another institutional arrangement for TA exists within industry where actors constitute representatives of new and emerging technologies that can improve access to modern energy services and enhance agricultural productivity and livelihoods.[22] For industrialists, questions of accountability become important especially when considering the impact technologies may have on coming generations - issues concerning the degradation of the environment have gained traction for many productive industries which have taken a greater interest in TA for sustainable development. It can be characterized by state-commissioned project bidding that require independent firms to experiment with new technologies on a priority area articulated by government. This institutional arrangement could also involve collaborative design between a target community and a producer – the consumer would then provide feedback for continued technology development.[23]

Research institutions play a vital role in designing TA methods and evaluating results of TA missions specifically geared towards advancing knowledge. These can be characterized by research and development (R&D) programs, university and research institutions that support knowledge-generating activities from academia and technical communities. Some knowledge-generating approaches used in TA include social judgement techniques, focus groups, polling of public opinion, content analysis, census and scenario development. These approaches are used to draw out variables and probe different possible results from social groups in a controlled environment.

[21] David Christensen and Arne Remmen. "New Modes of Constructive Technology Assessment for Developing Countries. (*Sustainable Innovation 2013*).
[22] Thien Tran, and Daim Tugrul Daim, *A taxonomic review of methods and tools applied in technology assessment*, (Technological Forecasting and Social Change, 2008), 1396.
[23] Tran 2008

Multi-lateral or network arrangements create avenues to obtain insight from a broad range of actors.[24] An example of such an arrangement is the Global Energy Assessment (GEA) conducted by the International Institute for Applied Systems (IIASA) engaging governments, NGOs, United Nations agencies and private sector to assess energy opportunities, challenges and strategies for developing economies.[25] The benefit of this approach is that it has the power to bring specific issues to the foreground of international norms and policy debate through collective efforts.

Transnational TA arrangements involve a broad range of international partnerships for TA centered around challenges of the global commons like climate change and global health pandemics.[26] The internet and ICTs emerge as a viable transnational institutional configuration for TA. The virtual and digital space offers new opportunities for developing countries to reduce cost of TA and also to ensure diversity and inclusivity in participant groups. Transnational TA are gaining significance due to the rapid technological advancements in emerging economies like India, China and Latin America.

Legislative institutions become important when considering questions of standards, ethics, equitable representation and accountability for those who create a technology, those who will use a technology and those who will be impacted by its use. These can manifest in agenda setting efforts by multiple stakeholders during policy negotiations as part of the first stage of public policy formation.[27] It can also be manifested in advocacy work from IP lawyers and practitioners who take a social justice approach to property rights acting as an intermediary between society and protected innovations (this is particularly relevant in the pharmaceutical and biodiversity sectors).

It is important to ensure gender balance in the team that will be implementing the TA mission.[28] If the TA teams are majority male or majority female, it may have consequences on the types of technology selected as there may be differing preferences based on prevailing gendered activities. The AfNet Steering Committee is an example of the prioritization of gender balance in an African TA related effort. Designing and disseminating technologies in a gender-sensitive way can impact technology adoption and potentially yield positive outcomes for male and female farmers. This is especially important for women who have slower rates of technology adoption than men.

Moreover, the dissemination of information, outreach and awareness-raising campaigns are also key features of TA capacity that impact participation at multiple levels of a project. Sustainable Energy Africa (SEA) represents an African sustainability-focused initiative that has been supporting stakeholder participation and capacity building through their information dissemination portal called Urban Energy Support. Contributing to stakeholder participation in a similar way is the Africa Forum on Science, Technology and Innovation hosted by the African Development Bank (AfDB) that involves civil society in decision-making processes by compiling insights from the Forum to create a roadmap for national STI policies. Another program having a bearing on African TA capacity and seeking to enhance policy and regulation

[24] Adrian Ely, Patrick Van Zwanenberg and Stirling Andy, *New models of technology assessment for development.*(STEPS, 2011), 25
[25] International Institute for Applied Systems, *Global Energy Assessment*, (Cambridge University Press, 2012)
[26] Ely 2011
[27] Ida-Elisabeth Andersen, and Birgit Jæger Birgit, *Scenario workshops and consensus conferences: towards more democratic decision-making, (Science and public policy* 26.5,1999), 331.
[28] Ely 2011

in Africa is the African Science, Technology and Innovation Policy Initiative hosted by UNESCO.

2. Status overview of technology assessment in Africa

2.1 Overview of technology assessment in Africa

Technology assessment (TA) is in its infancy in Africa. It is less common or practiced and institutionalized in Africa. So far, its conceptualization and application have been ad hoc and largely conducted by consultants as part of externally funded policy initiatives. TA has been often conceptualized around identification of unintended impacts or as cost-benefit analysis of technologies and/or new infrastructure projects (e.g. roads, rail and dams). Some aspects of TA have been embedded in environmental impact assessment (EIA) activities or programs that are now more institutionalized and legislated in many African countries. In the EIAs, emphasis is often placed on environmental impacts of technologies or investment projects in general. Environmental protection agencies are the main institutional mechanisms for undertaking EIAs, and often there is less synergy or coordination between such processes and national STI policy-making processes.[29] The conduct and governance of EIAs tends to be increasingly participatory in most African countries because of the existence of legislation and citizen groups or activists for the protection of the environment. This is not the case for STI policy where there are relatively small civil constituencies, budget deficits and weak institutional (particularly) executive leadership.

