FINAL TECHNICAL REPORT / RAPPORT TECHNIQUE FINAL

UPDATING THE CASE STUDIES OF THE POLITICAL ECONOMY OF SCIENCE GRANTING COUNCILS IN SUB-SAHARAN AFRICA

;

;

IDRC Grant / Subvention du CRDI: 108138-005-Science Granting Councils Initiative in Sub-Saharan Africa: Monitoring and Evaluation

Updating the Case studies of the Political Economy of Science Granting Councils in Sub-Saharan Africa

Full Report

To the International Development Research Centre (IDRC)

Science Policy Research Unit (SPRU), University of Sussex, United Kingdom

African Centre for Technology Studies (ACTS), Kenya

Principle Investigator: Chux Daniels

Authors: Chux Daniels, Rob Byrne, Rebecca Hanlin, Sandra Pointel and Ann Numi

May 2020

This page is left intentionally blank

Executive Summary

Background

This study, **Updating the Case studies of the Political Economy of Science Granting Councils in sub-Saharan Africa,** is a follow-up (Phase 2) to the case studies of the Political Economy of Science Granting Councils (SGCs) in sub-Saharan Africa research completed in 2017 (Phase 1, or baseline study). The study supports the Science Granting Councils Initiative (SGCI) in sub-Saharan Africa (SSA), funded by Canada's International Development Research Centre (IDRC), the UK Department for International Development (DFID) and South Africa's National Research Foundation (NRF). In the interest of generating evidence that can be deployed for economic and social development, the SGCI supports SGCs in 15 SSA countries. This research has been commissioned in response to an increasing recognition of the importance of improving understanding of the political economy (PE) of science and research in Africa and the roles that science, technology and innovation (STI)[1] play in the processes involved. The aims of the SGCI are to strengthen the capacity of SGCs to: manage research; design and monitor research programmes based on the use of robust STI indicators; support exchange of knowledge with the private sector; and establish partnerships among SGCs, and with other science system actors. In line with these aims, the approach outlined below by the SPRU and ACTS consortium draws from and builds upon the findings from the Phase 1 research.

Building upon the Phase 1 (PE1) research, which used an approach to political economy based on the concepts of "ideas", "interests" and "institutions", the Phase 2 (PE2) approach extends the concepts to include "structures". This addition stems from the PE1 findings, one result of which was the need to better understand how structural configurations influence the PE factors of SGCs in performing their activities, operations and functions. The four concepts inform the analytical framework adopted in the research. Drawing on mixed methods, the PE2 study methodology involved: (a) an extensive review of relevant literature, data, agents and actors; (b) semi-structured interviews with representatives from science funding and policy bodies – researchers, policymakers, research and innovation experts from industry, and civil society actors; (c) five national case studies of the PE1 study countries – Ethiopia, Kenya, Rwanda, Senegal[2] and Tanzania; and (d) analysis of grey literature.

Key findings

Among the key findings, (a) Human Resources and (b) Gender and Inclusivity emerge as cross-cutting issues, alongside five specific messages around: (1) Research excellence, (2) Narratives, (3) Private sector, (4) Structure, and (5) Governance and policymaking. In this Executive Summary, we discuss the two cross-cutting issues briefly and summarise the five key messages. The summary recommendations provided here are for all stakeholders. In Section 5, we provide detailed recommendations specific to different stakeholder groups.

Two cross-cutting issues:

a) **Human Resources** constraints were cited by many interviewees as an essential political economy feature of SGCs. Specifically, constraints in terms of skills and capabilities – particularly in STI

[1] Although we use STI in many sections of this report, it is important to note that the study primarily focussed on science and/or research systems. For example, capturing funding related to technology or innovation in SSA was out of the scope of this study and therefore not fully addressed.

[2] An important note about the PE1 study is that the Senegal case was "light touch": that is, it was not as detailed as the other countries due to logistical challenges related to data collection. In the PE2 study, however, the five countries received the same level of data collection, analysis and reporting.

related fields – result from inadequate access to quality university education, high costs of such access, curriculum-design, the kind of skills training needed, and the working conditions for researchers. This finding has implications for how the SGCI and SGCs design and implement training and capacity building: the kinds of training implemented, and the focus of such training exercises.

Recommendation: in designing and implementing training and capacity building programmes, ensure that curriculum designs cover a broader range of innovation studies concepts, and training addresses the skills of individuals as well as capability needs at organisational level.

b) Gender and Inclusivity did not feature as issues in our interviewees' responses, except when explicitly prompted to do so. This is an important finding for a number of reasons as it could be understood in a variety of ways: (a) that gender and inclusivity are not important, (b) the awareness of gender and inclusivity as issues is not recognised or properly articulated or, further still, (c) that gender and inclusivity, as issues/challenges, are not considered priorities. Therefore, if gender and inclusivity issues are to be addressed, concerted efforts are needed by stakeholders.

Recommendation: refocus attention on gender and inclusivity issues in SSA's STI systems, with a view to gaining a deeper understanding of (i) why some actors still do not consider these as priorities, (ii) why current efforts seem to be yielding ineffective outcomes, and (iii) what further changes – for example, institutional configurations (structures), capabilities and skills, research designs, policies and practices – need to be made in order that gender equality and inclusivity are embedded in SSA's STI systems and are adopted by stakeholders.

Five specific messages:

1. **Research Excellence** remains an important goal to SSA STI stakeholders. However, compared with the PE1 study, there is clearer evidence that research excellence is widely interpreted by STI stakeholders to mean research achieving societal impact. Respondents want to see research mean something socially and economically, alongside high-quality research as measured by the traditional metrics such as journal citations. In this updated study, the interviews explored research excellence explicitly, thereby providing a stronger evidence base from which three specific categories of issues emerge: research excellence in terms of (1) research focus, (2) research process and incentives, and (3) research support. With respect to research focus, for example, the emphasis was on the relevance of the research conducted in SSA and whether the focus is solely on academic problems, or the need to address societal challenges and national development goals. The consensus position is that research excellence must include a focus on addressing societal challenges and national development goals (impact) in addition to publishing in journals. The two objectives – of achieving development impact and publishing in academic journals – are not necessarily in tension. Details on the other two issues (research process and incentives, and research support) are provided in the main report, in Section 3.3.4.

   Recommendation: although research excellence in SSA has received more attention in recent years (from 2016, and through the PE1 study period, to present), efforts need to be sustained in order to ensure that the knowledge generated and lessons learned are diffused widely and embedded in the relevant institutions, policies and practices. This could be aided by extending political economy analyses beyond the current illustrative cases of the five SGCs and countries to the rest in the SGCI, regional analysis, and perhaps to the whole of SSA. As well as diffusing knowledge more widely, this would help deepen understanding by broadening the evidence base. Furthermore, to underpin future studies on research excellence, political economy, indicators and metrics on STI in SSA, there is a need to improve the availability, access and transparency of data.

2. **Narratives** at play among STI stakeholders, as expressed by those we interviewed, imply there are widely-held concepts of innovation and innovation systems in operation across the SSA region that need to be further explored. Innovations seem predominantly to be understood in the narrow sense to mean marketable products[3] and innovation processes seem to be understood in linear science-push terms. The concept of innovations as products leads to a sharp focus on intellectual property (IP) and IP protection regimes, where the underlying assumption is that strong IP protection leads to more and better innovation. However, evidence from the scholarly literature on this subject remains mixed, suggesting there are also other factors and processes that lead to innovation.

   The concept of a linear science-push innovation process means the innovation system model essentially collapses to a focus on university-industry (U-I) linkages and, in SSA contexts, how these can be strengthened. Strengthening U-I linkages may well be important but a broader view of both innovation and innovation systems could help to better understand the role of science in STI systems and therefore the role that SGCs (and the SGCI) could and should play in strengthening those systems. Care about understanding the role of science in STI systems is essential to understanding what capabilities, for example, need to be built and why. And to developing narratives that stakeholders can use to influence policy, funding priorities and other interventions that will indeed strengthen STI systems. This finding on narratives has a bearing on our first specific key message, discussed above, about the notion of research excellence. That is, narratives promoting a narrow conception of innovation and a linear science-push process may be raising expectations among policy makers, for example, that excellent research will lead unproblematically to significant development impact. This risks over-promising on the outcomes of funding science, potentially undermining the support of policy makers and others if outcomes do not materialise in the ways such narratives depict.

   Recommendation: reconceptualise innovation and science systems in SSA, and move from both: (a) a narrow view that focusses on products and processes to a broader view of innovation; and (b) a linear science-push approach that collapses innovation into university-industry linkages to a systems view that incorporates a broader set of actors.

3. **Private Sector** as a category is something in need of unpacking as it pertains to SSA contexts. When talking about continuing low levels of private sector funding for STI activities, many respondents argued that the private sector is mainly comprised of small and medium-sized enterprises (SMEs) and many of these operate in the informal economy. And, in some countries, the private sector is small and undeveloped. As such, "the private sector" is unable to invest in research. Nevertheless, some sectors or industries, especially where larger firms – both international and national – are operating, may be able to spend more on STI activities. In SSA contexts therefore, notions such as "the domestic private sector" become important in the work of the SGCI and SGCs, in that they raise some salient questions. For instance, if economic activities are mainly in the domestic private sector, what (STI-related) capabilities currently exist in this sector and how should these capabilities be built or enhanced? What new capabilities need building? What implications would a shift of focus onto the STI needs of the domestic private sector have on research excellence, STI policies, or the operations of SGCs? This calls for re-categorising what constitutes the private sector in SSA contexts and further unpacking what this implies for: (a) how data are collected and analysed, (b) how the discussions around funding from "the private sector" (being low or weak) are

[3] There was little attention to, or recognition of, other kinds of innovation such as in public services, social practices or business models, for example.

influenced or shaped by current narratives, and (c) how research and development investments by the private sector are handled.

Recommendation: a deeper analysis and (re)categorisation of what constitutes the private sector in Africa is essential to improving our understanding of the relevant PE factors influencing the sector. Deeper analysis, and re-categorisation of the private sector to include SMEs and actors in the informal economy, will support work in key PE aspects such as data and knowledge management, funding, skills and capability building, and policy interventions.

4. **Structures** that allow science or, more broadly, STI systems to be better coordinated in ways that enable effective performance of SGCs are important. Whilst care is needed not to overemphasise this importance, the findings reveal that there are structural issues to consider at different levels:

    a. **National-level governance of STI**: this relates to different actor's roles and responsibilities, independence, accountability, ease of securing funding and its stability, coordination and fragmentation. The specifics of these issues will differ, for example, in cases where multiple actors constitute the SGC, as in the case of Kenya, in contrast to cases such as Senegal where the SGC is one actor.

    b. **Sectoral level governance of STI**: this relates, among others, to the impacts of sectoral structures. For example, changes to the structure of the education sector in Tanzania have led to an under-supply of technicians, with impacts on human resources, funding and policies. In terms of human resources, more graduates and fewer technicians weakens support for the work of graduates and weakens the "system". With respect to funding, more financial resources flowing to Higher Education (universities in particular) may be at the expense of funds available for Technical and Vocational Education and Training. And, on policies, care needs to be taken to ensure that the focus of interventions does not unduly favour universities to the detriment of colleges and polytechnics.

    c. **Sub-systems or organisational level governance of STI**: this overlaps to a degree with sectoral level governance but is more about the specific sub-system structures conditioning how organisations operate. For instance, at university level, in reference to the types of degrees offered and fees being charged, few innovation-related degrees are available and, where they are on offer, universities charge higher fees than for other courses. Also, university academics are expected to do research but without the option to buy out teaching time.

    Recommendation: encourage and support policy experimentation with new and different structural and governance (see Key message 5 below) configurations at SGCs with a view to gathering empirical evidence that helps to demonstrate what works best, why, and in what circumstances.

5. **Governance and policymaking** emerges as an area requiring more stakeholder consultation – specifically, policy formulation, implementation and the governance of STI policies – as a means to achieving better policymaking in SSA. The governance issues highlighted in the study focus on silos and fragmentation, and the importance of coordination of actors across (a) government agencies and (b) the science systems, and the links to implementation of policies (where such policies exist). The findings on governance have a bearing on the four key messages discussed above. For example, the challenges of governance (in terms of actors working in silos, fragmentation, and lack of coordination across systems, and weak links to science/policy systems) have implications on how capabilities are built/strengthened, or how (human and financial) resources are managed. In addition, the governance approach adopted by SGCs has implications for the ways in which structural issues are tackled, and vice versa. Different structures – for example, an SGC made up of one or multiple actors – will have to deal with governance (and

policymaking) issues in different ways. Furthermore, where the SGC is located structurally – that is, its proximity to political power – could better promote or hinder its autonomy with respect to governing STI in a more transparent manner, promoting research excellence, shaping STI ideas and narratives, or delivering on multiple mandates.

Recommendation: similar to Key message 4 above, encourage and support policy experimentation with new and alternative governance configurations and policy approaches at SGCs with a view to improving knowledge of what works best, why, and under what circumstances.

Table of Contents

List of Acronyms and Abbreviations

ACTS	African Centre for Technology Studies
AESA	Alliance for Accelerating Excellence in Science in Africa
AfDB	African Development Bank
AIO	Africa Innovation Outlook
AVU	African Virtual University
COSTECH	Commission for Science and Technology
CTAs	Collaborating Technical Agencies
DFID	United Kingdom Department for International Development
ENOs	Espace Numérique Ouvert (or Open Digital Spaces)
ESTA	Ethiopian Science and Technology Agency
GERD	Gross Domestic Expenditure on Research and Development
GTP	Growth and Transformation Plan
IDRC	International Development Research Centre
IPRs	Intellectual Property Rights
KENIA	Kenya National Innovation Agency
LIWA	Linking Industry with Academia
MESRI	Ministry for Higher Education, Research and Innovation
MINEDUC	(Unit within the) Ministry of Education
NACOSTI	National Commission for Science, Technology and Innovation
NCST	National Commission for Science and Technology
NRF	National Research Foundation
NST1	National Strategy for Transformation
NSTIC	National Science, Technology and Innovation Council
PE1	Political Economy 1 (i.e. Phase 1 Research, same as the Baseline Study)
PE2	Political Economy 2 (i.e. Phase 2 Research)
PPPs	Private Public Partnerships
PSE	Senegal emergence plan
RECs	(African Union) Regional Economic Communities
SGC	Science Granting Council
SGCI	Science Granting Councils Initiative
SIDO	Small Industry Development Organisation
SMEs	Small and Medium-sized Enterprises

SPRU	Science Policy Research Unit
SSA	Sub-Saharan Africa
STEM	Science, technology, engineering and mathematics
STI	Science, technology and innovation
STIR	Science, Technology, Innovation and Research
TIRDO	Tanzanian Industrial Support and Development Organisation
TVET	Technical Vocational Education and Training
UIL	University-Industry Linkage
UNCTAD	United Nations Conference on Trade and Development
UVS	Virtual University of Senegal

Acknowledgements

The project team would like to thank the many individuals who co-operated with the fieldwork for this project, giving up their valuable time to be interviewed. We would also like to thank IDRC for commissioning the project. In addition, thanks to the IDRC, DFID, the Department of Science and Innovation and National Research Foundation of the Republic of South Africa for providing funding and support for the Science Granting Councils Initiative (SGCI). We are particularly grateful to Ellie Osir, Loise Ochanda, Diakalia Sanogo and Matthew Wallace from the IDRC for their support, inputs and advice throughout the project. Our gratitude also goes to our kick-off workshop participants (listed in Annex 7), held in Nairobi on 27-28 March 2019, for their inputs and generosity with their time over the two days, thank you!

We would also like to express our deep appreciation to our advisory group for providing their time, comments on the draft, and advice which has been invaluable to the project throughout: Professor Joanna Chataway (University College London, UK), Professor John Mugabe (University of Pretoria, South Africa), Professor Mamadou Sy (Senegal), Ms Ruth Oriama (African Technology Policy Studies Network, Kenya), Mr Boniface Wanyama (NACOSTI, Kenya), and Mr Donnelly Mwachi (MEL Consultant, Kenya). In addition to the comments from our advisory board, Remy Twiringiyimana, Aschalew Tigabu, Kassahun Yimer Kebede and John Kirkland provided comments on the drafts. We are also grateful for the useful feedback we received at our presentations during the SGCI Regional Workshop in Addis Ababa, Ethiopia, 24-28 June 2019, the Annual Forum in Dar es Salaam, Tanzania, 11-15 November 2019 and Final Workshop of SGCI Phase 1 in Dakar, Senegal, 11-13 February 2020. Our final gratitude goes to the staff and management of the Science Policy Research Unit (SPRU), the University of Sussex and the African Centre for Technology Studies (ACTS), Kenya.

1 Introduction

Political economy analyses are important because they can go beyond a focus on technical solutions and help to reveal underlying political and economic factors shaping decision-making, funding, or influencing the outcomes from science, research and innovation programmes, projects and policies. Examples of such underlying political and economic factors include ideas held by actors about what works and what does not work, narratives that convey these ideas in persuasive stories, institutions such as policies and regulations that enable or constrain action and structures of various kinds that condition the broader environment for what is possible. The insights gained from political economy studies can therefore help improve decision-making, inform policies and guide policymaking, redirect resources, improve the effectiveness of funding, or support monitoring and evaluation at different levels: organisational, programmatic, project and policy (DFID, 2009). Consequently, the study of the political economy of SGCs in SSA contributes to improving knowledge and understanding of the factors that influence or contribute to shaping the decision-making, funding, actors, and policies related to research and science, technology and innovation (STI) in Africa.

Our first political economy (PE) (Phase 1 or PE1) study revealed many emerging issues in the findings, with implications for the SGCI, SGCs and other stakeholders (see Chataway et al., 2017). The PE1 key findings are summarised in Box 1 below. The overall objective of this updated (Phase 2 or PE2) study was to investigate the ways in which the PE of SGCs has changed from the PE1 study findings. To achieve this objective, we focussed as far as possible on examining changes to selected qualitative information and quantitative indicators used in the PE1 study. The selection of the criteria for investigation was based on information and indicators that would enable the research team to identify change – incremental, radical or suggestive of change – since the completion of the Phase 1 study. Indicators examined included change in R&D per GDP[4] such as increases or reductions in science/research funding; change in narratives and perceptions; and other factors that might indicate change in science and research systems.