TA has also be conceptualized as part of health technology and medicines regulatory or approval processes in some African countries. Domiciled in ministries or departments of health, aspects of TA focus on assessing side effects or health risks of medicines, drugs and other health technologies. Some of these efforts have been tagged or labelled health technology assessment. This is misleading because such efforts or processes do not focus on societal effects but are narrowly aimed at health or medical aspects of technologies. Moreover, they are often not linked to or feeding into national STI policymaking. This is mainly because health ministries or agencies and government agencies in general tend to work or operate in 'silos', with limited synergies to each. There is also a tendency to rigidly define STI policy as the exclusive mandate of ministries of STI. In addition, ministries or departments of STI tend to less influential or powerful in the organizational structure of government, and thus are less resourced and capacitated to mobilize other government agencies to engage in multi-sectoral ways in TA which is multi-disciplinary and cross-sectoral.

Health TA has become a key part of public policy to respond to COVID-19 and related crises around the world. There is recognition that AI, digital innovations and data science offer an array of opportunities to help effectively combat the pandemic and pre-empt and prevent future infectious disease epidemics in SSA. They can enable health practitioners and policy-makers to design and implement context-specific interventions to trace, test and treat COVID-19 and other viral infections. Al, digital innovations and data science are pervasive and converging in unprecedented ways, making it possible to search for and develop treatments, exploit available scientific information about the pandemic and related epidemics, assist enforcement of containment policies, and monitor the impact of the disease on patients as well as on socio-economic systems. A number of countries in Africa are harnessing the technological and

[29] Mugabe, J., 2019. Governance of Science, Technology and Innovation in Africa in Kameri-Mbote, P., et al *Blazing the Trail*. University of Nairobi

scientific opportunities to confront and manage the COVID-19 pandemic and other infectious disease epidemics.[30]

2.2 A tentative bibliometric mapping of TA in Africa

The past decade or so witnessed growth or increase in publications on TA in Africa. A bibliometric analysis or search[31], shows that publications on TA and TA-like activities increased from 241 per year in 2010 to 1471 per year in 2019. During the period 2010 to 2019, a total of 7114 publications on TA and TA-like areas, both journal articles and papers in conference proceedings in the Web of Science (WoS) database.

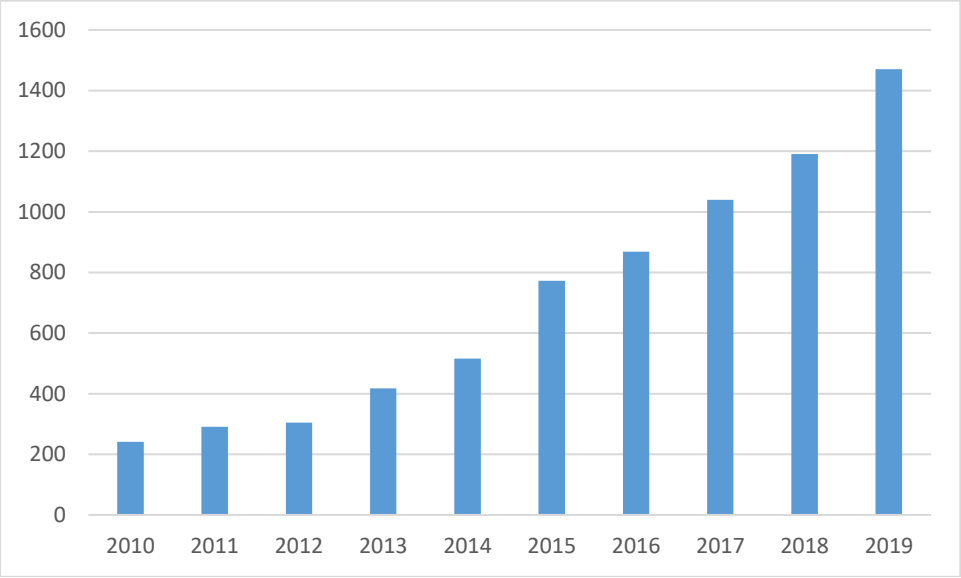

Figure 1: Number of publications on research on TA and TA-like activities in Africa 2010-2019.

Source: Scientometric analysis WoS database, January 2021

Table 1 provides an indication of publications on TA and TA-like fields per country in Africa. South Africa had the largest number of publications, producing 36.7% of the continent's total publications on TA and TA-like activities or subjects. Egypt follows with 14.9% of the publications. Kenya and Tunisia produced each 7.6% of the publications during that period, 2010-2019.

[30] Mugabe, J. and Manyuchi, 2021. Unlocking systemic barriers to innovation to respond to COVID-19 in Africa. Working paper, University of Johannesburg, South Africa.

[31] Scientometric/bibliometric analysis is undertaken in order to identify strengths and weaknesses in the research domains under investigation of the individual African countries, their domains of emphasis/priorities, their centres of expertise, their collaborative patterns, their main funding organisations, etc.