An additional indicator, not included in the Phase 1 study, relates to evidence of organizational or structural changes that may have occurred, as such changes may have implications for the work of the SGCI. For instance, Kenya has had challenges in defining and/or operationalising the roles and mandates of the National Commission for STI (NACOSTI), National Research Foundation (NRF) and Kenya Innovation Agency (KeNIA); while the status of the CEOs of both NRF and KeNIA, who were in acting capacities for a number of years, remained an interesting and relevant issue worth investigation. There are signs these situations could change in the near future[5] and, if so, there may be implications for the SGCI and SGCs. The PE2 study focussed on the same countries as those in PE1: Ethiopia, Kenya, Rwanda, Senegal and Tanzania.

To help ensure that we provide background to readers who may not be familiar with the PE1 study, we include a summary of the findings in this report (Box 1). Furthermore, to help improve comprehension and ensure adequate linking from PE1 to PE2, we include the Executive Summary of the PE1 study in this report (see Annex 8). The next section explains the analytical framework and methodology used for the study. Section 3 summarises the national case studies and discusses the main themes that emerge from them. In section 4, we provide our political economy analysis of the cases. We then provide a summary and recommendations in section 5.

[4] Paucity of data meant that this indicator could not be fully examined.
[5] For instance, with the recent recruitment exercise for the role of CEO at KeNIA.

Box 1: Summary of Key Findings from Political Economy Phase 1 (PE1) Study

1. All case study countries are committed to increasing funding for science but overall levels of funding are still low. National level SGCs are established or emerging in all countries and they are playing an increasingly prominent role in setting research agendas. Funding for SGCs, and the cost and effectiveness implications of different institutional configurations, could be tracked. SGC governance arrangements and spending on administration could also be monitored to enable analysis and comparison.

2. At the national and regional level there is reference to the important role that the private sector could play. However, private sector funding is low and engagement is patchy across countries. Greater involvement from the private sector will take dedicated effort and there is a need for greater communication between private and public sectors about the value of different types of research. SGCI may consider whether more resources need to be allocated to private sector engagement activities.

3. There is increasing activity at the regional level and interest in supporting programmes that shift ownership to Africa. Alongside increasing national funding, there are new regional level research funding and support actors emerging. SGCs can continue to leverage international funds. However, careful thought should be given to which international funders to prioritise in co-funding arrangements, and also what possible effects there may be on the level of national ownership.

4. There are divergent agendas at national and regional levels. SGCI could consider promoting discussion on the impact of various regional funders on national level SGCs. Alignment of agendas and a common understanding of "excellence" and criteria for funding cannot be assumed. Sub-regional bodies may play a role here in creating more specific agendas aligned with goals in East, South and West Africa and establishing locally relevant criteria.

5. There is no clear narrative about relative strengths of East, South and West Africa sub-regions. There is a potential issue for SGCI in monitoring whether regional initiatives have an equalising effect. The issue is compounded by a lack of consensus about existing strengths and weaknesses in sub-regions. National, and regional bodies have important roles to play in monitoring and evaluating the impact of funding.

6. Health and agriculture are the sectors which receive most resource in the SSA region but this may change over the coming years. The traditional sector focus of research in SSA (health and agriculture) is likely to be complemented over the coming years by research in a variety of new areas. It will be important to build capacity amongst researchers and funders to fund science over these wider areas. New international funders may become more significant in relation to funding and influence.

Source: Chataway et al. (2017) Case Studies of the Political Economy of Science Granting Councils in Sub-Saharan Africa, full report. Available at: https://sgciafrica.org/en-za/resources/Resources/PoliticalEconomy.pdf (accessed 10 February 2020)

2 Analytical Framework and Methodology

2.1 Analytical framework

Political economy is a broad term that refers to the interaction of political and economic processes, relations between state and non-state actors, and how these interactions shape evolving distributions of resources and power. As a broad term, there are many ways in which to conduct political economy analysis (see Hudson and Leftwich, 2014 for a discussion of various approaches). The Phase 1 study built upon a political economy framework based on DFID's approach (DFID, 2009), which focusses on structures, institutions and agents. But it became clear in that study that the development of science systems in SSA is shaped by the ways in which actors discuss those systems, implying a need to include the role of ideas in a political economy framework. As such, the analytical framework for this study is based on a discursive institutionalist political economy (e.g. Schmidt, 2008) that consists of three co-productive categories (e.g. see Kern, 2011): ideas, interests and institutions (or "rules of the game"). But, following feedback on the PE1 findings and comments from stakeholders that the PE1 study was weak in its attention to structures, we added to the framework a structural category. The sub-sections below discuss these four categories in turn, but it should be noted that they each interacts with the others to co-produce a specific and evolving political economy.

2.1.1 Discourse, ideas and narratives

An important feature of a discursive institutionalist political economy is that it allows us to analyse the role of discourse in constituting a specific political economy, through which we can gain a better understanding of the politics of its current form and explain the politics of its evolution. Ideas are at the heart of any discourse, where they are communicated, promoted, debated, contested and shaped by actors who are constructing and seeking to further their interests. According to Hudson and Leftwich (2014), "ideas [more generally, the ideational] are central to politics and the political context. Ideas define political identities; they frame political debates; they interpret and reflect interests; they guide behaviour". Tracing ideas, then, is essential for understanding and explaining a political economy, enabling us to reveal its political dynamics and offering the potential to see how these interact co-productively with interests, and with the political economy's institutional and structural dimensions.

One way to trace ideas, while also analysing the political work they do, is to identify the narratives at play in a discourse (Leach et al., 2010, Kern, 2011). Drawing on Roe (1991), (development) narratives simplify the complexity of the world into plausible stories that frame-in certain aspects of that complexity and frame-out others: e.g. certain actors, institutions, interests, issues, knowledge, perspectives, etc., are highlighted, constructing a specific picture that obscures other potentially relevant views. Leach et al. (2010) argue that a narrative is constructed from three main parts: a definition of the current development problem, a strategy for fixing the problem, and a description of the better outcome (end-goal) if the fix is successful. The plausibility of a problem-strategy-outcome narrative derives from its connection with "context-specific qualities of local culture, politics, history, economy, etc." (Byrne et al., 2018), achieving its persuasiveness through links with other locally-powerful narratives or "prominent socio-political agendas" (Raven et al., 2016b).

These are highly abstract concepts and so an example might help to clarify what they look like in practice, and how narratives can reveal ideas. In the Phase 1 study, one of the findings emerging from stakeholder interviews concerned the perception that there is a lack of political will to fund STI in Africa. In reporting this perception, the authors write (Chataway et al., 2017):

> The failure of African governments to provide STI funds continues to attract criticism from analysts across all parts of the STI system in Africa and is often blamed on a lack

> of political will. This may be an accurate diagnosis but, as one of our interviewees suggested, some of the blame may lie with actors in the STI system itself. That is, they have perhaps failed to demonstrate the importance of STI for development; to offer convincing arguments and solutions that policy makers can grasp and that provide evidence to support [STI] with implementation plans (p.29).

Whatever the validity of this claimed lack of political will, we can argue that there is a specific narrative at play in the discourse on STI-funding in Africa. Using the problem-strategy-outcome narrative structure, we could infer its parts to be:

Problem-definition: Government-funding for STI is good because of the benefits to society that STI brings, but African governments are under-funding STI because of a lack of political will.

Solution-strategy: STI actors must provide policymakers and political leaders with convincing arguments and evidence for the importance of STI to African development.

End-goal: Policymakers and political leaders will better understand the importance of STI for development, strengthening their political will. STI will thus be provided with sufficient funding from African governments and so be able to contribute to achieving Africa's development goals.

Examining this narrative, we can infer the ideas that may be at work. The main idea could be articulated as *STI contributes to development*. As an idea, this may be valid, but the ways in which it works are not articulated in the narrative. This could be because the narrative only connects rhetorically two otherwise separate but individually-powerful socio-political agendas: the agenda to strengthen African science systems, and the agenda to achieve development goals. So, in terms of investigating the idea more deeply, it would be important to analyse, for example, what actors believe to be the ways in which STI contributes to development. In other words, identifying a narrative provides a way to reveal the ideas that may be at work and, therefore, suggests which ideas need to be interrogated more closely. This would then, in our political economy framework (the rest of which is explained below), mean asking about how interests, structures and institutions condition, shape, constrain and enable how STI contributes to achieving development goals.

2.1.2 Interests and actors

In contrast to classic political economy in which actors are assumed to be personal-utility maximisers rationally pursuing known interests (Naess et al., 2015), we start from the view that development pathways materialise under conditions of complexity and uncertainty, where we cannot assume actors' interests are self-evident (Kern, 2011, Hudson and Leftwich, 2014). Instead, we assume that actors construct their interests through participating in discourses and assessing the opportunities for action emerging from structural conditions and institutional arrangements. Even if actors do have self-evident interests, it might not be clear how these will feature in an unfolding development pathway: those interests could become either more or less important over time. Thus, whether we are examining "hard" material interests (such as financial investments, sources of revenue) or "soft" interests (such as specific capabilities, a powerful institutional role), we should attend to how these co-evolve with ideas, as well as with structural conditions and institutional arrangements.

Where interests and actors are more clearly self-evident, such as who benefits from funding-flows, it can still be important to attend to how actors seek to maintain (or even enhance) them. Evidence for these efforts is likely to be available in policy debates and associated documentation (e.g. organisational submissions to a public consultation), but also in narratives. Similar sources of evidence will be useful for tracing emerging interests, or interest-construction. So, we would be looking for what arguments

are being promoted for ways to achieve development objectives – and, indeed, what development objectives should be pursued – and by whom.

We can illustrate some of these points by drawing on Chataway and Daniels (2020) and Chataway et al. (2019), and their discussions of an "excellent science" narrative at play in the SSA discourse on science-funding (see also Tijssen and Kraemer-Mbula, 2017 for further discussion of research excellence in Africa). Chataway et al. argue that an important assumption underpinning the excellent science narrative in SSA is that excellent science will lead to beneficial socio-economic outcomes. This assumption largely rests on the so-called linear model of knowledge-production-to-market-significance. But there is arguably a tension between national priorities for socio-economic impact and the promotion of excellent science. That is, national science-funders wish to see science address local development challenges, but the push for excellent science risks directing local scientific effort into addressing international science agendas, especially as it is here where many of the scientific rewards lie. Given that the bulk of science-funding flows from international sources, it is easy to argue that the interests of SSA scientists – whether in winning funding or in achieving scientific prestige – are more likely to be served responding to international agendas compared with national ones. As such, we may see SSA scientists argue that national science-funding should also be promoting excellent science rather than focus on addressing local development needs. In other words, we can see in this example how actors (e.g. scientists) might deploy ideas (e.g. excellent science) to help maintain or enhance their perceived interests (e.g. research funding) to influence institutions (e.g. SGC funding policies).

2.1.3 Structures

As we noted at the beginning of this section, stakeholders commented that the Phase 1 study was weak in its attention to structures. Therefore, we are adding this category to the political economy framework. It should be noted, however, that some of the reference by stakeholders was about organisational structures and some about more fundamental structures that condition what is possible in any given society. It is this latter understanding that the political economy approach usually uses to define structure. DFID (2009), for example, defines structures as long-term contextual factors that are not easily influenced. Hudson and Leftwich (2014) provide a more detailed and disaggregated definition of structures, but they share with DFID (2009) to some extent the notion that structures fundamentally condition what is possible in a given society and that they derive from many different sources: geographic, economic, political, social and ideological. Organisational structures do not feature in either the DFID or Hudson and Leftwich accounts of political economy. However, in response to the comments from stakeholders, for our purposes, we could see an organisational structure as a kind of political structure: e.g. within different organisations, there are different distributions and concentrations of decision-making authority, and different organisational policies (or institutions, see the next sub-section).

The Hudson and Leftwich disaggregation is probably too detailed for our purposes. Nevertheless, they include attention to power and how it works through different kinds of structure, and this is important to consider. For example, the PE1 study (Chataway et al., 2017) made reference to Ghana's proposed use of taxes on oil revenue as a way to fund science. And the study revealed how colonial legacies continue to influence political, economic, social and, to some extent, ideological structures. Thinking across these two structural examples, we could posit that Ghana's oil revenue would engender some degree of power for it to be able to direct its own science agenda, as opposed to international agendas, and so enhance its autonomy (or "ownership" of agendas, another issue revealed in the PE1 study) to counter the influences of colonial legacies. In other words, we see how geographic structure (a resource

endowment, in this case) provides a context within which institutions could be used to change the economic and political structures of the country.

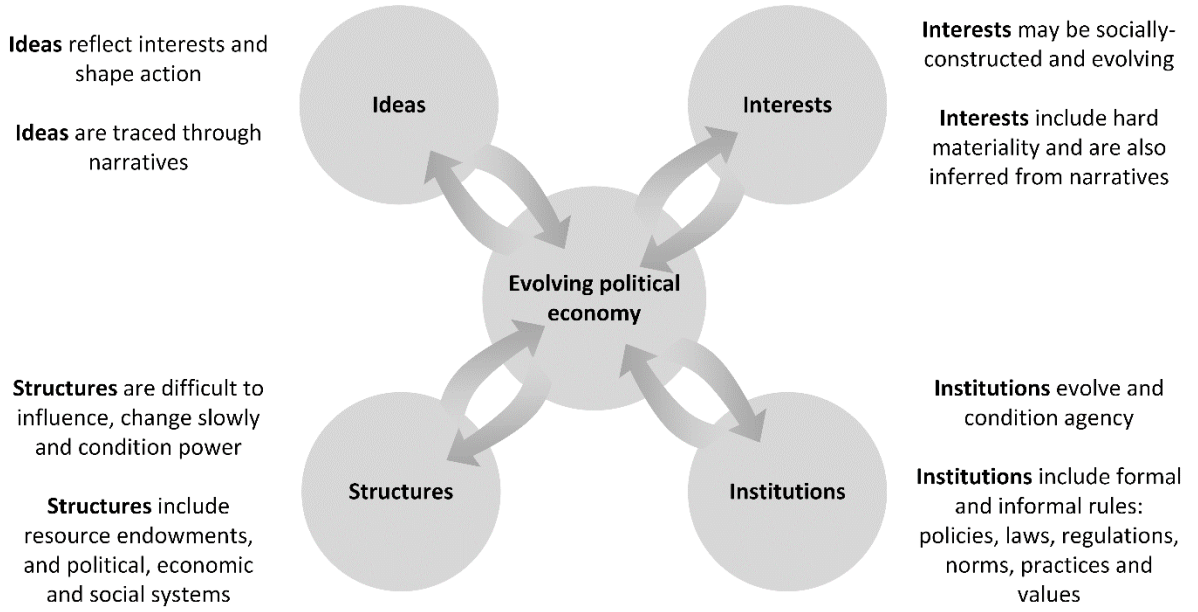
2.1.4 Institutions and agency

Agency, or the capacity to realise intended action, is variously enabled or constrained by formal and informal institutions or "rules of the game" (Kern, 2011). In line with Hodgson (2006) and others, we understand formal rules to be those that are codified and official – such as policies, laws, regulations, standards – while informal rules are those that are usually uncodified but influential – such as social, cultural and political norms, values, and so on. And note that we see organisations as actors rather than institutions. Although they are characterised as rules, institutions are not determinative of outcomes: actors can bend or break rules, challenge their legitimacy or argue they are unjust, damaging, ineffective, inappropriate, etc. So, whilst we can analyse any current set of institutional arrangements and what this means for a specific political economy, including what and whose interests are served or marginalised by specific institutions, we can also analyse the politics of institutional change and what this means for the development pathway of that political economy by attending to the ways in which actors argue for or against specific institutions (Hudson and Leftwich, 2014, Raven et al., 2016a, Byrne et al., 2018).

2.1.5 Summary of the political economy analytical framework

In summary, we use a political economy framework that consists of four main categories: ideas, interests, structures and institutions. Figure 1 provides a conceptual framework and diagrammatic representation of these four categories. The assumption the diagram attempts to depict is that each of the four categories interacts with the others through the evolving political economy, even if changes in the categories can be slow or difficult to effect (e.g. as with structures). Figure 1 also indicates how we trace the evolution of each category or how each category is operationalised.

Figure 1: Four co-productive categories of an evolving political economy



Source: Authors' construction, building on Byrne et al. (2018)

2.2 Methodology

From PE1 to PE2 – Updating the Political Economy of SGCs in SSA

To reiterate, the aims of the SGCI are to strengthen the capacity of SGCs to: manage research; design and monitor research programmes based on the use of robust science, technology and innovation (STI) indicators; support exchange of knowledge with the private sector; and establish partnerships among SGCs, and with other science system actors. In line with these objectives, the specific details of the methodology of the PE2 study are presented below. The methodology involved in-depth review of relevant literature on SGCs, in addition to the collection and analyses of quantitative and qualitative data. The research used similar methods to the Phase 1 study, but with a strengthened focus on narratives, structures, and changes in policy contexts at country level.

The SPRU and ACTS research team conducted five country case studies, the same as in the baseline study: Ethiopia, Kenya, Rwanda, Senegal and Tanzania. One of the main reasons for revisiting these cases was to investigate what changes, if any, have occurred in their respective political economies since the completion of the baseline study, and what the implications are for the work of the SGCs and the SGCI. Each case study involved literature review, data collection and semi-structured interviews. The literature review for each case focussed on reports, policy documents and academic work[6], and data and reports from the work of the Collaborating Technical Agencies (CTAs). As noted earlier, quantitative data were scarce and, where available, were aggregated rather than fine-grained.

For quantitative indicators, we intended to examine empirical data such as changes in the funds granted to SGCs, percentage of such funds spent on administration duties related to running the respective SGCs, percentage spent on research, and on evaluation of SGCs expenditure. Attempts were also made to collect data on the way spending is divided across different scientific areas (and the basis for the allocations): for instance, funds allocation to mission-based or challenge-based science or research streams. Furthermore, data on different types of funding mechanisms (such as early career, large vs. small projects) were sought. Unfortunately, a combination of paucity of quantitative data and non-responsiveness from key actors has meant we have been largely unable to examine such indicators and any changes to them.