Table 1: TA publications in per country Africa

Country	Number of publications	% of 7114
South Africa	2616	36.7%
Egypt	1065	14.9%
Kenya	544	7.6%
Tunisia	543	7.6%
Morocco	471	6.6%
Ghana	367	5.1%
Algeria	335	4.7%
Ethiopia	229	4.2%
Tanzania	244	3.4%
Uganda	242	3.4%
Nigeria	146	2.0%

Source: WoS database, January 2019

Institutional actors in research on TA and TA-like activities in Africa are mainly public universities. They include the University of Pretoria, University of Cape Town, University of Kwazulu Natal, University of Witwatersrand, Stellenbosch University, University of Johannesburg and University of South Africa (UNISA) in South Africa, Cairo University in Egypt, and Mohammed v university of Rabat in Morocco, and research institutes such as and the Council for Scientific and Industrial Research (CSIR) in South Africa.

Table 2 below shows that most of the research publications on TA and TA-like activities are in health, energy, agriculture and mining. Health TA is

Table 2: Classification of TA documents to broad scientific areas

Broad Scientific Area	Number of TA publications
Health	1156
Energy Fuels	620
Agriculture	609
Mining	75

2.3 A review of illustrative African initiatives for technology assessment

As stated earlier, TA is relatively new or less institutionalized in Africa. Various national, regional and international TA and relative initiatives have been undertaken in Africa in the past decade or so. Most of the national TA initiatives have focused new technologies, particularly biotechnology, nanotechnology and advanced manufacturing technologies. Biotechnology focused TA have been mainly in agriculture, with emphasis on biosafety of genetically modified crops. Framed as risk assessment of biotechnology development and application, TAs have been conducted in Burkina Faso, Ghana, Kenya, Namibia, Nigeria, Uganda, South Africa, Zambia and Zimbabwe. Guided by UNEP/GEF Guidelines for National Biosafety, these countries held expert and multi-stakeholder TA workshops, and some of them (for example Egypt, Kenya and South Africa) established biosafety committees of experts to frequently assess specific biotechnology products.

A study by David P. Keetch, Diran Makinde, Cholani K. Weebadde and Karim M. Maredia (2014) provides an overview of biosafety practices and experiences, and some of TA initiatives in agricultural biotechnology.[32] The case studies in the book saw that at least 10 African countries have adopted crop GM technologies and have conducted some form of risk assessment studies with emphasis on environmental and human health aspects. These assessments have been largely promotional. The study concludes that most of the countries do not have capacity for participatory TA in biotechnology.

South Africa experimented with both expert-led top-down and multi-stakeholder participatory biotechnology assessment initiatives. In 2001, the then Department of Arts, Culture, Science and Technology (DACST) established an experts' committee comprising of scientists from a variety of disciplines including science and innovation policy, economics and law, to provide an independent assessment of biotechnologies in agriculture, health, mining and industrial applications of the biotechnologies, propose to DACST and the country cabinet a national strategy for biotechnology. The committee had two international non South Africa experts. It conducted risk and cost-benefit analysis and proposed a national strategy for modern biotechnology. Government adopted the National Biotechnology Strategy in 2001. The Department of Science and Innovation (DSI) reviewed the strategy and developed a National Bioeconomy Strategy in 2016.

Participatory TA has been tried through South Africa's Public Understanding of Biotechnology (PUB) programme launched in early 2003 by South African Agency of Science and Technology Advancement (SAASTA) funded the National Research Foundation. The overall aims of PUB (www.pub.ac.za) are to build public awareness and understanding of biotechnology, and to promote public dialogue and debate on socio-economic and environmental impacts of the technology. PUB has conducted several studies and surveys including two assessments of public perceptions of biotechnology, its benefits and risks.[33] In the early 2000s, PUB and the National Advisory Council on Innovation (NACI) organized public workshops and seminars at provincial and national levels to solicit public views on and inputs to biotechnology policies.

SAASTA also coordinates the Nanotechnology Public Engagement Programme (NPEP) funded by DSI. The aim NPEP is to provide "information to enhance the public's knowledge and understanding of nanotechnology. … (and) to enable informed decision making on nanotechnology innovations to improve the quality of life."[34] In 2003, DSI (then DST) established a multi-stakeholder consultative process—the South Africa Nanotechnology Initiative (SANi)—for nanotechnology assessment to develop a National Nanotechnology Strategy. The process of developing the strategy was enriched by public views gathered through the NPEP.