The qualitative data collection employed included document reviews and expert interviews (see Annex 6 for the interview protocol). This helped to identify changes since the completion of the PE1 study. Information examined included: (1) change or perceptions of changes in R&D per GDP – for instance, the SGCs submit budgets to their governments yearly, (2) changes in funding priorities, (3) shifts in funding criteria, (4) changes in narratives and perceptions (e.g. relating to increases or reductions in science/research funding), and (5) other factors that might indicate change. The aim was to improve understanding of how SGCs can be further strengthened in line with the challenges they currently face, including challenges around capabilities and skills, funding, and multiple mandates.

Interviews were conducted with representatives of national SGCs, researchers, recipients of research funding, as well as policymakers or decision-makers with STI oversight. A total of 8-10 interviews per country case study were conducted, comprising a mix of interviewees from the Phase 1 study and new interviewees. In addition to the purposive sampling of "elites" or people with unique expertise in the field of PE of STI policy in SSA, other techniques such as snowballing were employed. A key difference between the methodologies of PE1 and PE2 is that in PE1 the data collection included regional level data in SSA. For this study, we focussed only on the national level data for the five case study countries.

[6] Only a small amount of relevant academic literature exists.

With respect to interviewees, some were the same as in the baseline study. However, there were some differences, especially in instances where individuals have changed roles, and if there was a need to strengthen the diversity of views compared with the baseline study's interview selection. In any case, the aim was to revisit up to 50% of the interviewees from the baseline study, with the remainder of interviewees being newly-selected. The addition of new interviewees helped to test the findings of the baseline study (in case there were important aspects missed), while also providing fresh insights on the focus of the research, choice of indicators, and methodology. However, this approach had implications on the interpretation of any changes detected. For example, to what extent would the changes be more about different actors' understandings or knowledge than actual changes? Careful analysis by the research team meant that such issues did not arise.

Triangulation of data and information across the quantitative, qualitative and desk research sources helped to shed light on changes in actors, narratives, structures, private sector, patterns of funding and operation of SGCs in aspects that include governance and policymaking. The changes captured range from particular sectors to national level science, research and funding actors, governance, and science and policy systems. Thus, the study illuminates important dynamics and trends in the operations of SGCs. The data gathered and the analyses served to update the five national case studies and the results are presented next in Section 3.

3 Summary of National Case Studies and Key Themes

3.1 Introduction

The national case study reports for the baseline study each included some contextual sections: a section entitled "Setting the context" and a section on the national STI system. Each of these sections serves as a basis for the updated study to capture important changes since the baseline study was conducted. Some of the work on identifying important changes was done ahead of interviews, complemented with data and information that emerged from interviews. It was useful for the project team to share internally these updated draft contextual sections, or Contextual Reviews, for internal peer review purposes. This helped to maintain quality and consistency across the case studies. In the remainder of this section, we provide brief summaries of the five national case study reports. The detailed reports are provided as Annexes 1 to 5. When we conducted the national case studies, we asked people questions in line with the analytical framework (Figure 1 above), and using the concepts of ideas, interests, institutions and structures to shape the data collection and analyses.

3.2 Summaries of the national case studies

Summaries of the national case studies are presented next, followed by brief discussions of key themes arising from the case studies.

3.2.1 Ethiopia National Case Study Summary

3.2.1.1 Overview of the policy environment

As per the STI policy, the organisational structure of the National Science, Technology and Innovation System governance in Ethiopia has four functional levels:

i. National STI Council
ii. Technical Advisory Committee of the National STI Council
iii. Ethiopian Science and Technology Agency
iv. Science and Technology (S&T) operational Institutes and Centres

The National Science, Technology and Innovation Council (NSTIC) is the regulatory body for the STI policy and action plan in Ethiopia. It is mandated to establish and coordinate the general strategy and framework for the development of STI. The Prime minister is the core chair of the council and the Minister of Innovation and Technology is the secretary of the Council. The secretary of the Council nominates experts from S&T institutions/centres who are later appointed by the Council as NSTIC members. The Council monitors and evaluates performance of STI activities.

The STI policy is under review by the Ministry of Innovation and Technology (MInT) in collaboration with the United Nations Conference on Trade and Development (UNCTAD) (Tralac, 2019). The revised STI policy is aimed at transforming Ethiopia's economy into one that is technology-led. It is hoped that the revised policy will help drive Ethiopia from "consumer" status into a manufacturing country. Revision of the policy was stimulated by a number of reasons from the previous version: non-compliance to economic reforms, misalignment with various sectors, and non-progression towards an industrial economy. Within the revised policy, science and technology are targeted to contribute 2 billion dollars to the GDP, create 20,000 technical jobs and 2000 SMEs. These targets are to be achieved within two years (Tralac, 2019).

In March 2019, a declaration on enabling an equitable research system in Ethiopia was launched by the Ethiopian Academy of Sciences (EAS) in collaboration with the International Network for the

Availability of Scientific Publications (INASP). The declaration is aimed at creating a holistic, equitable, and collaborative research system. It also aims at identifying the factors hindering the creation of an equitable system. The then Minister for Innovation and Technology emphasized the need for researchers to focus on research that addresses community issues. He also added that their research output should be shared widely for public input (EAS, 2019).

3.2.1.2 Political economy issues raised

In the Phase 1 study (Chataway et al., 2017), we observed that Ethiopia's STI landscape was fragmented. This continued to be raised as a key issue, both by respondents and during the literature review for this Phase 2 study. In addition, issues relating to capacity, resource and funding constraints were also raised in both studies.

Fragmentation of the STI ecosystem and poor policies

We found that there continues to be weak coordination of research activities among organizations undertaking STI, with limited involvement of the government, private sector and academia. The weak coordination of research activities has led to duplication of research in universities. On the policy front, respondents stated that policies needed more work to ensure they adequately suit the needs of Ethiopia, and that it is important to strengthen the knowledge and expertise on policy issues of people involved in policy formulation and implementation.

Limited capacity building, human resource and infrastructure

There is need for capacity building in terms of training and infrastructure development in STI. This will enhance expertise in STI and create a conducive environment for researchers, lowering the risk of researchers moving to other countries and thus reduce brain drain. Furthermore, on capacity, it was pointed out that the majority of the personnel working in STI are educated about theory but lack the technical skills to effectively execute their duties. There are very few highly skilled professionals in innovation studies. In addition, respondents pointed out that universities do not yet have courses that focus on training students on innovation.

Limited funding for implementing STI activities

There is a sense among respondents that insufficient funding for STI has also slowed down the implementation process of the STI policy. In addition, there is a lot of bureaucracy involved in accessing government funding for R&D. This discourages researchers from seeking government funding, opting instead for partnership-based funding from foreign universities/organizations. From the public sector, it was mentioned that private sector funding for R&D is continuously diminishing. The private sector is not well familiar with the benefits of R&D and so does not see the value in investing in it. From the private sector, it was pointed out that private sector priorities lie elsewhere and R&D is seen as a poor investment choice due to the long waiting period for output.

Low technology transfer

A number of interviewees highlighted the difficulty of technology transfer; one even argued that local innovations are not supported. According to a representative from a government STI organisation, most of the machinery used in Ethiopian industries is imported, and the human resources needed to operate it are also from outside the country. The interviewee went on to argue that this discourages local innovators from developing new innovations due to lack of market and capacity.

3.2.1.3 Summary

Since the last report, Ethiopia's policy landscape has not significantly changed. The place of STI on the policy landscape was noted to have significantly improved during the PE1 study and the focus on STI has not diminished in the last three years. In fact, it has probably strengthened a little. However, there are still capacity and performance issues, as noted by interviewees and from recent data sources examined for this study update.

3.2.1.4 Recommendations for STI actors in Ethiopia

Science Granting Council: MInT's Innovation and Research Affair's wing

MInT must ensure that the STI Policy revisions are completed and implemented. The lack of clear policy documents will hinder the movement towards improved productivity in the area of STI. Increasing funding for research must also be a priority.

Private sector actors

Ethiopia has a vibrant export oriented agro-processing and manufacturing sector that benefits from many supportive government policies. The private sector must see value in research and innovation and be provided sufficient incentives to work, for example, with universities.

Policymakers

Consideration of improved implementation of policies as well as reducing staff turnover will be imperative to build stakeholder trust in the organs of government. For example, the government could provide clearer guidance for foreign investors who might participate in STI activities.

3.2.2 Kenya National Case Study Summary

3.2.2.1 Overview of the policy environment

The PE1 report in 2017 highlighted that the enactment of the STI Act in 2013 led to the realignment of STI programmes to the Kenyan national agenda as well as the strengthening of the national system of innovation. Through the STI Act, three organizations were established to coordinate national STI activities. These are the National Commission for Science, Technology and Innovation (NACOSTI), the Kenya National Innovation Agency (KeNIA) and the National Research Fund (NRF).

Since the first study reported in 2017, Kenya's political landscape has changed, with the introduction of the Government of Kenya's "Big Four" initiative. This is a targeted approach to achieving Kenya's Vision 2030 through a focus on four key challenges: food security, affordable housing, manufacturing, and affordable health care. The PE1 study also emphasised the importance of the devolution efforts in the country, which created county governments and brought decision making in many areas nearer the grassroots. However, devolution's impact on STI and research funding is not yet clear.

The Kenyan growth rate rose to nearly 6% in 2018 but the country still suffers from high levels of unemployment and a negative trade balance. A change in the education curriculum in 2017 to introduce competency-based learning is an attempt to build the skills needed for a stronger economic future.

3.2.2.2 Political economy issues raised

In the PE1 study, we reported that Kenya had taken the step of delineating responsibility of STI regulation and promotion across three different agencies (those noted above: NACOSTI, KeNIA and NRF). The issues facing these three agencies and other stakeholders highlighted in the PE1 study included the relative power and influence of different stakeholders as well as the availability of needed

capabilities and skills. These issues were also raised, alongside a set of new issues, in the interviews and literature review for this PE2 study.

Funding available and linkages for research and STI

According to interviewees, funds contributed to research and STI by the national government remain low due to competition from priority sectors in the Big Four development agenda: i.e. health, food security, housing and manufacturing. The scarcity of public funding means there is a significant focus on foreign funding sources for STI and research. Interviewees also said there is a continuing lack of private sector funding, arguing that private section organisations do not invest because they do not see the importance of research. Even where they do see an importance, they keep STI activities in-house; they rarely link with universities or other research organisations.

Level of skills and capacity for STI

Interviewees argued there is a mismatch between graduate skills and industry requirements, and this has been a major contributor to the high level of unemployment among the youth in Kenya. The mismatch of skills is mainly attributed to weak linkages between universities and industries, poorly structured curricula, rapid conversion of technical learning institutions into universities and limited infrastructure. This has led to a continued importance on improving technical and vocational education and training (TVET) in Kenya over the past three years since the PE1 report.

Unclear mechanisms for policy implementation, monitoring and evaluation

Interviewees pointed to a need for alignment of policies rather than their current fragmentation, clear implementation frameworks and stronger engagement by relevant stakeholders in government to push implementation forward. It was noted that the three mechanisms that make up the Kenyan science granting council platform (NRF, KENIA and NACOSTI) were still in their infancy (in their new roles) and therefore were still "finding their feet" in terms of how to operate. In addition, efforts were further hampered by continued silo-working by ministries and lack of interaction between stakeholders more generally, which limited the ability for effective policy implementation. Several interviewees noted the need for new funding mechanisms that de-linked education funding from funding for STI at ministry level: i.e. funding mechanisms that would enable the Science Council organisations to be more independent from their home ministry, which is primarily focussed on education.

Fit with development priorities

A common argument made by stakeholders in Kenya is that they are unable to see the relevance of STI research for business or societal benefit. However, efforts were being made in 2019 to align Kenya's STI policy with the SDGs and the Big Four national development agenda.

Recognition of the issues facing STI implementation

It is important to note that some of the issues raised above – and in the PE1 report – have been acknowledged as challenges by NACOSTI (which is tasked with regulating and advocating for the sector), with many of the above being listed in a 2018 report by NACOSTI itself.

3.2.2.3 Summary

Since the PE1 report, Kenya's policy landscape has been shaped by a move towards the Big Four agenda and a marked shift in emphasis on TVET and enhancing TVET opportunities in the country, including innovation through TVET colleges. This latter move is partly due to a continued recognition of the skills gap facing the country. More generally with regard to STI funding, we found that private sector

funding remains low and there are calls to introduce a new funding model for STI. Specifically, there is a need to de-link education funding from funding for STI at ministry level.

3.2.2.4 Recommendations for STI actors in Kenya

Science Granting Council: NRF

Data availability on the NRF website has improved in terms of lists of projects funded. However, there is still no clear public access to funding figures in terms of the amount of funding given to each project. Having publicly available information on the demand and uptake of funding will provide significant support for increasing funding allocated to the agency. The NRF is encouraged to share data.

Private sector actors

There is need to focus on TVET for initiatives that increase innovation in SMEs and R&D outside of "the lab". Potentially, this is also important given the type of private sector actors working in Kenya, the majority of whom are not focussed on traditional R&D intensive sectors, but are in small SMEs often in the informal sector.

Policymakers

There are renewed efforts to align Kenya's STI activities with different agendas (Big Four, Vision 2030 and the SDGs). It will be necessary to ensure there is coordination of these efforts to avoid duplication, overlap or contradiction. On funding, it has been argued that the introduction of tax incentives/waivers, recognition and award schemes could encourage financing of research activities from the private sector, development partners and philanthropists (Njau, 2018).

3.2.3 Rwanda National Case Study Summary

3.2.3.1 Overview of the policy environment

In 2013, the National Commission for Science and Technology (NCST) was established with a mandate to regulate national science, technology, research and innovation activities, and advise government on policy and legislation in STI. Its establishment was part of a national focus placed on using STI as a catalyst for the country's development. Since the PE1 report (Chataway et al., 2017), the STI political landscape has changed. Although the country retains the same President, the new Ministry of Information and Communication Technology (ICT) and Innovation was formed in 2019. This shift implies a change of innovation policy coordination role and thus will affect the mandate and activities of NCST.

In addition, in 2018, a new Director was appointed to the Science, Technology, Innovation and Research (STIR) Unit, under the Department of Education Planning, within the Ministry of Education (MINEDUC). Although the NCST is a semi-autonomous agency reporting to the Ministry in the President's Office, the Minister of Education remains the co-chair of the NCST governing council. This is partly based on Rwanda's belief in STI capacity development across all levels of education, which is part of the mission of the education ministry. NCST is responsible for the National Research and Innovation Fund (which is focussed on aligning research to strategic areas). In 2019, NCST was preparing a National Research Agenda document as part of its efforts to align research to strategic areas. Activities by NCST and other sectoral stakeholders such as the STIR Unit in education – and the National Industrial Research and Development Agency (NIRDA) and Rwanda Information Society Authority (RISA), affiliated to the Ministry of Trade and Industry and the Ministry of ICT and Innovation respectively – fit within a wider policy environment that until recently has been dominated by the national development agenda, Vision 2020. A new National Strategy for Transformation (NST1)

is meant to bridge the completion of Vision 2020 and the commencement of a new development plan, the Vision 2050.

The 2013 revised STI Policy is still the main policy document providing guidance for NCST and others in their efforts to promote the production and use of STI in Rwanda. Further review of the Rwandan STI policy was conducted by UNCTAD in 2018. The recommendations from this review include strengthening of policy synergies and identification of interrelationships and trade-offs among the goals. It also recommended that national STI policy should be formulated based on the national innovation system (NIS) conceptual framework. The prolonged approval process of the revised STI policy hinders its implementation.

3.2.3.2 Political economy issues raised

In the PE1 study, issues relating to limited interaction between research organisations, and limited resources (financial and human) and incentive structures, were raised. These were raised again in this follow-up study together with a number of other issues.

Lack of capacity of staff in STI organisations

Lack of expertise in STI was identified as a major challenge by several of the interviewees whom we met during this follow-up study. They noted this is a problem both within research institutions – e.g. universities – but also within the bodies responsible for regulating and promoting STI in Rwanda. The lack of qualified staff (especially at PhD level) is particularly noteworthy as is the need to promote more centres of excellence and innovation hubs.

Reliance on external actors for funding

Interviewees noted a continued reliance on external actors for funding, but two efforts are being made to change this. The first is that the Private Sector Foundation has revitalised its Research Centre. The second activity focusses on what already exists: i.e. to conduct frugal innovation, and to use current resources and traditional knowledge. However, several interviewees noted that the private sector will be reluctant to invest in this area until they recognize the value of R&D.

Limited interactions between STI stakeholders

All the interviewees highlighted the limited interaction between STI stakeholders (policy makers, universities, private sector, communities, etc.). However, it was argued that improvements to university-industry interaction are taking place and that regional cooperation would be useful to bridge gaps in interaction, especially where knowledge does not exist in Rwanda.

Improving research quality starting with the school curriculum and TVET

Recognition of the importance of improving research quality starting from school age has increased in the last two years. The Ministry of Education launched another phase of the "Quality Education Enhancement Awareness Campaign" in 2019. One of the main aims of the campaign is to emphasise the role of ICT in enhancing the quality of education. Other factors highlighted include: a change to a competency-based curriculum across primary and secondary schools, and an increased focus on TVET and the role of innovation outside of formal university research environments.

3.2.3.3 Summary

This PE2 study of Rwanda's STI system has highlighted a number of new funding initiatives being rolled out by NCST and efforts being made to enhance the sustainability of research activities in the country through a focus on STEM across the education sector. However, the lack of a clear overview

of funds granted and indicators of the status of STI makes it difficult to assess the impact of the STI system. The consolidation of research within the University of Rwanda is a major effort by the government to focus research efforts, but the success or otherwise of this initiative is yet to be seen and so needs to be evaluated as it is a very different approach to the neighbouring countries.

3.2.3.4 Recommendations for the STI actors in Rwanda

Science Granting Council: NCST

A revision of the website to provide a clear overview of the funding schemes available, and their historic grant allocations, would provide an incentive to researchers to apply for grants and enable more effective tracking.

Education providers

The decision to consolidate research into a single university will need to be reviewed in the coming years, as is a thorough review of all efforts to stimulate innovation, science and technology, and research. There appear to be many initiatives at various levels, from clusters work and innovation hubs through to PhD studies. A review of the indicators of successful STI is also required to ensure that the focus is not simply on patents and publications/citations as the various efforts being made are now more complex than this. Indicators and metrics that help to assess or capture impacts of science and research on national development objectives or aspects such as reduction of inequality, mitigated climate change or improvements in gender in STEM and inclusivity, are strongly encouraged.

Private sector actors

Efforts of the Private Sector Foundation and those working with universities are commendable. However, more needs to be done. Those representing the private sector must find ways of making the arguments for investment and attention to R&D and STI attractive to those in business. Greater recognition of the different types of business and the need for innovative action beyond just formal manufacturing of products would also be beneficial. The current focus on TVET education is a good opportunity to make in-roads in this area.

Policymakers

All interviewees noted the difficulty of implementing the STI Policy because it has not yet been ratified. Furthermore, all interviewees noted the need to raise public awareness of the STI policy and to promote it through a clear implementation plan, with progress monitored on a regular basis.

3.2.4 Senegal National Case Study Summary

3.2.4.1 Overview of the policy environment

Regional initiatives to promote STI in SSA, strong expectations for STI to contribute to Senegal's long-term development strategy – spelled out in the Plan Sénégal Émergent (PSE) (or Plan for an Emerging Senegal) – and implementation of higher education reforms, have all contributed to an increased awareness of the STI field in the country. Organisational and institutional reforms within the Ministry for Higher Education, Research and Innovation (MESRI) have also seen the creation of a dedicated directorate to lead on STI activities.

In the absence of a dedicated STI policy, sectoral measures related to higher education reforms and the PSE guide the SGC's funding and R&D, and MESRI's activities on STI. The 11 Presidential Decisions and associated directives, in particular, provide a roadmap for the SGC to follow and objectives to be achieved by 2022. These objectives include expanding higher education institutions to the entire country

and diversifying the university map, developing STEM, and promoting the use of ICTs for teaching and research as a way of increasing student's access to professional work. The reforms aim to increase investment in higher education and research. One way to achieve this objective is to increase training of human resources and create the necessary knowledge for "emergence", placing a specific emphasis on research and innovation. For example, Decision 8 outlines measures to "provide a fresh impetus to research and innovation" in Senegal, including identifying the country's main research priorities as they relate to its socio-economic development ambitions and implementing an appropriate system of performance indicators to evaluate national policy for STI.

The PSE also provides the direction for development of STI activities in Senegal, placing an emphasis on tertiary education and building further education institutions. In addition, the PSE emphasises the need to increase access to education for more people and from a wider range of socio-economic and marginalised groups. Furthermore, the plan allocates funding to create a second University of Dakar (with a focus on S&T) and a City of Knowledge in Diamniado, a suburb of Dakar. Among other things, the City of Knowledge is expected to host a dedicated space for governance and evaluation, as well as specific spaces for research and innovation, learning and the promotion of a scientific culture. Implementation of the PSE started in 2016 and the Ministry of Economy was expected to publish its Sectoral Development Policy Letter (*Lettre de Politique Sectorielle de Développement*, LPSD) at the end of 2019. Lastly, the government reform agenda and the PSE place specific emphasis on the development of ICTs to promote access to higher education and STI.

3.2.4.2 Political economy issues raised

As discussed above, there are many encouraging steps and progress in the STI system since the PE1 study. However, interviewees identified several stumbling blocks and challenges in effectively implementing STI activities. The political economy factors raised include the need for high-level policy support, greater articulation of issues of (STEM) education and gender in research, low research funding, capacity building, and investment in equipment and infrastructure, which remains a major obstacle to addressing research needs. In addition, there is need for greater efforts to promote STI and vocational training. These efforts must broaden beyond higher education to take a systemic approach to the whole education sector, thereby facilitating the development of STI from primary school upwards. Progress in this will help ensure that STI contributes to Senegal's socio-economic transformation. Further support at presidential level of governance and policy, including robust indicators and fully-fledged STI policy, would enable clear goals and prioritisation for the STI agenda in Senegal.

3.2.4.3 Summary

Senegal has a number of well-established universities and research institutes. MESRI's mandate covers all higher education institutions, including universities and higher institutes of vocational training (ISEP) as well as the Senegal virtual university (*Université Virtuelle du Sénégal*, UVS). The 2013 President Decision mandated the creation of a virtual university and 50 Digital Open Spaces or ENOs, at least one in each government department across the country. Research institutes fall under the remit of sector ministries. The most well-known of these is the Senegalese Institute for Agricultural Research Institute (ISRA). In total, Senegal had 16 functional research centres and test centres in 2015, up from nine in 2014. The aim of the government was to have 33 functional centres by 2018.

3.2.4.4 Recommendations for the STI actors in Senegal

Science Granting Council

High-level policy support: Although there is an increased awareness of STI among different actors in Senegal, greater support from executive and legislative powers is needed to provide further impetus to the emerging sector. This includes engagement not only from policy makers at MESRI and related agencies but also support from politicians, particularly the President of Senegal. High level support from the Presidency would send a strong signal in recognising STI as a priority for the country's socio-economic transformation. Members of Parliament could also play a role in promoting STI at the legislative level. Senegal's SGC can help facilitate and coordinate the high-level support.

Education: There is a need for further articulation of the role of education in delivering skills for STI. This includes strengthening efforts in higher education access, in general, and STI disciplines, in particular. In addition, a systemic approach to the education sector is essential, starting from primary school upwards and including vocational training. Further interactions between the three relevant ministries, as well as involvement of education practitioners and other actors such as the private sector and NGOs, would enable deeper understanding of the STI field boundaries, potential contributions and synergies. Again, Senegal's SGC can play an important role in this regard: in the processes involved in articulating the education system and fostering interactions among relevant actors.

Private sector

Reliance on limited state funding for research is a major stumbling block in the implementation of STI activities. STI actors in Senegal are encouraged to increase public spending towards research and innovation as well as development of partnerships to provide additional sources for R&D, which would enable further support for research. This could include partnerships with domestic and international actors as well as the development of public-private partnerships (PPPs).

Policy makers

There is need for policy to focus on overcoming silos and reducing fragmentation. The fragmentation of programmes, projects, activities and actors in the STI field makes it difficult to develop and maintain a common understanding of needs and potential contributions. The completion of the on-going national survey to provide up-to-date relevant indicators as well as a fully-fledged STI policy would help in ensuring a clearer assessment of needs and identification of STI priorities for socio-economic development. Relatedly, policies and regulations are needed to improve the availability, quantity and quality of data on STI, alongside data transparency. It is imperative that policy makers' focus on this.

3.2.5 Tanzania National Case Study Summary

3.2.5.1 Overview of the policy environment

Since the PE1 study, there have been few political changes that have influenced the STI landscape in Tanzania. John Pombe Magufuli remains President, and improved management of public resources and public administration, as well as eradication of corruption, have been the priorities since his appointment in 2015.

In 2018, Tanzania's GDP growth rate decreased to 6.7% from 7.1%, but inflation decreased to 3.5%. Tanzania did not receive any external funding for its 2018/19 budget due to governance issues. Official figures show that funding into public revenues by international donors has been extremely low in the period since the first PE report. Nevertheless, a significant amount of donor and international funding is used for STI and research activities.

The Commission for Science and Technology (COSTECH) remains the organisation with the mandate to oversee STI and research activities in Tanzania. COSTECH has set priority research areas in STI to enhance national socio-economic transformation, mainly through industrialization. This is in line with the national development strategy, Tanzania Development Vision 2025, to promote technology transfer and innovation. The main aim of the vision is to shift the country from agrarian-led growth into industrial and service-led economic growth. As part of these efforts, the existing (2010) STI Policy was reviewed, and was to be updated and published before the end of 2019. However, at the time of writing, the updated policy was still unpublished.

3.2.5.2 Political economy issues raised

In the PE1 study, we reported that Tanzania was doing well relative to other countries in terms of gaining funding from the private sector but that changes in policy and emphasis by donors and the government were negatively impacting the STI system. Very few of the same issues were raised during interviews and the literature review for this updated study, except for the influence of funders' priorities in research undertaken.

Low expertise and motivation

There are two elements to the issue of low expertise and motivation. First, there is a lack of skilled human resources, both in terms of PhD holders in the research sector and those with technical skills. These gaps are blamed on poor levels of technical and vocational training and a more general issue of poor education standards across the board. This raised a question, asked by one respondent, with respect to what type of skills and qualifications are important for Tanzania's development. Second, a number of interviewees noted that it was difficult to be research active due to levels of teaching and administration required.

Research funding priorities

Funding is crucial in sustaining researchers and research activities. Insufficient funding reduces the quality of the research output. It was noted that often research focus areas are determined by those providing the funding and not necessarily by the research needs arising from national priorities. This issue was deemed to be compounded by the long timeframes required for much research as opposed to government and private sector expectations for "quick wins".

National innovation system and policy environment

Interviewees characterised the Tanzanian national innovation system as nascent. They highlighted various limitations of the system including institutional issues, difficulties with infrastructure and poor linkages between key actors. In addition, they said that the different sectors and associated ministries operate in silos.

One reason for this might be the allied issue of difficulty implementing STI-related policy, which a number of respondents raised. They argued that knowledge of the field is poor as most policy makers have limited understanding of the STI concept. Some have argued for the need to reconceptualise and expand the limited understanding of STI in Africa (e.g. see Daniels, 2017). A related argument made by respondents is that the general public's awareness of organisations like COSTECH is limited. Specifically, they argued that, potentially, the fact that COSTECH only has an office in Dar es Salaam, and lacks regional or zonal offices, limits their ability to serve the entire country.

3.2.5.3 Summary

Since the PE1 report, Tanzania's ranking in the Global Innovation Index improved, rising 27 positions to 92 from the previous recorded rank of 123 in 2013, despite the findings of this report that highlight a significantly unfavourable environment for research and STI. Tanzania, therefore, risks slipping back down the Innovation Index at a time when the efforts of the country to work towards sustainable industrialization place a focus squarely on the importance of STI and research. Revision of the STI policy – ongoing at the end of 2019 – will be highly important in this respect. The key finding in this follow-on study is that the successful implementation of any revised STI policy is likely to be possible only if the bottlenecks relating to the policy environment (notably the resourcing of COSTECH and its autonomy) are satisfactorily addressed.

3.2.5.4 Recommendations for STI actors in Tanzania

Science Granting Council: COSTECH

COSTECH needs to cement its place within the STI system in Tanzania. If it can enhance its position so as to become the effective "go-to" place for anything relating to research and STI, it will be able to leverage increased numbers of collaborations which, in turn, will strengthen the STI system. This may involve moving its location to within the Office of the President, as other countries have done. There is need for enhanced collaboration between COSTECH and appropriate ministries in order to work towards industrialization. In addition to this, donor requirements for multidisciplinary teams could encourage these collaborations.

Private sector

The private sector needs to increase their support for research and development through funding. Those involved in R&D need to continue advocating for the government and private sector to understand the importance of research, and the importance of collaborations between these two groups of actors.

Policy makers

There is need to enhance capacity building to ensure that the policies developed can be easily implemented, starting with the revised STI policy. An enhanced focus on the influencing factors during the policy design, development, implementation and evaluation processes are essential together with development of corresponding mitigation strategies.

3.3 Key themes from the national case studies

Having provided brief summaries of each of the case studies, in this section, we discuss five themes that emerge from across all of them. The discussion here is based primarily on the interview material, especially as it is from this material that we are able to gain a clearer picture of what STI stakeholders themselves are thinking and why they are acting in particular ways. The themes we discuss are (1) governance and development strategies, (2) human resources, (3) funding, (4) research excellence, and (5) innovation systems. After discussing each of these themes, in the section that follows, we analyse the political economy factors that we determine are at play in the five case study countries.

3.3.1 Governance and development strategies

There is a recognition across those interviewed for the case studies that STI is cross-cutting and so needs to be considered by all government ministries. However, although this recognition exists – amongst the interviewees and many others – we were told that it remains largely rhetorical. That is, the recognition of STI as cross-cutting and important is clear in policy and political discourse, but many

interviewees argue it is lacking in implementation. Where implementation is happening, there tends to be only weak coordination and collaboration, with STI bodies and institutions working in silos. Consequently, many interviewees suggest that, to help achieve better coordination and collaboration, there is a need for clearly defined roles and responsibilities amongst the various actors involved in STI. This speaks to an overall governance challenge to which we return shortly.

Commenting on what is happening in practice in the STI field, many interviewees observe that economic development is mainly occurring in the informal sector, in service industries, and mainly involves "low" technology. Although these observations are likely to be disappointing to SGCs and other STI stakeholders, the observations do not necessarily mean that no "higher" formal-economy technology or innovation development is taking place. Nevertheless, it does raise the question that if such higher technology development is happening then why is it difficult to see? And interviewees were concerned that there needs to be a focus on development problems and the type of industrialisation that is promoted, which are issues closely connected to interviewees' views on what constitutes research excellence (see the research excellence discussion below).

It also brings us back to the issue of governance we mentioned above. Here, interviewees highlighted the need for alignment between STI policy and long-term national strategy. Interviewees in Senegal and Kenya gave examples of how this alignment has not been achieved. Senegal's 2035 PES is in place but there is no STI policy yet. In Kenya, the "Big Four" agenda was formulated after the STI Act, an Act that was in place before the (still ongoing) formulation of STI policy. And, as noted in the brief summaries in the previous section, Ethiopia and Tanzania are in the process of updating their STI policies but have not yet done so, and Rwanda has not yet gazetted its 2013 STI policy.

In terms of whether STI policy and implementation are taken seriously, interviewees tended to argue that organisations such as SGCs would be best located at a high political level, such as in or close to the national leader's office (whether president or prime minister). This is the case in Ethiopia and Rwanda, but not so in Kenya, Senegal and Tanzania. Whilst such location of an SGC is likely to mean there is more chance of STI policy and implementation, there is also the question of whether STI agendas could be captured by narrow interests. At the very least, there is a tension here between a structure that provides the power and resources needed to act, and the importance of independence in setting agendas and promoting a strong and credible scientific and research sector.

Finally, in regard to governance, although gender did not appear strongly in interviewee's comments, it did arise. Specifically, some interviewees argued that there is a need to get women into decision making roles. This will not, in itself, address all the complex challenges of gender inequality. However, as one interviewee argued, if women get into decision making roles they are more likely than men to try to achieve wider changes that will benefit more women as they understand the effects of gender inequality in ways men may not. Participation of more women in decision making positions will be an important step in beginning to address gender inequality, assuming those women do have real power.

3.3.2 Human resources

Capacity constraints are cited by many interviewees as an important feature of the political economy of SGCs. There are various views on what the specifics of these constraints are and how to address them. These include claims about university access and the quality of university education, arguments for the kinds of courses that should be offered throughout education systems – from primary to higher levels – and the kinds of skills training needed, and critiques of the pay and working conditions in the STI field that create a brain drain.

Access to university, according to several interviewees, is constrained in different and to some extent interrelated ways including by geography, socio-economic status and gender. Many universities are located in large urban areas where accommodation is expensive, and the number of student accommodation places on many university campuses falls far short of demand. The costs for many of attending university are therefore prohibitive for students from poor families or when students have to spend much of their time commuting because they have to live far from campuses where accommodation is cheaper. For women from poor rural families, the situation is significantly more challenging. If the family has to choose between supporting one child in further education, a male child will almost always be preferred to a female regardless of ability. And rural families tend to prefer their daughters do not spend long periods in the city away from the home. Although not expressed in interviews, we might expect that similar, or perhaps more difficult, challenges face students living with disabilities.

One partial solution to some of these access constraints could be virtual universities, several of which have been in operation across the African region. The African Virtual University (AVU) is the longest-established, with 19 countries having signed its Charter. But other country-based virtual universities exist in Africa, including the Virtual University of Senegal (UVS), which will be linked with at least 50 ENOs (*Espace Numérique Ouvert*, or Open Digital Spaces) located across the country (there are currently 13 according to one interviewee) to provide students with access points to UVS (Hanlin and Sawadogo, 2017, Cissé et al., 2019). We do not have any indication of the extent to which the UVS, for example, has made access to university education easier for those with disabilities, but Cissé et al. (2019) claim that "female students represent 47% of the UVS", in contrast to the average of about 30 per cent across the country.

Even where there is access to education, a number of interviewees made the point that there is a lack of courses and training on STI at all levels from primary to higher education. The point about starting such education early is perhaps most important in countries like Senegal where education is based on the French system, which channels students in specific directions from a young age. According to an interviewee, only about 5000 college students per year take the Maths and Science route. This has implications for the extent to which the country can nurture its capabilities to exploit natural resources for economic development, and a similar lack of capabilities was something echoed by many interviewees across all the case studies in regard to their own countries. The aspiration in Africa for transformation from natural resource-based to knowledge-based economies (AUC, 2014, AUC, 2015) has resulted in many of the countries rethinking their approaches to STI policy making and capabilities building, and a growing interest in "transformative innovation policy" (Daniels et al., 2020).

According to many interviewees, and across all the case study countries, insufficient provision of STI courses and training has in part resulted in a mismatch of skills between those of graduates and those needed by industry. However, even where students graduate from relevant STI training, there is a lack of the kinds of technical skills that industry needs. As one interviewee expressed it, universities are focussed too much on "white collar courses" to the neglect of technical skills training. Interviewees offered different reasons for the inadequate supply of skills they see are needed. One explanation offered lays blame with universities – and perhaps governments – who, it is claimed, charge higher fees for STI-related courses thus incentivising students to choose cheaper options. Another reason suggested is that students themselves do not believe STI-related courses will equip them with marketable skills. Yet another reason, given by a Tanzanian interviewee, identifies a change in the structure of the tertiary education system for the inadequate supply of technical skills. In this case, most of the technical colleges have been upgraded to universities resulting in an over-supply of engineers, although another interviewee said the proportion of graduates from tertiary education is low in Tanzania. Either way,

both interviewees spoke of an under-supply of technicians who, one interviewee claimed, are a major source of innovation as they are involved in the daily handling of machines and technology development.

To address the mismatch of skills, various strategies and solutions were mentioned by interviewees. Stronger links between university and industry were suggested, with references to specific country programmes that are already underway, and we will return to this in the section below on innovation systems. The most cited strategy, however, was to strengthen Technical and Vocational Education and Training (TVET), sometimes for university graduates as well as at the technician level. In terms of university courses and graduates, some interviewees suggest incorporating structured internships for students in industry and in SMEs, the involvement of industry in setting degree-course curricula and developing training, and moving to competency-based curricula – at least in Kenya and Rwanda – as a way to connect academia and research to national development goals as well as promote critical thinking.