In the area of energy in South Africa, TA has largely been conducted at a number of public universities as part of their research and doctoral programmes. For example, at the Stellenbosch University there have been at least five doctoral research dissertations completed in the past decade on energy technology assessment. Once such dissertation, Musango (2012), provides a good analysis of the status of energy TA in South Africa. It concludes: "In the South Africa

[32] Keetch, D., Makinde, D., Weebadde, C., and Maredia, K. (2014), Biosafety in Africa: Experiences and best practices. Michigan State University, East Lansing.
[33] See for example DST, 2015, *Public Perceptions of Biotechnology in South Africa*. Department of Science and Technology, NRF, SAASTA and PUB www.pub.ac.za
[34] www.saasta.ac.za

context, specifically, there is no formal and coherent approach to energy technology assessment from a sustainability perspective. Without a formal comprehensive or well integrated technology assessment approach to evaluate the sustainability of any technology, the policymakers, technology designers, and decision-makers are faced with difficulty in terms of making reasoned decisions about the appropriate technology options."[35]

In the past three years or so, the South African National Energy Development (SANEDI) has commissioned or funded a number of TA-like exercises at the Stellenbosch University, University of Pretoria and University of Cape Town. SANEDI has the Applied Energy Research, Development and Innovation Programme and is establishing centres of excellence in energy research and innovation in the country.[36] One such centre is the Renewable Energy Centre of Research and Development (RECORD) with a remit to coordinate TA activities.[37] Most of SANEDI's programmes are relatively new and the institute lacks adequate capacity for TA. According to one official from the DSI, SANDI should be encouraged to invest more in TA activities at universities and the CSIR. However, these investments and related TA outputs should be directly linked to national energy technology policy-making processes in the country.[38]

There is scanty information on energy TA in other African countries. Studies such as Salif S., Sarkodie O.W. and Gnamien C.K (2016)[39] use the concept or phrase 'energy technology assessment' to refer to the status of energy technologies or technologies deployed in the energy sector. They do not focus on the assessment of risks and benefits of specific energy technologies. However, there are some recent academic studies such as Agunyo, Bacwayo and Kizza-Nkambe (2020)[40] and Nabuuma and Okure (2006)[41] focus on energy TA in Uganda, and Adenle (2020)[42] is a TA-like research focusing on benefits and risks of solar energy technologies in Ghana, Kenya and South Africa. These academic energy TA studies can be useful bases for setting comprehensive policy TA exercises in the countries.

In the area or sector of health, there have been several TA and TA-like initiatives in different African countries. Focusing mainly on assessing risks of health technologies (particularly medicines, vaccines, and devices) many African countries are starting to invest in TAs as part of their regulatory governance mechanisms to ensure that the technologies do not cause have side-effects or cause harm to patients or are generally safe to use in healthcare. Health TA has also been used to inform resource allocation in healthcare systems in Africa.

There a number of studies on HTA, its conceptualization and practice in the region. For example, a doctoral thesis by Kachieng'a (1999) on the application of HTA comparing Kenya

[35] Musango, J., (2012), Technology Assessment of Renewable Energy Sustainability in South Africa, p 32. PhD Dissertation, Stellenbosch University.
[36] www.sanedi.org.za
[37] www.record.org.za
[38] Personal communication with staff/official of DSI, Pretoria, 18 January 2021.
[39] Salif S., Sarkodie O.W. and Gnamien C.K, 2016. Renewable Energy Technology Assessment: Case Study of Senegal, Ghana & Cote d'Ivoire.
[40] Agunyo, M., Bacwayo, E.K. and Kizza-Nkambe, S., 2020, Assessment of the socio-cultural viability of integrated-to-energy systems for Uganda. *International Journal of Renewable Energy Technology* Vol 11, Issue, 3 pages 272-294.
[41] Nabuuma, B., and Okure, M., 2006, Field-Based Assessment of Biogas Technology: The Case of Uganda, pp.481-487 in *Proceedings from the International Conference on Advances in Engineering and Technology*, https://doi.org/10.1016/B978-00804512-5/50052-2
[42] Adenle, A., 2020, Assessment of solar energy technologies in Africa: opportunities and challenges in meeting the 2030 agenda and sustainable development goals. Energy Policy Volume 137, February 2020 111180.

and South Africa identified tentative efforts at designing and applying TA for health policy.[43] It identified lack of awareness and knowledge of TA among policy-makers, institutional disarticulation (e.g. between departments of health and those for STI). In Tanzania, "[b]etween the period 2014 and 2018, HTA was introduced … with a formal HTA committee being established and inaugurated followed by the successful completion and adoption of HTA into the National Essential Medicines List of Tanzania (NEMLIT) revision process by the end of 2017. Consequently, the country is in the process of institutionalizing HTA for decision making and priority setting."[44] In South Africa, "HTA is yet to be institutionalised or consistently applied in South Africa. The country aims to include this agenda as South Africa moves towards UHC through implementation of the National Health Insurance (NHI)."[45] The South African National Department of Health (DoH) published policy guidelines on HTA in 1997 and established a steering committee. However, little has been done to move to practice, particularly participatory HTA that focuses on wider social, economic and environmental imacts of health technologies.

A study by Ahmad Fasseeh, et al (2020) concluded that HTA is still in its infancy in North Africa.[46] It outlines a number of capacity constraints or challenges to institutionalizing HTA in the region. These include limited skills, lack of awareness and knowledge of TA, weak policy and legislation, lack of dedicated budgets for TA, and technocratic centralized cultures of public policy-making.