Some interviewees also highlighted specific programmes, already in operation or planned, that aim to enhance TVET. Examples include plans for a TVET college in every one of Senegal's 45 departments, where each college will link to the local economy; an ongoing national employment programme in Rwanda to provide TVET capacity building to graduates; graduate training in entrepreneurship and innovation management, run by the University of Dar es Salaam Innovation and Entrepreneurship Centre; and international links such as between the Ethiopia Textile Industry Development Institute and an Indian leather institute through which 60 students are being trained at masters level in fashion technology, garment manufacturing, and chemical engineering.

Much of the concern with inadequate human resources is focussed on STEM subjects, but some interviewees noted there is also a lack of expertise and capacity in STI at the policy level. This includes the role of researchers, with one interviewee suggesting there is a need for experts to conduct research that informs STI policy. But there is also a lack of expertise in policy formulation, meaning that government officials need to be better informed and knowledgeable about STI. Furthermore, one interviewee claimed there are frequent changes of government personnel, resulting in poor institutional memory and a slowdown of policy implementation processes.

One more issue raised by some interviewees was that of brain drain, where there is a risk that those who do have relevant expertise and skills go abroad, further exacerbating the scarcity of skills. The few interviewees who mentioned the brain drain issue did so in relation to the science and research systems rather than industry and so the problem might be more acute when it comes to retaining university-based researchers. In explaining brain drain, two reasons were offered by interviewees. One relates to the lack of STI training in-country such that students must go abroad but then fail to return. The second explanation concerns those who are already qualified researchers. Because of the lack of research infrastructure – something mentioned by many interviewees across all the case study countries – researchers "go to the West" or elsewhere in search of better working conditions, which could include better salaries, opportunities and more prestige, not just better research infrastructure. And it is likely that the better working conditions abroad, to the extent that they do indeed exist, act as an incentive for students trained abroad to remain there. But a further issue related in a sense to brain drain is the risk of "poaching" that local organisations face when nurturing the development of their staff. In this case, a local organisation might be reluctant to invest effort in upgrading the skills of their staff, even if this is needed, because those staff then become attractive to other local organisations who might offer better salaries or career opportunities. At a system level, there is a benefit in terms of skills and expertise available in the system – an example of brain circulation – but it amounts to something of a zero-sum game at the organisational level.

3.3.3 Funding

Funding for research, and STI more broadly, remains low across the case study countries. SGCI is especially interested in the level of private sector funding and this, according to practically all our interviewees, is very low or negligible. Where there is private sector funding, it tends to be sourced externally or spent in-house by large multinational companies who have subsidiaries in the case study countries. Most research funding comes from donors – e.g. foundations or bilateral and multilateral development partners – and flows directly to researchers or research organisations rather than through governments. Much of the little funding provided by the case study country governments is for staff costs, not for research itself. Many of our interviewees provided reasons for why funding is so low, especially from private sector sources, and offered thoughts on how the situation could be improved. These included comments on the ways in which the funding systems themselves are functioning.

As mentioned, private sector funding of STI activities remains low or negligible in all the case study countries. Various reasons were suggested for this situation, three of which were most widely offered: the local private sector is dominated by SMEs who do not have the financial capacity to invest in R&D or other STI activities, with interviewees from Rwanda and Senegal further observing that their formal private sectors are too small or undeveloped to be concerned with research; private sector actors do not see the business value in research; and the private sector does not trust government research organisations, thereby making it difficult to establish private sector-research linkages. But several other reasons for a lack of private sector funding in STI were suggested by some interviewees. These included a lack of R&D or STI expertise in local firms, poor or non-existent incentives for private sector investment in R&D (whether local or international private sector), and a fear among university researchers – in Senegal at least – that conducting R&D for private firms would constrain their academic freedom and autonomy. Although not widely expressed by interviewees, this fear is a potentially important issue in need of careful reflection and debate if some of the outcomes described by Jasanoff (2005) in relation to the repercussions of the 1980 US Bayh-Dole Act, which deals with patenting of discoveries resulting from federal research grants, are to be avoided. The Bayh-Dole Act, according to Jasanoff's account, had profound effects on the US university and – to some commentators at least – seriously eroded the science system's Mertonian ideals, attracting large private investments into university-based R&D, with claimed negative impacts on academic disinterestedness, peer-review and the robustness of scientific findings, among others.

Solutions to raising private sector STI investments included policy changes to create better incentives. Few interviewees gave concrete suggestions for incentives but those who did mentioned examples such as public-private partnerships for STI activities, tax reductions for firms engaged in R&D, and government subsidies for private sector R&D. Beyond direct financial incentives, some interviewees suggested government investment in research infrastructure could help, such as the nurturing of innovation or incubation hubs that would, presumably, relieve private sector actors of the expense of establishing their own research facilities and so help to encourage private sector STI activities. Such measures could also include public sector support for commercialisation of STI. Also, some interviewees claimed there is a need to establish a clear legal framework that could form the basis for foreign investment in local R&D as well as foster stronger local research-industry linkages. And many interviewees suggested that researchers and other STI actors need to persuade private sector actors of the benefits to their businesses of investing in research, with some interviewees referring to what they perceive to be a need to develop a better research culture.

On this point about improving the research culture, some interviewees said this not only needs extending into the private sector but also needs fostering among those in the science systems of the case study countries. According to some interviewees, the poor research culture they claim exists within the

science systems is in part an outcome of the ways in which the government funding systems work. For example – at least in Ethiopia, Rwanda and Tanzania – several interviewees claimed that accessing government funding is highly bureaucratic and so, together with the low level of government funds available, many researchers look to sources other than research grants to supplement their income. The resulting "loss of research focus" as one interviewee put it tends to weaken the research culture (see the section on research excellence for more on research culture). But other problems with government funding were identified by our interviewees such as the funds mainly paying salaries rather than for research (Kenya), recall of research funds (Tanzania) or failure to disburse promised funds (Ethiopia), low priority for STI compared with other demands such as education (Kenya and Tanzania), and poor high-level political commitment to, or understanding of, STI and its role in national development (Tanzania).

And the problems with low and uncertain government funding have consequences for the sectoral distribution of research funds. As discussed in the first political economy study (Chataway et al., 2019, Chataway et al., 2017), the agricultural and health sectors receive by far the most money and this, according to our interviewees, has not changed. A common reason expressed in interviews is that these are priority sectors in all the case study countries. However, some interviewees also said that this means other important objectives are being neglected and many STI system actors are unable to get access to research funding. For example, the drive for industrialisation in the case study countries, for which STI could play a crucial role, is undermined because of weak government support. Competitive bidding for the small amount of money available means the relatively undeveloped areas such as engineering or policy research lose out to actors in the more developed agricultural and health research sectors. To address this problem, several interviewees suggested that there needs to be capacity building for researchers in these neglected areas to be able to write better proposals. The need for government support of this kind is perhaps underlined when we consider that, according to some interviewees, donors are less interested in funding research in areas beyond health and agriculture.

3.3.4 Research excellence

The issue of research excellence emerged out of the work for the first political economy study (Chataway et al., 2017, Chataway et al., 2019) and is further explored in Chataway and Daniels (2020). In essence, the issue centres on a definition of excellence as used by some science funders in which there is only one measure and that is the traditional notion of scientific excellence, judged by peer review, as opposed to an alternative definition of excellence that incorporates the impact of research. For this updated study, we asked about research excellence explicitly in the interviews and so we now have a stronger evidence base from which to highlight various aspects of the issue more specifically. These can be summarised as falling into three categories: research focus, research process and incentives, and research support.

On research focus, many interviewees questioned the relevance of the research being conducted and this relates strongly to whether research is focussed on "purely" academic problems or on variously addressing societal challenges and national development goals, or what could be described as the perceived dichotomy between basic versus applied research. Practically all our interviewees said research excellence meant having societal impact, if we can describe addressing societal challenges and national development goals in this way. Many of these interviewees did not dismiss publishing in journals; the two objectives are not necessarily in tension. For example, one interviewee said that good-quality journal papers can influence policy makers, implying at least an indirect societal impact. Any tensions that may arise could be between what many actors on the ground perceive as important and how some funding bodies assess research quality, something we noted in the first political economy

study (Chataway et al., 2017) in regard, for example, to the singular notion of excellence the Alliance for Accelerating Excellence in Science in Africa (AESA) appeared to be using.

Implicitly or explicitly, several interviewees argued that agenda-setting must be owned nationally in order to achieve the kind of research excellence they identify. The logic in this argument lies in the need to first understand the national (or sub-national) societal challenges that must be addressed and the control over allocation of funds to motivate research that answers those challenges. From this perspective, some interviewees suggested donors should fund such "baseline" studies and then allocate their research funding in accordance with their findings. Other interviewees argued for more national autonomy, whether in terms of research funding or agenda setting, or both.

Judging by comments in two of the Senegal interviews, this latter perspective seems to be based on the idea that it is not in the interests of foreign actors to either address national development challenges or help build local capacity to address them. The concern is that foreign actors – donors, private companies and others – currently benefit economically from holding the necessary expertise and so are less likely to promote, or might actively undermine, the development of local research excellence. This has some resonance with the argument made by an interviewee in our first political economy study that some donor-funded health research, for instance, is targeted at diseases of interest to the donor countries: that is, the research is motivated by a desire to understand diseases that might in time affect the populations of the donor countries. But not all foreign funding is necessarily so deliberately self-interested. One of the Senegal interviewees noted that the research themes of international funding calls or scholarships are difficult to align with national needs. Nevertheless, it brings us back to the issue of ownership – or sovereignty as the Senegal interviewee expressed it – and an argument that research excellence is something of a governance issue.

In addition to the focus of research, several interviewees from across the country case studies related research excellence to the process of how research is or should be done. There seem to be two aspects to this: (1) research culture, and (2) the need to encourage research collaborations and interactions or working across different sectors. Two interviewees mentioned research culture explicitly and a further five interviewees referred indirectly to research culture and its links to excellence. Those who spoke explicitly of research culture argued there is a need for researchers to be more committed to research and develop a culture of high quality, productivity and efficiency in their work. There was no space in the interviews to explore what these things mean and how they could be assessed, if at all. Nevertheless, several interviewees pointed to the importance of incentives to improve research culture, whether they mentioned culture explicitly or implicitly. At present, according to interviewees in all the case study countries except Ethiopia, such incentives are not in place. Incentives range from the less material, such as encouraging curiosity and creativity at an early age, to monetary inducements that will motivate researchers to be more proactive and engage in meaningful research. And one interviewee argued for a change in leadership mentality in organisations, something that is arguably another dimension of research culture. The point here is that organisations need visionary leaders who will mobilise resources to fund impact-based research.

On the aspect of collaborations, many interviewees see these as ways to ensure the research process achieves excellent outcomes. Many suggested the need to improve university-industry links as one strategy to promote research collaborations, and several interviewees mentioned the need to work across silos such as those between industry, government, communities and academia. Some interviewees also see working across silos as a way to improve policy implementation, again speaking to governance issues. One Senegal interviewee cited a concrete example of the potential benefits of collaborations amongst researchers. The collaborations were facilitated through the SGCI and included researchers from Burkina Faso and Senegal:

> The collaboration initiative … did not get much funding. Nevertheless, it has enabled us to identify the researchers, finding the financial means, and create a community of researchers in projects for health and agriculture. We, and even researchers who were not selected, have welcomed this initiative. A total of 17 research projects with researchers from both countries were submitted. They really appreciated to work together. But the budget only allowed for the funding of 2 projects. This stifles enthusiasm/motivation. If at least it was 50% but 2 out of 17 – for high level researchers – this needs to be addressed to have adequate resources and have organisational capacities to address STI challenges [otherwise], for others, the door is closed.

This relates to research support, the third broad category of issues relevant to research excellence. In the view of several interviewees, lack of or weak research infrastructure is one of the more important issues that needs addressing. The specifics of what this means seem to vary but they include establishing laboratories with testing and other equipment, R&D facilities, and centres of excellence. Perhaps with the exception of centres of excellence, the kinds of infrastructure suggested imply that many see research predominantly in terms of the natural and physical sciences, and how this relates to achieving societal impact implies "innovations" (and perhaps STI generally) are widely understood to mean marketable products and services. There is more evidence from our interviews to support this interpretation and we will return to this in the section below analysing the political economy of SGCs. But, besides a need to improve infrastructure, some interviewees referred to the importance of establishing research teams and a conducive research environment, as well as building capacity for administrative support for teams and research projects, and the need to create technical and innovation support units in governmental institutions.

3.3.5 Innovation systems

Within all the themes so far discussed, a cross-cutting issue that has appeared several times is that of support systems for STI. Under the governance theme, for example, weak policy implementation is blamed in part on STI bodies and organisations working in silos, which leads to weak coordination and collaboration in STI governance. This silo problem – extended to include other sectors beyond governance – is also identified as an issue hindering the achievement of research excellence. Under the themes of human resources, funding and research excellence, more systemic issues were identified. These include poor university-industry linkages, and the need for more innovation or incubation hubs and centres of excellence. And more specific sub-systems were identified as problematic. Here, many interviewees cited issues with intellectual property rights (IPRs), product commercialisation and, as noted under several themes, research support infrastructure. In this final theme discussion, we focus on issues we have so far not explored but have emerged strongly from our interviews: university-industry linkages, IPRs and product commercialisation.

Various problems with linkages in STI systems were mentioned by interviewees across all case study countries, and weak system linkages would certainly be seen as a problem by analysts in the innovation systems literature. However, the most common kind of linkage discussed in interviews was between universities and industry. The reason this kind of linkage seems to be important, at least according to our interviewees, is that innovations are assumed by many to originate in university-based research. This resonates with the point made towards the end of the previous theme discussion on research excellence that innovations are widely understood to mean marketable products and services. In this view, which came across strongly in the interviews, university researchers are expected to produce high-quality science that can eventually lead to innovative and marketable products and services. In turn, these products and services will address societal challenges and contribute to economic growth and

development. We will explore these ideas further below in this theme discussion but, first, we discuss university-industry linkages specifically.

The general diagnosis of the state of university-industry linkages across the case study countries is that they are poor or weak and so, according to the widely-held view that they are key to generating innovations, STI systems are not producing the expected products and services needed to meet societal challenges. On the university side of these linkages, some interviewees suggested there is too much emphasis on disciplinary education that is also lacking, as we said earlier, in the development of TVET skills relevant to industry. The reasons for this are many but include little power and few resources for STI government departments within ministries, no policy frameworks for knowledge or technology transfer from academia to industry, no incentives for academia to work with industry and, as we discussed in the Senegal case earlier, some reluctance among academics to enter into relationships with private sector actors.

On the industry side of the linkage, according to our interviewees, the private sector has little understanding of STI needs and, as we discussed earlier, either sees no business case for investing in STI in universities or is dominated by SMEs who have no resources to invest in STI activities. And, mirroring academic reluctance to enter into relationships with the private sector, some interviewees suggested that industry does not trust public research organisations. As a Rwanda interviewee said, "the networks are full of suspicion".

In a partial answer to some of these issues, interviewees highlighted several efforts aimed at strengthening university-industry linkages. In Ethiopia, the University-Industry Linkage (UIL) initiative has, according to an interviewee, been established in all public universities and has strengthened links between academia and several industries, with manufacturing, service, hotel and health specifically mentioned. Also in Ethiopia, according to another interviewee, at the governmental level, the separation into a Ministry of Innovation and Technology and a Ministry of Science and Technology has meant more effective implementation of STI policy, which includes more efficient management of UIL. In Kenya, Linking Industry with Academia (LIWA) promotes a triple-helix model of innovation – where government, industry and academia form the three helixes – and is working to increase private sector engagement in the national innovation system, amongst other activities. And one interviewee pointed to a policy in Kenya that mandates universities to involve the private sector in research.

In Rwanda, an interviewee noted an initiative led by the Ministry of Education and funded by the African Development Bank (AfDB) to increase linkages between higher education and industry. And the Government has launched the National Industrial Research and Development Agency (NIRDA) that, among other activities, aims to encourage collaborations between private and public sectors. According to the interviewee, R&D funding has increased over the years but, as we have noted elsewhere in our discussion, the private sector in Rwanda is small and so has limited capacity to support R&D. In Tanzania, we have no specific details. One interviewee did say, "There are some programmes here and there but there is a huge need to have proper coordination and collaboration between players". Unfortunately, we have no data to explore the extent to which any of the initiatives mentioned here are succeeding in strengthening university-industry linkages.

As we said above, the outcomes of university-industry linkages are expected to include innovations that will become products and services to address societal challenges. And such products and services might also originate from the private sector without the involvement of universities or other research institutes. Many of our interviewees had thoughts on these processes, and it is here that the issues of IPRs and product commercialisation were raised. It is clear from our interviews that many actors are focussed on

technologies of various kinds when they discuss innovations: technologies such as drugs for curing diseases, technological consumer products and technologies to improve manufacturing. And, because these products are expected to be released into the market by private sector actors, the health of the business environment features in many interviewees' comments. From this view, the importance of IPRs and patents is paramount. Without strong IPR protection, the argument is that research is unlikely to lead to marketable products because innovators fear they will be copied and so innovators will be unable to appropriate enough profit to recoup their investments. In addition to this risk, innovating from research to market is seen as expensive and so it is difficult for the many SMEs who populate the case study countries to engage in innovation. And, even if innovators do attempt to get intellectual property protection, patenting processes can be bureaucratic, time-consuming and expensive.

Some interviewees offered either thoughts on ways to address these challenges or mentioned specific efforts that are in operation to do so. For example, a number of interviewees called for more innovation or incubation hubs that could be used to help innovators turn their ideas into commercial products. Such hubs could be provided through public organisations and some interviewees pointed to such hubs now in place. However, one Tanzania interviewee also noted that innovation hubs lack the skills necessary to commercialise products. One Rwanda interviewee said there was a need for a national body to support innovators (the interviewee did not mention NIRDA), something that Kenya has introduced – Kenya National Innovation Agency (KeNIA).

In Tanzania, one interviewee mentioned the Small Industry Development Organisation (SIDO) and the Tanzanian Industrial Support and Development Organisation (TIRDO) as potential support organisations for innovators. However, the interviewee noted that SIDO does not have an official mandate to support business and technological development, and TIRDO's research output is not used. In terms of strengthening university-industry links, one Kenya interviewee argued for better technology transfer offices and suggested that universities could be good locations for incubators. And another Kenya interviewee called for simplifying the patenting process and reducing its cost or waiving the fee altogether.

Overall, when interviewees talked of some of the problems in an innovation system, they focussed on a small part it – the university-industry linkage or, in a few cases, the triple helix. And much of the discussion assumed innovation to mean marketable products. Little mention was made of wider innovation system actors beyond universities, industry and the government. No interviewees talked of other kinds of innovation, such as in policies or social practices. Although it could be argued that innovative and marketable products are the most economically significant, and therefore most important, and that these are most likely to emerge from a well-functioning triple helix, there are potential risks in this view. In our political economy analysis, to which we now turn, we will explore these risks more fully.

4 Analysis and Discussion of the Political Economy of SGCs

4.1 Introduction

We begin our analysis and discussion of the political economy of SGCs by examining what we can deduce about the dominant ideas shaping efforts to strengthen STI systems in our five country cases. As we discussed in Section 2, where we explained our conceptual approach, ideas can be revealed by, or inferred from, the ways in which actors talk about the system in which they wish to intervene, what strategies or interventions they think are needed to change the system, and why they believe such interventions are needed. Combining what we deduce about these ideas with evidence on what is being implemented, we can better identify actors' understandings of STI systems to provide a basis upon which we can highlight possible tensions and synergies between the strategies employed and the realisation of desired outcomes. In this section, we first analyse what we can discern about the dominant ideas of innovation and innovation systems. We then briefly discuss some of the alternative understandings before considering what policies (or institutions) are being implemented as a result of these dominant ideas. This brings us to a consideration of some of the policy risks associated with the dominant ideas and what adopting a broader understanding of innovation and innovation systems might mean. We then reflect on how different structures are affecting STI in the case study countries, and then consider different actors' interests and roles in strengthening STI systems. We end the section with a focus on research excellence and what issues arise from efforts to achieve it.

4.2 Ideas: understandings of innovations and innovation systems

As we noted at the end of the previous section, there seems to be a specific concept of innovations (as outputs or outcomes) dominating actors' narratives. Judging by the comments of those we interviewed, innovations are widely understood to be technological products marketed by private firms, and the hope seems to be that such products will enable citizens to improve their lives in some way, thereby achieving societal impact and national development. In the case of some interviewees, the concept of innovations extends to include services and, in the view of a few other interviewees, incorporates manufacturing technologies or perhaps manufacturing processes. In line with this understanding of innovations, science and research are expected to generate the raw materials with which to develop technologies that can become marketable products or can facilitate service-provision.

Considering, then, the relationship between science and innovations, the understanding we have just described suggests that the most important actors in an STI system are researchers (whether in universities or research-based organisations), technology-development support organisations, private (entrepreneurial) firms, business incubators and policy makers. The roles and responsibilities in this chain of actors are assumed to begin with researchers making discoveries from which they refine technical principles. These can be used by technology-development support organisations to design technological prototypes. Private firms can then work with business incubators to turn these prototypes into marketable products and viable businesses that can attract finance. These products are then released into the market where customers can buy them, assuming the products are both well-marketed and of some value to customers. Policy makers set the terms under which these different activities unfold and the regulatory frameworks that ensure fair play, safety, and relevance to national development. Importantly, the particular understanding that seems to dominate is that the direction of flow is from science through to products in the market. In other words, as we suggested in the first political economy study, there appears to be a dominant understanding of innovation as a unidirectional science-push process, the so-called "linear model of innovation" long-ago discredited in the innovation studies literature. As Daniels (2017) argues, there is a need to broaden the conceptualisation of innovation in

Africa, partly to go beyond the linear science-push framing and narrow view of innovation as products, but also to ensure that innovation address issues related to inclusive development (Daniels et al., 2017).

Although these understandings seem to be dominant, we should note that some interviewees expressed alternative or broader ideas. Interestingly, those with slightly different ideas were all in Tanzania. This might be significant of some wider phenomenon in the country or could just be an artefact of the interviews we happen to have managed to secure. In any case, an interviewee from an organisation trying to promote business solutions to development challenges, when asked who the main actors involved are, included technology enthusiasts, the public and development partners along with the kinds of actors we listed in the previous paragraph. Another interviewee emphasised the importance of policy-focussed research, not just research in the natural and physical sciences, and how neglect of this was a problem for improving the STI system. And one other interviewee expressed a similar view, identifying a misconception of innovation as a problem, and saying:

> most people think that innovation is only for engineers and scientists. Most of the financial support for innovation is directed towards applied research (product development) and small amount goes into financing the qualitative research (policy research and system analysis) in innovation.

The same interviewee also pointed to a lack of intermediaries in the STI system, another kind of actor whose role would be to broker knowledge between others. And the interviewee further identified weak connectivity between the different elements in the STI system.

Policy recommendations that flow from the dominant understanding of innovation and the innovation system, as we have characterised them above, would rest on assuming that more funding of science-based R&D – and therefore more activity in science-based R&D – would lead to more discoveries or refinements of technical principles. Then, assuming the rest of the science-to-innovation system is working well, the outputs of science-based R&D would eventually lead to more products appearing in the market and there would be more chance of addressing development challenges. As such, science-based R&D needs more funding, and there needs to be more funding for the technology and product development process as well as better linkages between the actors along the innovation chain. All of this needs to be tied to national development goals so that public money is spent on addressing relevant national challenges. Attention also needs to be given to support systems, such as education (from primary through to higher education), and to specific policy instruments such as private and intellectual property protection. And private investment is needed to supplement scarce public money to support R&D as well as to finance product commercialisation.

4.3 Institutions: policy risks associated with the dominant understandings

The evidence gathered for our five country case studies, especially in interviews, suggests that the above interpretations of the dominant understanding of both innovation and innovation systems in those countries are plausible. And the nature of the policy problems identified by our interviewees in the five countries resonates with what policy recommendations we would expect to flow from this understanding. Although we do not wish to argue that the dominant view of innovation is in some sense "wrong" or that the policy recommendations associated with this view are inappropriate, we do wish to argue there are risks that need to be examined if they are not to undermine the strengthening of STI systems. Certainly, innovative products and services do make both a difference to people's lives and can have significant impacts on economic growth and development.

Such products and services can have roots in science-based R&D, and support throughout the innovation chain, as characterised above, can help to usher science-based ideas into innovations in the

market. But if these outcomes fail to materialise or materialise in ways deemed insufficient by political and policy actors there is a risk that support for STI will either continue to be weak and unstable (at best) or perhaps be withdrawn altogether. It is well-understood in the innovation studies literature that innovation is a risky and highly uncertain process. Iconic or celebrated innovations that have significant economic impacts – e.g. the Internet, smart mobile phones, mobile money – happen rarely and, incidentally, when they do they are often the result of significant public investment (Mazzucato, 2013). In this sense, confining the understanding of innovation to marketable products and services, and the innovation process to a science-push model, looks like an "all-eggs-in-one-basket" strategy: i.e. that everything rests on one approach that could fail.

Broadening both the concept of what counts as an innovation and how an innovation system works (Daniels, 2017) could help STI stakeholders to better understand the roles of science and research in STI systems as well as foster more ways in which innovations are realised. For example, few interviewees talked about innovations in public services but the introduction in Senegal of a virtual university (the UVS) could be seen as one such outcome. According to the information we have about its impacts, the UVS has enabled thousands of Senegalese in rural areas to access higher education and, importantly, has raised the proportion of women studying for degrees. There are likely problems with the UVS model, but it is not clear that it would even exist if all efforts to promote innovation were focussed on generating marketable products from science-based R&D as per the characterisation we discussed above. Innovations in other public services across our case study countries could have important societal impacts too. This underlines the point made by two of our Tanzania interviewees on the importance of policy-focussed research, and not just for STI policy.

But another aspect of the risks associated with too narrow a focus on science as the origin of marketable innovations arises from the reported suspicion amongst Senegalese academics of working with private sector actors, and the reference to the US Bayh-Doyle Act as discussed by Jasanoff (2005). In this respect, if the science system is expected to work closely with private sector actors to generate products then it could become overly instrumentalised and captured by private interests. This could fundamentally undermine the science systems, compromising notions of scientific excellence that could have implications for the place of African science globally. We do not wish to argue that this danger is imminent. Rather, it is something that policy makers and STI actors may need to reflect upon when advocating for ways in which STI systems – and research excellence – can be improved.

4.4 Structures: geographical, social, political and organisational influences

Whatever understanding of innovation and innovation systems is dominant, there are several structural issues that also condition what is possible or desirable in the STI systems that SGCs are seeking to achieve. We have already mentioned something about geography, and how this can affect access to services, when we discussed the UVS. Another aspect of geographical structures relates to resource endowments. In several of our case study countries, oil and gas deposits offer economic opportunities those countries wish to exploit. To this end, some of the countries are developing elements of innovation systems centred on oil and gas exploitation, such as establishing degree and postgraduate courses to nurture capabilities in these sectors. This raises difficult questions that policy makers and STI actors may need to consider. If STI systems around oil and gas are successfully developed, there is the question of whether such systems would then need to be dismantled as climate change action intensifies. Considering the enormous amount of work needed to establish STI systems, dismantling them will not be easy: not only will they be economically important, thus creating the challenge to replace them with equally important economic sectors, they will also create powerful vested interests and, if they do become obsolete, there is the risk of creating stranded STI systems not just stranded assets. More

generally, STI actors may need to consider the extent to which they wish to develop systems based on other resource endowments or, perhaps more usefully, how they will ensure that reliance on such endowments is sustainable.

We have also seen some effects of social structures. In this case, it was around gender roles and access to higher education. Women tend to enjoy less access to education than men because of gendered practices in the home, but also in terms of how gender relations are understood to play out in urban areas, making it less safe for women to live alone in cities far from their families. There may be similar or more severe effects for people living with disabilities. Other studies could investigate these issues more specifically. Without equality of access to education and other public services, and without equality in governance roles, apart from the ethical and justice issues raised, STI systems will not benefit from the best available human resources.

In terms of political structures, we noted the comments by some interviewees in regard to the position of SGCs in their national governance systems. There is a potential tension here between locating an SGC close to the highest level of political power, which would provide the SGC with the authority and resources to act more effectively on STI policy, and locating it in a position where it can act autonomously. The risk of location at the highest level of power is that it could then be easily captured by whatever is the prevailing political interest of the time. Locating the SGC away from such dangers could mean it is unable to function, especially if it is unable to secure the support of the highest political level. This clearly points to the need for strong institutions so that SGCs are buttressed against daily political dynamics.

At the organisational level, we did not reveal much about how structures affect implementation of STI activities. One exception, perhaps, was in the way academics are expected to work. Several interviewees spoke about universities being focussed on education (teaching) to the neglect of research, with academics expected to deliver heavy teaching loads. In Kenya, academics are apparently not relieved of teaching duties even if they win research grants. Such organisational arrangements are not conducive to fostering a research culture let alone the production of excellent research.

The extent to which these various structural factors condition STI systems is a matter of discussion. Some of them are likely to be more important than others: resource endowments, for instance, could have profound impacts; structural inequalities could have significant practical impacts but are also issues of justice in their own right. However, we cannot suggest what might be the right kind of structures, and so recommend what should be done to create or shape them, because the same challenges seem to be present across all the case study countries. Instead, we would suggest there needs to be specific research done to understand the effects of different structures on the development of STI systems.

In summary, therefore, structure is important because difference structures can condition how, for example, funding flows, accountability is exercised, coordination is enabled, or high-level political support is achieved. In principle, structures that embed STI governance within the presidency or prime minister's office, for instance, risk capture of STI actors to narrow interests and reduced autonomy. On the other hand, structures that place STI governance far removed from such high-level positions risk low levels of support for STI actors and poor access to resources such as funding. Interestingly, although each of the countries studied has its own structure, some of these issues seem to be present across all of the cases. This suggests that, regardless of the structure, emphasis needs to be put on addressing the specific issues, rather than focussing too much on structure itself. In other words, it is important not to over-emphasise the significance of structure.

4.5 Interests: understanding different actors' roles in strengthening STI systems

The final political economy factor we should note is that of interests. These are apparent in all aspects of the STI systems of the case study countries. It is unsurprising to state that every actor has their own interests and also that these various interests do not always align with each other. We have already discussed some of these in the thematic section. For example, we discussed the claim that donors are not always funding activities relevant to national interests because they have their own interests at heart, and international actors could also have their own interests to protect, meaning they are less likely to help local actors develop their own capabilities. We also heard that local private sector actors do not see the business case for investing in R&D; they do not see their interests being furthered by such activities. And researchers, or academics who could engage in research, are not incentivised to conduct research; their interests are not being served by their national STI systems.

Many interviewees suggested solutions to these issues, but these solutions were general in nature – e.g. creating incentives – or targeted at one specific part of the system such as improving IPR regimes. We would suggest that more careful and in-depth study of the interests of different STI system actors, and the ways these interests interact with others, would be of benefit to SGCs and other STI stakeholders. Such a study could include attention to how interests are aligned in examples where there has been success and attention to how more problematic interests have been managed. One specific issue that arises from our study is that the private sector is more complex than it is often portrayed. In our country cases, for example, there was discussion of international companies, local large and powerful companies, local formal sector SMEs and local informal SMEs. Each will have different kinds of interests, different capabilities and different resources at their disposal. Understanding how to get the private sector to invest more in R&D will therefore require a much more nuanced understanding of these interests and resources.

4.6 Summary: narratives about science and STI systems

The key messages flowing from this analysis of the political economy of SGCs bring us back to the notion of research excellence, as it is understood by practically every one of our interviewees. On this basis, it seems clear that STI stakeholders are primarily interested in seeing societal impact; in addressing national development challenges. They believe that well-functioning STI systems can contribute profoundly to achieving these goals. The question is what SGCs can do to help strengthen STI systems, given the political economy contexts in which they are working. From our analysis here and from our first political economy study, we would suggest there is a need for a clearer and widely adopted understanding of what innovation and innovation systems mean. Within this clearer understanding, the role of science and research needs to be better articulated, as do the roles of the many other kinds of actors involved, not just the private sector. A clearer understanding of this kind could help to define what research excellence is, how it relates to scientific excellence, and how STI systems can be shaped to achieve these desired outcomes. In turn, STI stakeholders may be better able to construct more realistic narratives that can be used to persuade policy makers of the importance of science, research and innovation, and the ways in which these can help or not to meet development challenges. Over-promising in regard to STI, as it appears some of the narratives at play are currently doing, risks losing the support of policy makers if the kinds of outcomes depicted in such narratives do not materialise as expected.

5 Conclusions and Recommendations Arising from the PE Study

5.1 Concluding remarks and general recommendations for STI stakeholders in SSA

i. **Innovation systems and development**: STI plays a crucial role in addressing a range of development challenges. However, current understandings of innovation and STI systems, as expressed by the SSA actors covered in this study, could be characterised as narrow, partial and linear, a reflection of the ideas and narratives at play. Broadening understandings of innovation beyond consumer products and industrial production technologies, and understandings of STI systems beyond university-industry linkages, could help science system stakeholders better articulate the role of science in achieving development goals. This, in turn, could help stakeholders participate more effectively in debates about science funding and other interventions aimed at strengthening STI systems in SSA.

ii. **Capabilities and skills**: Strengthening STI or, more specifically, science systems, requires building a wide range of capabilities and skills. At present, approaches to capability building and strengthening tend to reflect the current understandings of innovation and innovation systems. In line with broadening these understandings, capability building must critically examine what people are being trained to do and why. Capability building that achieves systems-level impact will require all stakeholders to work together in the design and delivery of training, adopting a co-learning approach. Another important aspect of skills development relates to the training of policymakers (including leaders, decision-makers, and parliamentarians) and SGCs in innovation systems thinking. This is complementary but different from training of those within the system such as students or private sector employees.

iii. **Gender and inclusion**: Gender and inclusivity issues do not yet seem to feature fully in the operations and activities of some science system actors in SSA. If this is indeed the case, urgent action is needed in at least three respects. One, it is important to understand why these issues are seemingly neglected or not considered a priority. Two, stakeholders would need to formulate and implement policies and strategies to mainstream gender and inclusivity in their programmes, projects and activities. And, three, action needs to be reflexive so as to understand what works and why, and under what circumstances, so that lessons learned can be shared and good practices replicated where applicable.

iv. **Research excellence**: The findings of this report suggests a widespread view that research excellence is achieved not only by publication in high-quality academic journals but also by achieving societal impact. However, realising research excellence in these terms, according to those we interviewed, means change is needed on many fronts. Significant improvements are needed, for example, in research environments (e.g. research cultures, organisational structures), research infrastructures (e.g. laboratories and other facilities), and research incentives (e.g. funds, prestige, career opportunities, possibility to buy out teaching time).

v. **Structure, in relation to governance and policymaking**: Structure is an important conditioning factor for effective governance (including accountability, autonomy, coordination, and transparency), efficiency, and resource (such as human, financial, technological) management. Structure can affect the operations of SGCs and their ability to effectively manage science and research, reduce fragmentation and silo mentality, and actively engage with policy processes and policy making. All STI stakeholders in SSA are therefore encouraged to work collaboratively in seeking out structural configurations that foster effective performance of SGCs in SSA, starting at national levels, moving on to regional (RECs) levels and to the African Union level. Achieving this will require innovation, experimentation, mutual learning and reflexivity.

5.2 Recommendations for STI Stakeholders in SSA

In this section we outline some specific actions that stakeholders could take. The recommendations focus on how each stakeholder could contribute to addressing the general recommendations provided in Section 5.1 above. The list below is not exhaustive, and so stakeholders are encouraged to do more.

5.2.1 Recommendations for SGCI and International Development Partners

i. Commission and help to facilitate further research, stakeholder engagement events, and policy interventions that contribute to addressing the five general recommendations above.
ii. Support training and capability strengthening initiatives that help improve stakeholders' understanding of broader views of innovation and science systems.
iii. Ensure that gender and inclusion are addressed in every programme or project commissioned, in terms of participation and representation, and in (research, programme or project) design.

5.2.2 Recommendations for SGCs

i. Continue to strengthen organisational capabilities and individual's skills in STI and policy.
ii. Re-evaluate and, if necessary, redesign programmes, projects and activities to ensure they are in line with a broad view of innovation and science systems, as discussed in this study.
iii. Re-examine issues related to structure and governance in ways that help to address silos and the fragmented nature of STI institutions and accompanying policies.
iv. Address the many existing issues of gender inequality and the related but separate issue of inclusion in STI.