In additional national TA and TA-like initiatives, the African Union (AU) has tried to launch continental or multinational TAs for biotechnology and other emerging technologies. One case of Africa-wide TA for biotechnology is the AU High-Level Panel on Modern Biotechnology (APB) established by the African Union (through ministerial and presidential decisions and declarations) in 2005. The APB comprised of experts from the continent and from outside conduct the TA. Its operations and remit were largely based on the AU Summit decisions, in particular the following:

- Declaration of the First NEPAD Ministerial Conference on Science and Technology (adopted on 7th November 2003), whereby AU Member States committed to "[r]esolve to build regional consensus and strategies to address concerns emerging with advances in new technologies, including biotechnology, nanotechnology, and information and communication technologies"

The APB review a large body of reports on biotechnology—its risks, benefits and governance, conducted stakeholders' consultations in regions of the continent, organized public hearings, received submissions from researchers, NGOs, individual citizens and private sector. In 2007, the Panel produced and submitted to the AU Summit (Heads of State and Governments) a

[43] Kachieng'a, M.O., 1999. Health technology assessment in Sub-Saharan Africa: a cross-national study of Kenya and South Africa. PhD Dissertation, University of Cape Town.
[44] Surgey G, Chalkidou K, Reuben W, Suleman F, Miot J, Hofman K (2020). Introducing health technology assessment in Tanzania. *International Journal of Technology Assessment in Health Care* 36, 80–86. https://doi.org/10.1017/ S0266462319000588
[45] Kim MacQuilkan, Peter Baker, Laura Downey, Francis Ruiz, Kalipso Chalkidou, Shankar Prinja, Kun Zhao, Thomas Wilkinson, Amanda Glassman & Karen Hofman (2018) Strengthening health technology assessment systems in the global south: a comparative analysis of the HTA journeys of China, India and South Africa, Global Health Action, 11:1, 1527556, DOI: 10.1080/16549716.2018.1527556
[46] Fasseeh, A., et. al., 2020, Implementation of Health Technology Assessment in the Middle East and North Africa: Comparison Between the Current and Preferred Status. *Frontiers in Pharmacology*, February 2020, Vol. 11, Article 15 www.frontiersin.org

report, *Freedom to Innovate: Biotechnology in Africa's Development*. The report was adopted by the AU Summit and Regional Economic Communities (RECs) in 2007. The APB was largely a form of participatory TA process. Some countries such as South Africa have and RECs such as SADC have used some of the evidence and recommendations of the Panel to develop programmes and policies for biotechnology.

Another AU effort at TA is the African Union High Level Panel on Emerging Technologies (APET). In January 2016, the AU Summit Heads of State and Government decided that the AU Commission and NEPAD should establish "a system of obtaining expert contributions on the matters of technology development, and the acquisition and deployment for economic development."[47] The AU Commission establish a ten-member team of APET comprising of eminent persons. The APET has conducted "a survey to ascertain emerging technologies of potential economic importance. The panel identified ten emerging technologies as priority areas of relevance for Africa's socio-economic development." So far, it is unclear the AU and individual countries are using APET's reports and advice. From discussions with two officials at AU Commission and NEPAD (AU-AUDA), the challenge of turning advice from APET into policy pertains to weak institutional arrangements at national levels. It is also due to a lack of active engagement of legislative or parliamentary institutions in STI policy processes.

2.4 Policies and institutional arrangements for TA in Africa: Illustrative examples

Policies are critical for institutionalizing and governing TA at national and even regional and international levels. As indicated in section 1.3 of this paper, explicit and implicit policy provisions for institutionalizing and conducting TA are deposited in some international and regional trade and environmental treaties. However, actualizing these requires national measures for domestication of TA. Some African countries have policies for promoting or institutionalizing TA in their STI, environmental, Foreign Direct Investment (FDI) and trade policy frameworks. For purposes of this paper, we give identify STI policy frameworks that contain provisions for TA.

In Uganda's 2009 National Science, Technology and Innovation (STI) Policy explicit provisions for TA are outlined in section 4 of the policy document.[48] They are articulated or stated as part of the policy objective of creating an enabling environment to foster STI for national development. The five main provisions are:

"(i). Conduct technology audits and forecasts and advise on STI policy and programs.
(ii). Conduct policy studies on topical issues to facilitate evidence-based advice and decision making in all matters pertaining to STI.
(iii). *Evaluate and promote technology choices for public and private sector investment* (italics emphasis is ours)
(iv). Create a system to facilitate the transfer, promotion and development of technologies.
(v). Strengthen collaboration with Research and Development Institutions (RDIs), professional bodies, private sector, NGOs and civil society in facilitating technology transfer and utilization.

[47] www.nepad.org
[48] Republic of Uganda, 2009. *National Science, Technology and Innovation Policy*. Ministry of Finance, Planning and Economic Development, Kampala.