5.2.3 Recommendations for Academia

i. Play a more active role in the development of curricula in STI training, skills development and capability strengthening for stakeholders (SGCs, policymakers, decision-makers, etc.).
ii. Continue work on research excellence to ensure that knowledge generated is diffused across SSA and that progress made is embedded at appropriate levels, and in institutions and agencies.
iii. Carry out policy research to support the work of SGCs and STI policy making.

5.2.4 Recommendations for Industry

i. Commission (alone or in collaboration with other stakeholders), fund and support research and other initiatives that help to improve knowledge and understanding on the notion of the "private sector" in SSA in relation to STI.
ii. Increase engagements and collaborations with STI stakeholders (academia and SGCs in particular), as this contributes to strengthening the innovation, science and research systems.
iii. Strengthen the capabilities and skills of the sector in STI and policy.

5.2.5 Recommendations for other Stakeholders

This group includes civil society, NGOs, grassroots innovators, entrepreneurs, and community leaders.

i. Continue to highlight issues sometimes ignored by stakeholders: e.g. gender and inclusion.
ii. Strengthen capabilities and skills in STI and policy, and engage in policy processes.
iii. Engage in discourses that shape STI ideas. This helps to ensure that innovation in SSA is for development and transformation, and that excellent research contributes (or leads) to impact.

To all stakeholders: disseminate this report widely and help actors implement the findings.

5.3 Limitations

Information and data collection

Information and data collection from interviewees and secondary sources was a major challenge during the study. In spite of the extensive knowledge and networks of the research team, it was difficult to secure interview respondents and conduct the interviews via the preferred channel of telephone. Eventually, some interviews had to be done via face-to-face meetings, which resulted in additional travel, costs and time delays. In terms of secondary sources, as at the time of carrying out the PE2 study, work on the Africa Innovation Outlook III (AIO3), for example, was still in progress. This meant that more up to date STI data from AIO3 could not be used and integrated into the study. In addition, concerted efforts to obtain information and data related to the AIO3 and other sets of STI data (at mostly regional, but also national levels) from Collaborating Technical Agencies (CTAs) were unsuccessful, as CTAs did not respond to our requests or engage with the study team as expected. Access to data from CTAs on indicators such as changes in R&D and research grants, for instance, could have helped in updating the funding flows developed in the PE1 study.

Therefore, due to the extremely limited resources (time, finance, and access to some data) for this study, the researchers took a pragmatic approach as to how information and data were collected. The team made a differentiation between what kind of information to gather during interviews and what could be gathered from literature and available data sources. In general, it was determined that asking questions in interviews that could be answered by reviewing reports, for example, is likely to be a less efficient use of time (although sometimes helpful for triangulation). The interview protocol was therefore focussed by taking these considerations into account.

5.4 Further Study

Further studies that seek to improve the knowledge and understanding of the political economy of STI and SGCs in SSA may focus on one or more of the topics outlined below.

1. Broaden the current narrow view, focus and understanding of science and innovation systems, and the role of science and innovation in development. Research of this nature can potentially inform future STI policies and policy making in SSA.
2. Unpack the notion of "the private sector" further and deepen the understanding on the sector in SSA. This could help shed more light on questions such as: how best to categorise, collect data, and manage the knowledge from this sector; what counts as R&D in this sector; strategies to increase R&D funding from the sector; and the role of SMEs and informal sector in innovation.
3. Gain deeper understanding on new and alternative structural configurations and the implications on governance, covering the 15 SGCs and, if possible, the whole of SSA. Further research in this area might improve our knowledge of the effects of different structures on the development and strengthening of science and innovation systems, and STI policies in SSA.
4. Despite the progress on research excellence (RE) in recent years, what RE is and how to achieve it are still unclear. Further research could deepen our understanding of impediments to RE, incentives that could accelerate good practices, diffusion mechanisms and possible routes to mutual learning, and structures that best promote RE in SSA.
5. Examine the interactions between and among the five key themes emerging from this study, how they influence each other, and the possible implications for SGCs and the SGCI.
6. Deepen research on (a) gender, and (b) inclusivity in SSA's STI systems to better understand why gender and inclusion are not considered important by some STI stakeholders; what political

economy-related regime structures and lock-ins need changing; what routines, behaviours and practices require change; and what ideas, narratives, institutions, and rules may be impeding progress.

7. Commission and fund research on data and indicators in STI. Not only do we need more data (on the current indicators that we already know about and use), we also need a more diverse range of indicators. In addition, there is need for a broader set of data on what works and what does not, why, and in what contexts; and data on how SGCs measure their performance. Furthermore, it is important to undertake more quantitative studies that examine the treatment of indicators.

References

AUC 2014. Science, Technology and Innovation Strategy for Africa 2024. Addis Ababa: African Union Commission.

AUC 2015. Agenda 2063: The Africa We Want. A Shared Strategic Framework for Inclusive Growth and Sustainable Development: First Ten-Year Implementation Plan 2014-2023. Addis Ababa: African Union Commission.

Byrne, R., Mbeva, K. & Ockwell, D. 2018. A political economy of niche-building: Neoliberal-developmental encounters in photovoltaic electrification in Kenya. *Energy Research & Social Science,* 44**,** 6-16.

Chataway, J. & Daniels, C. 2020. The Republic of Science meets the Republics of Somewhere: Embedding scientific excellence in sub-Saharan Africa. *In:* Kraemer-Mbula, E., Tijssen, R., Wallace, M. L. & McLean, R. (eds.) *Transforming Research Excellence: New Ideas from the Global South.* Cape Town: African Minds.

Chataway, J., Dobson, C., Daniels, C., Byrne, R., Tigabu, A. & Hanlin, R. 2019. Science Granting Councils in Sub-Saharan Africa: Trends and tensions. *Science and Public Policy*.

Chataway, J., Ochieng, C., Byrne, R., Daniels, C., Dobson, C., Hanlin, R. & Hopkins, M. 2017. Case Studies of the Political Economy of Science Granting Councils in Sub-Saharan Africa. Science Granting Councils Initiative: SPRU (Science Policy Research Unit) and ACTS (African Centre for Technology Studies).

Cissé, F., Diémé, J., Assion, L., Sy, M., Daniels, C. & Ting, B. 2019. ICT in Higher Education in Africa: Example of the Virtual University in Senegal. Brighton: Transformative Innovation Policy Consortium.

Daniels, C. 2017. Science, technology and innovation in Africa: Conceptualisations, relevance and policy directions. *In:* Mavhunga, C. (ed.) *What Do Science, Technology and Innovation Mean from Africa?* Chicago: MIT Press.

Daniels, C., Schot, J., Chataway, J., Ramirez, M., Steinmueller, E. & Kanger, L. 2020. Transformative Innovation Policy: Insights from Colombia, Finland, Norway, South Africa, and Sweden. *In:* Cele, M. B. G., Luescher, T. M. & Fadiji, A. W. (eds.) *Innovation policy at the intersection: Global debates and local experiences.* Cape Town: HSRC Press.

Daniels, C., Ustyuzhantseva, O. & Yao, W. 2017. Innovation for inclusive development, public policy support and triple helix: perspectives from BRICS. *African Journal of Science, Technology, Innovation and Development,* 9**,** 513-527.

DFID 2009. Political Economy Analysis How To Note http://www.gsdrc.org/docs/open/po58.pdf (accessed on 30/05/2017).

EAS. 2019. Declaration launched to enable an equitable research system in Ethiopia.

Hanlin, R. & Sawadogo, N. 2017. The political economy of the Senegalese science granting councils. Science Granting Councils Initiative: SPRU (Science Policy Research Unit) and ACTS (African Centre for Technology Studies).

Hodgson, G. M. 2006. What Are Institutions? *Journal of Economic Issues,* 40**,** 1-25.

Hudson, D. & Leftwich, A. 2014. From political economy to political analysis. *DLP Research Paper* Birmingham: Developmental Leadership Programme.

Jasanoff, S. 2005. *Designs on Nature: Science and Democracy in Europe and the United States,* Princeton NJ, Princeton University Press.

Kern, F. 2011. Ideas, institutions, and interests: Explaining policy divergence in fostering 'system innovations' towards sustainability. *Environment and Planning C: Government and Policy,* 29**,** 1116-1134.

Leach, M., Scoones, I. & Stirling, A. 2010. *Dynamic Sustainabilities: Technology, Environment, Social Justice,* Abingdon, Routledge.

Mazzucato, M. 2013. *The Entrepreneurial State: Debunking Public vs. Private Sector Myths,* London and New York, Anthem Press.

Naess, L. O., Newell, P., Newsham, A., Phillips, J., Quan, J. & Tanner, T. 2015. Climate policy meets national development contexts: Insights from Kenya and Mozambique. *Global Environmental Change,* 35**,** 534-544.

Njau, M. 2018. Kenya mulls tax incentives to attract research funding. *KenInvest website*.

Raven, R., Kern, F., Smith, A., Jacobsson, S. & Verhees, B. 2016a. The politics of innovation spaces for low-carbon energy: Introduction to the special issue. *Environmental Innovation and Societal Transitions,* 18**,** 101-110.

Raven, R., Kern, F., Verhees, B. & Smith, A. 2016b. Niche construction and empowerment through socio-political work. A meta-analysis of six low-carbon technology cases. *Environmental Innovation and Societal Transitions,* 18**,** 164-180.

Roe, E. M. 1991. Development narratives, or making the best of blueprint development. *World Development,* 19**,** 287-300.

Schmidt, V. A. 2008. Discursive Institutionalism: The Explanatory Power of Ideas and Discourse. *Annual Review of Political Science,* 11**,** 303-326.

Tijssen, R. & Kraemer-Mbula, E. 2017. Research excellence in Africa: Policies, perceptions, and performance. *Science and Public Policy,* 45**,** 392-403.

Tralac. 2019. Ethiopia: Ministry manoeuvres toward digital economy.

Annexes

Annex 1: National case study report on Ethiopia

National Case Study Report of

Ethiopia

Science Granting Council

1 Context of Ethiopia's STI System

Science, Technology and Innovation (STI) play a crucial role in national economic and social development. In an effort to strengthen STI in Ethiopia, the government has taken several measures over the last 10 years. These measures include increased funding, adoption of an STI policy and a strengthened STI governance institutional framework (TECHIN, 2019). The STI system in Ethiopia has evolved over the years as a result of various occurrences, as shown in Figure 1 below.

Figure 1: Timeline showing major historical milestones affecting the national STI system

In the 1990s, it was realized that STI could not be used as a tool for national development due to the absence of an STI policy and the unfavourable conditions for research and science and technology (S&T) management. Against this backdrop, the government commissioned the formulation of an S&T policy and the process was completed in 1993. Objectives articulated in the policy document include: ensure the efficiency of the national S&T activities and ensure they are directed towards national development; develop the national capacity for S&T to enable realization of the national socio-economic objectives; and, increase national awareness of S&T and improvement by knowledge and culture. The objectives of the S&T policy were not fully realized due to political unrest from border conflicts (1998 to 2000) between Eritrea and Ethiopia. The S&T policy document was revised by the Ethiopian Science and Technology Agency (ESTA) formerly known as the Ethiopian Science and Technology Commission (ESTC). The review process was finalized in June 2006. The revised policy

document had a new STI governance structure with the following functional levels: National STI Council; Technical Advisory Committee of the National STI Council; Ethiopian Science and Technology Agency; S&T operational Institutes and Centres (Mouton & Boshoff, 2006).

The main aim of this case study is to identify the different political, economic and social aspects affecting the performance of STI in Ethiopia. Key informants from different sectors were interviewed either via Skype/phone or in person (see the Annex for interview information). Additional information was also collected from secondary sources through literature review. This study was carried out between May and September 2019.

1.1 Contextual factors arising between 2017 and 2019

1.1.1 Political overview

In April 2018, Ethiopia elected a new Prime Minister, Dr. Abiy Ahmed Ali. His previous position as Ministry of Science and Technology in 2015 is said to ensure that STI continues to be advanced in the country.7 The country also benefits from having an inter-ministerial committee on STI issues (see below). Its STI policies also align with the Sustainable Development Goals.

1.1.2 Economic overview

The current population of Ethiopia is approximately 110,449,766 (Worldometers, 2019). In 2017/18, there was a decrease in economic growth due to political uncertainty, civil conflicts and changes in the political regime (AfDBhttps://afdb.org/, 2019). Currently, the government is implementing the second phase of the Growth and Transformation Plan (GTP II) 2019/2020. The plan targets an 11% GDP annual growth rate and transformation of Ethiopia into a manufacturing hub through expansion of physical infrastructure (World Bank, 2019). Manufacturing and industry sectors are expected to be the major contributors to this economic growth with the support of the education system in the provision of skilled professionals (Teferra et al., 2018)

According to the United Nations Industrial Development Organization (UNIDO), Ethiopia has the lowest level of income inequality in Africa. The rapid population growth and low starting base have been a major contributor towards the low poverty levels in Ethiopia. Recently, the country has experienced economic growth due to expansion in the agricultural and service sectors. A reduction in the national poverty level has been foreseen due to the increased economic growth (UNIDO, 2019).

Ethiopia experienced a decline in GDP growth rate in fiscal year 2017/2018 to 7.7%. This decline was attributed to a lag phase in industrial growth, increased prices of imported material and shortage in foreign exchange. Poor performance in manufacturing and agricultural sectors was also a contributing factor in the decreased GDP growth rate (World Bank, 2019). The country experienced a 10% decrease in exports during this period, resulting from reduction in export of Ethiopia's major products: coffee, oilseeds and pulses. Agriculture remains a major contributor to GDP with a contribution of 37%. It is also the largest source of employment, employing 73% of the workforce (FAO, 2019). In addition, the service and industry sectors were major contributors to GDP growth, contributing 8.8% and 12.2% respectively (AfDB, 2019).

The government has made efforts to increase Ethiopia's exports through the leather and floriculture industries. However, leather sector performance has been on the decline in terms of production, employment and export volumes. This poor performance has been persistent despite the huge

[7] See: https://africanbusinessmagazine.com/region/horn-of-africa/the-dawn-of-ethiopian-tech/ (accessed 27/4/20)

population of livestock herds, large labour force and government support. There have been attempts to address this challenge through policy interventions. However, such policy interventions have been unsuccessful in the creation of backward linkages to the livestock sector. Contributing factors to the sluggish performance of the leather industry include over-reliance on the road transport system, lack of diversification in tanneries and creation of a poor business environment for foreign investors due to fear of competition.

In contrast, the floriculture and horticulture sectors have experienced outstanding performance with an export value of USD 225 million in 2015/16. In addition, the sectors also attracted investments from Europe. They have also made major contributions to job creation with 50,000 and 130,000 people employed in floriculture and horticulture respectively. The high performance of the floriculture sector has earned Ethiopia a top five position in production and exportation of roses worldwide. Factors contributing to the success of both sectors include readily available affordable land, efficient air transportation, incentives, and accessible industrial financing (Oqubay, 2018).

1.1.3 Science and technology system overview

The most recent reforms made to the STI system in Ethiopia are the formation of the Ministry of Innovation and Technology (MInT) and the Ministry of Science and Higher Education (MoSHE) in October 2018. The Ministries are mandated to strengthen and orient activities in the national STI system of the key actors in the national innovation system. The MInT is divided into three parts. The first (responsible for the activities corresponding to a Science Granting Council, SGC) is the Innovation and Research Affairs wing. The other two wings are the productive improvement technologies sector and the ICT sector. There is also a science, technology and innovation policy directorate, which is a separate entity under MInT. MoSHE is responsible for universities, technical and vocational training centres, and the promotion of research centres of excellence and university-industry linkages (Gizaw, 2019).

The National Science, Technology and Innovation Policy remains the key policy document in the structuring of the national science and technology system. The main focus of the policy is the provision of strategies for the country based on its overview of the national science and technology landscape and the need for reinforcement of the linkages among the actors within the national innovation system. The national information and communication technology (ICT) policy also plays a crucial role in STI. The national research systems in agriculture and health are more advanced and well organized compared to other sectors within the economy. Research activities in agriculture are mostly focussed on crop, livestock, biotechnology, land, water, farm machinery, agricultural economics and climate. The research outputs are used to enable smallholder farmers to increase their produce though improved access to advanced technologies in agriculture. In the health sector, the focus areas are health and nutrition, modern medication and traditional drugs. Industrial research within the manufacturing sector remains low. Various industry development institutes have been established by the government for the purpose of capacity building and research development in industries. The government has also heavily invested in the establishment of industrial parks to promote capacity in technology and innovation, resource mobilization and job creation. Ethiopia has made tremendous advances in research including vaccine transportation drones developed by the Ministry of Innovation and Technology, and water harvesting, mowing and grinding machines developed by Gondar and Bahir Dar universities. Despite these advancements, Ethiopia still lags in research and development (see below). More effort is needed to facilitate the shift from an agriculture-led economy to one led by industry (TECHIN, 2017).

As per the STI policy, the organizational structure of the National Science, Technology and Innovation System governance in Ethiopia has four functional levels:

i. National STI Council

ii. Technical Advisory Committee of the National STI Council

iii. Ethiopian Science and Technology Agency

iv. S&T operational Institutes and Centres

The National Science, Technology and Innovation Council (NSTIC) is the regulatory body for the STI policy and action plan in Ethiopia. It is mandated to establish and coordinate the general strategy and framework for the development of STI. The Prime minister is the core chair of the council and MInT is the secretary of the Council. The secretary of the Council nominates experts from S&T institutions/centres who are later appointed by the Council as NSTIC members. The Council monitors and evaluates the performance of STI activities.

The STI policy is under review by the Ministry of Innovation and Technology in collaboration with the United Nations Conference on Trade and Development (UNCTAD) (Tralac, 2019). The revised STI policy is aimed at transforming Ethiopia into a technology-led economy. It is hoped that the revised policy will help drive Ethiopia from "consumer" status into a manufacturing country. Revision of the policy was stimulated by a number of reasons from the previous version: non-compliance to economic reforms, misalignment with various sectors, and non-progression towards an industrial economy. Within the revised policy, science and technology are targeted to contribute USD 2 billion to GDP, create 20,000 technical jobs and 2000 SMEs. These targets are to be achieved within 2 years (Tralac, 2019).