Kenya's National Science, Technology and Innovation Act of 2013 also contains policy provisions for promoting TA.[49] The overall objective of the Act of Parliament is to "facilitate the promotion, co-ordination and regulation of the progress of science, technology and innovation of the country; to assign priority to the development of science, technology and innovation; to entrench science, technology and innovation into the national production system and for connected purposes."[50] The Act establishes the National Commission on Science, Technology and Innovation (NACOSTI) whose functions include to: "(a) develop, in consultation with stakeholders, the priorities in scientific, technological and innovation activities in Kenya in relation to the economic and social policies of the Government, and the country's international commitments; … co-ordinate, monitor and evaluate, as appropriate, activities relating to scientific research and technology development; …promote the adoption and application of scientific and technological knowledge and information necessary in attaining national development goals."[51]

Under Article 15(3) of the Act, technologies or materials imported into or exported out of Kenya must meet environmental, food safety, human health standards that are set in legislation such as (a) the Industrial Property Act (Cap. 509); (b) the Seeds and Plant Varieties Act (Cap. 326); (c) the Wildlife (Conservation and Management) Act (Cap. 376); (d) the Customs and Excise Act (Cap. 472); (e) the Biosafety Act (Cap. 321A). Some TA process or activities must be undertaken to enforce this provision of the legislation. According to this Act, NACOSTI has the legal responsibilities for ensuring that TAs are conducted. However, it has limited capacity to coordinate TA. Awareness of TA and skills for conducting such policy studies are in very short supply in the organization.[52]

Other African countries with policy and legislative frameworks with provisions on TA include Tanzania and Namibia. The 1996 National Science and Technology Policy for Tanzania has paragraphs 15 and 16, contain provisions for TA. Paragraph 15 of the policy states that "monitoring the importation or acquisition of foreign technology, including its evaluation and selection", and para 16 states that the Government shall "establish an appropriate legal framework for the development and transfer of technology, including Intellectual Property Rights, monitoring and controlling the choice and transfer of technology, as well as biosafety."[53] Namibia's 2014 National Research, Science and Technology Act has provisions on TA. It establishes the National Commission for Research, Science and Technology (NCRST) to coordinate TA, and technology forecasting and monitoring.

There are limited examples of TA missions on the continent however, specific institutional actors have taken up activities with aspects of TA. The actors involved in the following intuitional arrangements undertake TA missions for various reasons, sometimes remaining within their respective silos. Fragmentation of these institutions may undermine opportunities for learning, anticipation and feedback from TA missions in Africa. A case can be made for creating synergies amongst the various institutional configurations mentioned here.
The following represents a mapping of the institutional actors involved in TA in Africa and their arrangements, with particular focus on energy and agriculture:

[49] Republic of Kenya, 2013. *Science, Technology and Innovation Act No. 28 of 2013*. Government Printer, Nairobi.
[50] Republic of Kenya, 2013, op. cit.
[51] Republic of Kenya, 2013, op. cit.
[52] Personal communication with member of the Board of NACOST, 18 January 2021.
[53] Republic of Tanzania, 1996.

- Government entities are dominant actors for TA in Africa as the national development plans of various African countries recognise STI as important enablers for development. Government TA activities occur through public funded conferences, debates, research programs or projects administered by various national departments/ministries (E.g., Department of Science, Technology and Innovation or the Department of Mineral Resources and Energy).
- Research institutions are an important institutional arrangement for TA in Africa providing technical support to government and industry. African universities like Makerere University in Kampala, Uganda are increasingly pursuing innovative joint projects with private sector, government and civil society which have components of TA[54]. In the same way, collaborative research arrangements like the OpenAir African Innovation Research Partnership, SciSTIP and Tralac contribute to designing, conducting and building capacity for TA in Africa.
- Citizen juries are another TA arrangement that have been taken up in Mali[55] and Zimbabwe.[56] This approach has had particular success in India by affirming the voices of groups that are normally marginalized like women and people from lower castes.
- The TRIPS Council provides an avenue for negotiation and criticism (recognizing voices of public representatives) - South Africa and several other developing countries have recently made use of this arrangement - making a case for the social imperative of unrestricted or reduced restrictions to accessing medication.
- TA actors also exist in multi-lateral international configurations with actors like the United Nations Economic Commission for Africa (UNECA), UNESCO, and the World Bank.
- Regional institutional actors in Africa also conduct TA missions through regional partnerships like the East African Community which commissioned the Digital Health and Interoperability Assessments carried out by the East African Science and Technology Commission[57].
- Communities, households, farmers associations, workers unions are necessary actors of TA as they would directly or indirectly experience the impact of a technology introduction. It is necessary to include insight from these actors in the design, operation and implementation of a technological advancement.
- NGO's premised on societal and environmental objectives can play a useful role in advocating for inclusivity of society members in TA, or contribute to agenda setting.
- Funding institutions are vital to the practical
- surveys of success of TA that can sometimes be expensive – banks, national research funds, or public crowd funding campaigns provide a worthy source of financial support for TA. Some examples in Africa are, the National Research Foundation, SUNREF South Africa and the Technology Innovation Agency.

In the African context, the Africa Forum on Science, Technology and Innovation hosted by the African Development Bank seeks to involve civil society in decision-making processes by compiling insights from the Forum to create a roadmap for national STI policies. Another program having a bearing on African TA capacity seeks to enhance policy and regulation in

[54] Makere University College of Health Sciences, Strategic Partnerships: https://chs.mak.ac.ug/content/strategic-partnerships
[55] IIED 2007
[56] Rusike 2003
[57]East African Science and Technology Commission, East African Community Digital Health AND Interoperability Assessments Results at a Glance: Rwanda, (MEASURE Evaluation, 2020)

Africa through the African Science, Technology and Innovation Policy Initiative hosted by UNESCO.

Differing stages of STI development between African countries create disparities in the policy and legislative space required for TA. African countries would benefit greatly by explicitly defining what a regional TA policy framework would consist of as well as how far harmonization of standards should go - to form a clear regional agenda for TA – these questions will become increasingly important when managing TA capacity within the African Continental Free-Trade Area.

3. Technology Assessment CAPACITY in Africa

3.1 Overview TA capacity challenges

Based on unstructured interviews with 11 officials and representatives from DSI South Africa, NACOSTI Kenya, Stellenbosch University, AU Commission, and a review of reports and literature shows that there four categories of TA capacity needs in Africa. These are (a) awareness and knowledge (information) (b) skills or human resources (c) institutional arrangements, and (c) policy and legislative frameworks.

On the first category of capacity needs or challenges, awareness of and knowledge on TA is very limited in most African countries. All the 11 interviewees for this study identified lack of information on TA as one of the five main barriers to institutionalizing TA in most African countries. As shown from the bibliometric analysis, most of the TA publications are academic articles. These are not easily accessible to policymakers such parliamentarians and officials in STI departments or ministries. Generally, policymakers and civil society in Africa is not aware of TA and its usefulness in technology policymaking. Unlike for EIA, there is less media and newsletter coverage of TIA in Africa.
Related to awareness deficits, policymakers (including parliamentarians) in some African countries do not have access to appropriate methodological tools for comprehensive participatory TAs for STI policymaking. Most of the TA and TA-like exercises or initiatives conducted in Africa are ad hoc and not configured as part of STI policymaking or feeding into specific policy agendas because of organizers or agencies that do not have methodological tools or trained in TA.

The second category of capacity needs pertains to the paucity of TA skills or human resources in government departments of STI and parliamentary STI committees in Africa. According to most officials interviewed, expertise in TA is largely in some universities with departments or schools of technology management and in some private companies, particularly foreign multinationals in energy and mining sectors. Most of the graduates in technology management and technology policy studies have gone into employment in universities and private sector as well as a few STI policy NGOs on the continent.

Skills and experience in various areas of STI policy studies and technology management are important for successful TA in Africa. There is very scanty information on available human resources or capital for TA. Tentative surveys show that some Africans have been trained in TA and related areas, and some have conducted postgraduate studies in TA. According to personal communication with two leading academics at the Science Policy Research Unit (SPRU), at least ten Africans were trained at the SPRU, University of Sussex UK in Multi-

Criteria Mapping (MCM) in the last five years or so. As stated earlier, MCM is a technology assessment and prioritization methodology developed by researchers at the University of Sussex.

The third category of capacity challenges or needs is about the absence of appropriate institutional arrangements and policy cultures for participatory TA. In most African countries, institutions (particularly departments or ministries) for STI policy and development policy in sectors such as agriculture, health, energy, transport and ICT tend to work in silos. There is weak institutional articulation or synergy that is mandatory or need to mobilize expertise and society across sectors given the interdependent nature of the many of aspects or issues at a participatory TA seeks to address. As some interview remarked, "you should not be surprised if you go to some countries and find that expertise for technology assessment and foresighting or forecasting is in one department of government but even people in that department do not know" that it exists.

Related to the challenge of institutional synergy within government is one of weak linkages between executive arms (e.g. departments of STI) and parliamentary ones (parliamentary committees on STI). In many countries, synergy between these two important policymaking is poor or weak making it difficult to implement TA and STI policy in general.

Lastly, institutionalization and implementation of TA in some African countries is difficult because of the absence of the necessary policy and legislative frameworks. In South Africa, for example, there is not a specific STI Act or legislation designating a specific agency to provide leadership for TA. Thus, TA and TA-like activities or initiatives are spread across the institutional terrain.

3.2 Capacity building programs for technology assessment

There are a number of programmes for building TA capacity in Africa. Most of these are in universities in South Africa. For example, in the area of energy TA the University of Cape Town and Stellenbosch University have postgraduate and short certificate courses on energy TA and energy technology management. Most of the short courses on energy TA are offered to participants from private companies. The University of Pretoria's School of Public Health offers *The Health Technology Assessment Practice* short course that "introduces the medical, social, organisational, ethical and economic implications of development, diffusion and use of health technology. You will learn about this multidisciplinary field of policy analysis which encompasses the assessment of the quality, safety, efficacy, effectiveness and cost-effectiveness of healthcare intervention and technology."

It is likely that there are many TA training courses covering various aspects offered by many other universities on the continent. Information on such initiatives is scanty. A survey is needed to provide a comprehensive profile of TA capacity building in Africa. There are continental institutional arrangements contributing to TA activities in Africa, like the African Development Bank (AfDB) which supports skills development and capacity building through their public forums that provide an opportunity for state actors to engage with experts, private sector and civil society to create a common roadmap for scaling up STI in Africa. Demand for TA capacity will increase in Africa as countries increasingly focus on the formulation and implementation of STI to attain SDGs. Therefore, building TA capacity at national and continental levels is

vital (or even critical) to enabling African countries to attain the SDGs and related aspirations of the AU Agenda 2063 through the STISA-2024.

4. Building technology assessment capacity in Africa

Below are five clusters of recommendations that should be considered by UNCTAD and other key actors including African governments and the AU to help build TA capacity in Africa.

4.1 Raise awareness of technology assessment

Building awareness and knowledge is a critical part of strengthening African capacity for TA. As indicated earlier, many officials in governments, parliaments and civil society groups are unware of TA and/or have limited understanding of it. One way of changing this is to develop an *online TA newsletter* and other public education resources for African policymakers. Resources such as *policy briefs on TA* with cases of good practices are also need. Related to this is organizing virtual forums dedicated to TA and introducing TA onto the agenda of existing regional and continental STI such the UNECA, AU and AfDB African Forum on Science, Technology and Innovation are important to building awareness and broadening constituencies for TA in Africa. UNCTAD's new project for building TA capacity in Africa should focus on awareness raising and promotion of information sharing through various forums. Virtual forums for TA can enable participation of many institutions and citizens in from many Africa countries.

4.2 Developing and disseminating methodological tools

Related to above, designing and disseminating methodologies for participatory STI policy-oriented TA will help to empower officials in governments and parliaments in Africa to engage confidentially with TA. *An African guide to TA or body of guidelines for TA* will help to institutionalize systematic processes within countries. Such a guide or guidelines would contain international good practices and approaches to TA from around the world, including how and when TAs are successfully initiated, organized and conducted.

4.3 Mobilizing capacity through an African network for technology assessment

This study shows that there scattered and ad hoc TA initiatives and related expertise in Africa. There have been prior efforts by the AU to organize continental TA-like processes. The experiences from Europe show that transnational TA networks and programmes can be good ways of building shared expertise, institutions, and agencies. African countries such draw lessons and inspirations from such initiatives to establish platforms and networks for TA. Under the auspices of the AU and with technical support from UNCTAD and other agencies, *an African Network for Technology Assessment (ANTA) should be established*. It would be a multi-stakeholder forum for inclusive participatory TA and a source of expertise and experiences that individual countries can draw from. The ANTA should be directly linked to legislative bodies such as the Pan African Parliament (PAP) and parliamentary assemblies of RECs as well as bodies such the African Observatory on Science, Technology, and Innovation (AOSTI).

Related to the recommendation to establish an ANTA, is the need to promote and strengthen Africa's participation in international TA processes and networks. Through established or existing AU-EU STI cooperation platforms, Africa should explore modalities of collaborating

with European TA networks and programmes. It should also strengthen its engagement in the work of the United Nations Technology Bank and UNCTAD's TA processes.

4.4 Enhancing skills or human resources for TA

Enhancing existing skills and building new ones through short-term training courses and postgraduate programmes at African and international universities should be a core part of efforts at building TA capacity in Africa. As indicated earlier, a number of African universities already offer courses in TA. Governments and parliaments should be encouraged through support their officials to attend and participate in such courses by providing fellowships or scholarships. UNCTAD and other agencies of the UN, private foundations and funding agencies in general should help to strengthen existing TA courses in Africa through a variety of means including grants for tuition or fellowships, helping technical expertise to review course curriculum to align it with SDGs and direct support participants. In addition, scholarships to African students to study TA at postgraduate level at European and other foreign universities should be enhanced.

4.5 Strengthening policy and legislative frameworks

As stated earlier in this study, policy and legislation are key to institutionalizing TA and helping to embed it in parliamentary and executive STI policy processes and development practice in Africa. Few African countries have explicit national policies and related legislation on TA. It is crucial that countries are supported to develop and adopt appropriate frameworks for TA, this particularly so for those that are currently (e.g. Botswana, Uganda, and Namibia) reviewing and revising their old national STI policy instruments. UNCTAD should seek to help such countries through STIP review and consider partnering with institutions such as UNECA, AfDB, UNESCO and the AU to conduct a systematic review of TA in national policy and frameworks in order to provide informed guidance to countries on best ways and means of integrating specific provisions for TA.

Related to policy review and legislative reform, there is a need to help strengthen national, regional and the Pan African Parliament (PAP) TA capacities. This should involve undertaking an assessment of parliamentary TA capacity status and needs in each country through a structure online survey. Based on the assessment specific capacity-building interventions can be launched. Again, UNCTAD in collaboration with the AU, PAP and other agencies should play a major role in helping to address this critical need for parliamentary TA capacity.

CONCLUSION

This study is exploratory, largely based on secondary data and snowballed small interviews with officials in governments and different agencies in Africa to scan TA initiatives and capacities in Africa. It shows that TA is at infancy but there is high demand to institutionalize it, to be part of STI policy processes. As countries engage or focus on address global and local challenges such COVID-19 and aim at attaining SDGs, the need to TA capacities in order to make appropriate technology choices. The countries are exposed to a large and growing body of scientific knowledge and related technological innovations through foreign direct investment, technology transfer and a variety of other mechanisms. Again, TA capacity is need for them to be able wisely govern FDI and technology transfer for sustainable development.

The study recommends that raising awareness, promoting sharing of information and experiences, mobilizing, and enhancing skills, establishing a pan African network, strengthening institutional coordination and synergies, and improving policy and legislative frameworks are key as aspects of building TA capacity in Africa. UNCTAD working with governments and other institutional actors should proactively step to help grow TA capacity in Africa.