In March 2019, a declaration on enabling an equitable research system in Ethiopia was launched by the Ethiopian Academy of Sciences (EAS) in collaboration with the International Network for the Availability of Scientific Publications (INASP). The declaration is aimed at creating a holistic, equitable and collaborative research system. It also aims at identifying the factors hindering the creation of an equitable system. The then Minister for Innovation and Technology emphasized the need for researchers to focus on research that addresses community issues. He also added that their research output should be shared widely for public input (EAS, 2019).

2 Challenges affecting the STI system

In the first Political Economy (PE1) Study, it was observed that Ethiopia's STI landscape was fragmented (Chataway et al., 2017; 2019). This was due to a number of issues highlighted in the PE1 study:

- Limited mandates and weak policy implementation
- Competing interests and weak collaboration between stakeholders
- Inappropriate funding mechanisms and significant bureaucracy
- Insufficient funding and/or incentives for researchers
- Limited human resources and infrastructure deficits

Several of these issues were raised in this follow up study during interviews conducted for fieldwork and from the literature review. These are discussed below.

2.1 Recap of STI system issues: Evolution of STI system 2017 to 2019

2.1.1 Fragmentation of the STI system

According to an informant in the MInT, there is weak coordination of research activities among institutions/organizations undertaking STI. This has led to duplication of research in universities. Respondents also pointed out the presence of a weak legal framework for technology transfer and lack of a formal innovation system in product and service sectors. It should be noted that the restructuring of the ministries and the creation of the MInT would question this. One informant, a researcher, pointed out that the limited involvement of the government, private sector and academia in STI has resulted in insufficient funding, and poorly qualified human resources. Academics have an understanding of STI but are not motivated to promote awareness of STI to the public.

On the policy front, an informant from a government STI organisation stated that the policies needed more work to ensure they adequately suited the needs of Ethiopia. Another informant from a local university also pointed out that the people involved in policy formulation and implementation lack expertise on policy issues. According to a researcher in one of Ethiopia's universities, policy formulation should be contextualized, and all the relevant stakeholders should be involved in the implementation process. In addition, he also pointed out that the frequent change of government officials in the institutions mandated to do policy formulations and implementation slows down the implementation process because the new officials need to familiarize themselves with the processes first. New government officials should be taken through rigorous capacity building and orientation before the previous officials leave office.

2.1.2 Limited capacity building, human resource and infrastructure

A university informant emphasized the need for capacity building in terms of training and infrastructure development in STI. This will increase expertise in STI and create a conducive environment for researchers. This will in turn lower the risk of researchers moving to other countries, thus reducing brain drain. This is in line with the response from a representative in the leather industry who mentioned that most inputs required for innovative activity – e.g. latex and equipment – are not locally available and have to be imported at a high cost. He also referred to high taxation fees and high transport cost due to the limited transport infrastructure. Furthermore, on capacity, it was pointed out that the majority of the personnel working in STI are educated about theory but lack the technical skills to effectively execute

their duties. There are very few highly skilled professionals in innovation studies. Nevertheless, a researcher in one of Ethiopia's universities pointed out that universities do not yet have courses that focus on training students on innovation.

According to the Higher Education Proclamation (2009), for academic staff to qualify for a promotion/salary increment, they are required to engage in research. This approach does not seem to be effective compared to incentives. Incentives could be more effective in encouraging researchers to produce high quality research output. The incentives should have a particular component that cushions researchers from economic pressures. This will reduce the need for researchers/academic staff to seek alternative sources of income (Woldegiyorgis, 2019). That said, there has been a national level reform process through adjustments to various policies. The government has implemented strategies towards the creation of research universities. For instance, in 2014, Adama University and the Addis Ababa University of Science and Technology were transformed into science and technology universities. These universities are central institutions to the national industrial strategy. Their main focus areas are applied research and technology transfer. Education Sector Development Programme (ESDP V's) targets to establish three research universities with 50% PhD-holders as staff and 20% postgraduate students. This is a clear indication of the increased experience and relevance of local STI institutions over the years (Tamrat, 2019).

However, the lack of experience and knowledge of university board members has been seen to be a contributing factor hindering university-industry relationships, resulting in the misalignment of research to the national agenda. Tamrat (2019) has put forward different strategies to address this issue including: capacity building and accountability requirement of board members; and the Ministry of Science and Technology should play an intermediary role between the board and government (Tamrat, 2019). Currently, Ethiopia has 50 public universities, 174 private institutions of higher learning, and 1547 TVET colleges (Gizaw, 2019).

2.1.3 Limited funding for implementing STI activities

There is a sense among respondents that insufficient funding for STI has also slowed down the implementation process of the STI policy. According to an informant from one of the universities, there is a lot of bureaucracy involved in accessing government funding for R&D. This discourages researchers from seeking government funding, opting instead for partnership-based funding from foreign universities/organizations. An informant from the public sector mentioned that private sector funding for R&D is continuously diminishing. The private sector is not familiar with the benefits of R&D and so does not see the value in investing in it. A private sector representative also pointed out that private sector priorities lie elsewhere and R&D is seen as a poor investment choice due to the long waiting period for output.

Despite increased investment and infrastructure for higher education, the research and innovation quality and quantity remains low compared to other African countries. Most universities allocate less than 2% of their annual a budget to research. This has a direct impact on the research output. During the 8th research week at Addis Ababa University, the Minister of Science and Higher Education, Prof. Hirut Woldemariam, outlined strategies taken to address this challenge. These strategies include holding various dialogues with the aim of improving allocation of resources and creating a conducive environment for research in public universities, restructuring of research at directorate level, and digital repository development. In accordance with the higher education proclamation, institutions of higher learning are mandated to have a fund for research and innovation where research resources are mobilized and managed. Part of the funds can be used to provide incentives to researchers in alignment with the institution's quality assurance protocol (Woldegiyorgis, 2019).

2.1.4 Low technology transfer

A number of interviewees highlighted the difficulty of technology transfer; one even argued that local innovations are not supported. According to a representative from a government STI organisation, most of the machinery used in Ethiopian industries is imported and the human resources needed to operate it are also from outside the country. The interviewee went on to argue that this discourages local innovators from developing new innovations due to lack of market and capacity. The basic level of technology in the country has been attributed to lack of innovativeness, lack of a national technological infrastructure, limited access to finances and lack of technology market. However, this may be changing, given the MInT's mandate is focussed on supporting local innovations and technology development through a product and services engineering directorate, incubation centre development directorate, an incubator and a start-up strategy.

Technology transfer should be enhanced through importation of machinery from developed countries into lower developing countries. The machinery should be fabricated locally, and local human resources should be trained to use the machinery. This will narrow the wealth and technology gap and ensure sharing of knowledge and technical skills. Use of new technologies introduces techniques of production of cheaper goods, and accumulation of capital (TECHIN, 2019b). It was also recommended by an industry representative that the government should offer more scholarships to researchers and support innovators through provision of financing and establishment of more incubation centres.

3 Research funding

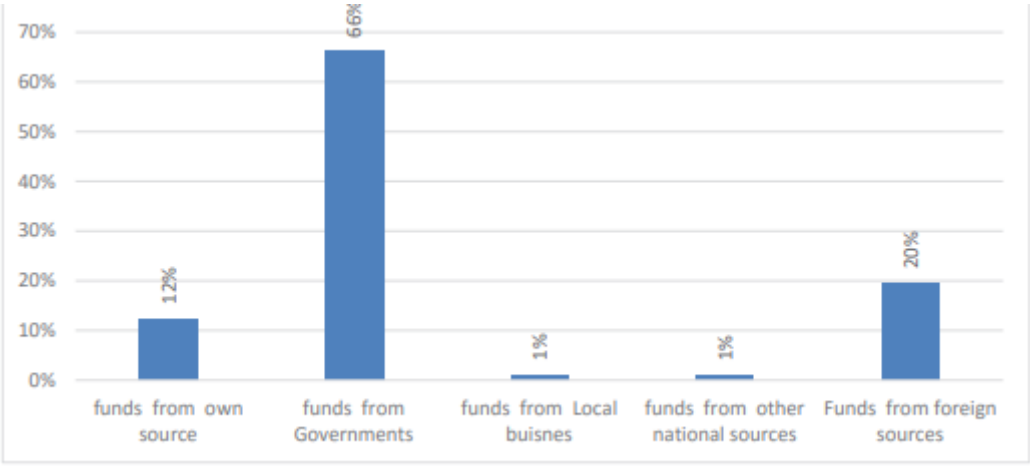
3.1 Science funding

	2017	2019	Notes
R&D expenditure as % of GDP	0.60%	No data	UNESCO, 2015: Ethiopia
- Distance to national target of 1.5%	0.9%	No data	
- Distance to regional target of 1%	0.4%	No data	
- % from government	79.07%	No data	UNESCO, 2015: Ethiopia
- % from business enterprise	0.75%	No data	UNESCO, 2015: Ethiopia
Role of foreign funders over the past five years	↑	No data	

↑↑↑ high and increasingly on agenda; ↑ on agenda and slow increase in attention; --- no change

There has been mixed commitment by the Government to increase R&D investment to the 1% AU target. In fiscal year 2016/ 2017, ETB 5.02 billion was allocated to R&D. This is a decrease from the GERD in the fiscal year 2013/2014, which was ETB 5,242,890,110. The largest contributor to the GERD is the government, who contributed 66% of the total amount, as seen in Figure 2 below (TECHIN, 2017).

Figure 2: Sources of the Gross Expenditure on Research and Experimental Development (GERD)

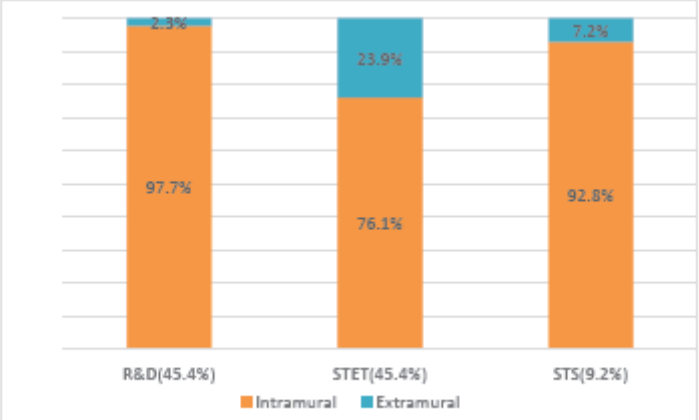


Source: TECHIN (2017)

Local business and other national sources contributed the least percentage (1%) to the GERD. A substantial percentage of 20% was contributed by external/foreign sources, as shown in Figure 2 above.

A recent report (TECHIN, 2019a) on the status of STI in Ethiopia notes that science and technology activities (STAs) are categorized into three groups in the country: Scientific and Technical Education and Training (STET); Scientific and Technological Services (STS); and Research and Experimental Development (R&D). In the fiscal year 2016/2017, R&D and STET received equal amounts of ETB 2.25 billion, while STS received the least amount (ETB 456.3 million) of the federal government expenditure, as shown in Figure 3.

Figure 3: Categorized government expenditure on STAs



Source: TECHIN (2019a)

According to a survey done by the TECHIN in 2016/2017, intramural activities took up the majority of the funding in R&D (97.7%), STET (76.1%) and STS (92.8%), as shown in Figure 3 above. This indicates the low level of government funding for R&D activities in non-governmental organizations and businesses.

The survey further revealed that the current expenditure (labour and other current costs) for all the STAs was allocated more funding compared to the capital expenditure for infrastructure development. The intramural expenditure for STS, STET and R&D was ETB 292.6 million, ETB 1,397.5 million, and ETB 1,801.7 million respectively, while capital expenditure was allocated less than 21% in each category, as shown in Table 1. For the extramural expenditure, 52% of the STET funding was allocated for overseas entities payment, while 48% was outsourcing domestic entities. Within the R&D expenditure, applied research received the majority (64%) of the funding compared to basic research (28%), as shown in Figure 4. Experimental development received the lowest amount of funding (8%) from the Federal government R&D expenditure (TECHIN, 2019a).

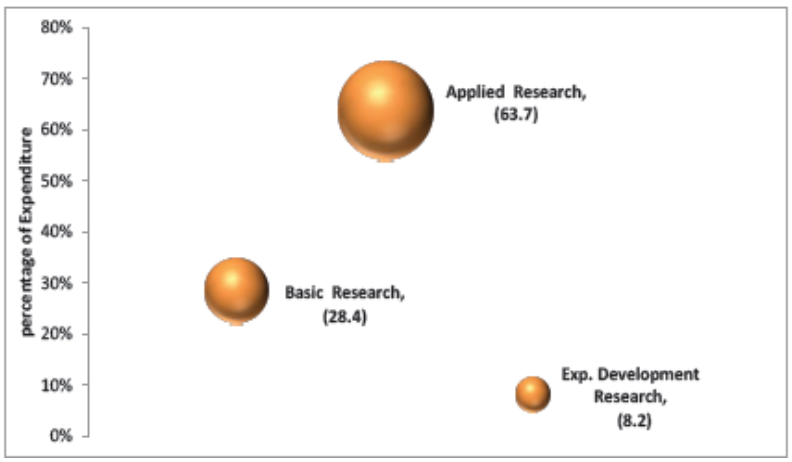
Table 1: STAs fund allocation in the Federal government expenditure

(Details)		R&D *(n=96)*		STET *(n=52)*		STS *(n=28)*		Total STAs (n=121)	
		In million ETB	%	In million ETB	%	In million ETB	%	In million ETB	%
Intramural	• Current expenditure	1,801.7	81.8	1,397.5	82.5	292.6	79.3	3,491.8	81.8
	• Capital expenditure	388.7	17.6	296.8	17.5	76.6	20.7	762.1	17.9
	• Unspecified	12.2	0.6	0	0	0	0	12.2	0.3
	Total Intramural Expenditure	**2,202.6**	**100**	**1,694.3**	**100**	**369.2**	**100**	**4,266.1**	**100**
Extramural	• Domestic payments	50.2	100	255.6	48.1	23.4	81.2	329.2	54.0
	• Overseas payments	0	0	275.4	51.9	5.4	18.8	280.8	46.0
	Total Extramural Expenditure	**50.2**	**100**	**531.0**	**100**	**28.8**	**100**	**610.0**	**100**
Unspecified		0		25.8 (1.2%)		58.4 (12.8%)		84.2 (1.7%)	
Total Expenditure		2,252.8		2,251.1		456.3		4,960.2	

n = number of sectors engaged in each STAs category

Source: TECHIN (2019a)

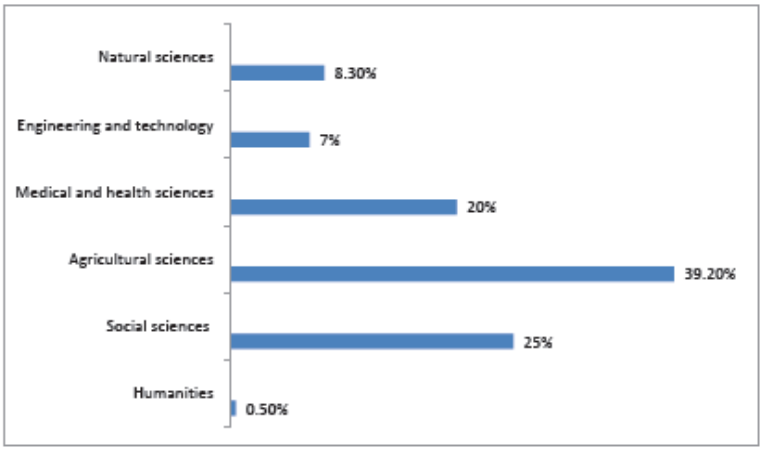
Figure 4: Categorized R&D expenditure for the Federal government



Source: TECHIN (2019a)

According to a survey by TECHIN, agricultural sciences received 39.2%, which was the largest portion of the R&D expenditure of the Federal government in fiscal year 2016/2017, as shown in Figure 5. Social sciences, and medical and health sciences, received 25% and 20% respectively, while humanities received the lowest percentage at 0.5% (TECHIN, 2019a).

Figure 5: Distribution of R&D expenditure across various disciplines.



Source: TECHIN (2019)

3.2 Science impact

	2017	2019	Notes
Field of science receiving most R&D funds	Agricultural science	No change	UNESCO Science report 2015
Place of STI on policy agenda over the past five years	---	No change	
Importance of applied research over the past five years	↑	No change	
Importance of multidisciplinary research over the past five years	↑	No change	
Importance of user-integrated research over the past five years	No data	No change	

↑↑↑ high and increasingly on agenda; ↑ on agenda and slow increase in attention; --- no change

There is very little evidence of significant changes in the place of STI on the policy agenda since 2017. The introduction of a dedicated Ministry of Science and Technology occurred before the 2017 data collection period of the first study (Chataway et al., 2017) and the change to the new MInT has not changed the enhanced focus on STI. That said, the study did find a few examples of where STI activities had been shown to address current societal/national issues, specifically:

- The Nutritious Maize for Ethiopia project, which involves conventional crossbreeding, aims to improve food security and nutrition for approximately 3.98 million people through the promotion of the cultivation and consumption of the quality protein maize (QPM) varieties. These maize varieties are of high nutritive value and are highly productive. The government/project implementers have sensitized farmers and consumers on the benefits of the maize through 1233 learning events (UNCTAD, 2017).

- A start-up called Flowius has been developed to build affordable water pipelines using solar power, microfinance and surveillance tools. According to Markos Lemma (co-founder), this innovation was developed to curb the need for people to walk long distances to access water. GroHydro developed by Wondim, a young female entrepreneur, is a start-up company that manufactures a hydroponics system that enables farmers to grow their crops in the absence of soil (BBC, 2019).

3.3 Science capacity

	2017	2019	Notes
Researchers in R&D (per million people)	45.12	No data	UNESCO, 2015: Ethiopia
# of staff in SGC	5	No data	
- Distance to target	No data	No data	
Improvement in science system to absorb funds in terms of researcher quality	No data	No data	
Improvement in science system to absorb funds in terms of fund manager quality	No data	No data	

We found no additional data on science capacity in this round of the political economy study.

4 Conclusion and recommendations

Since the last report, Ethiopia's policy landscape has not significantly changed. The place of STI on the policy landscape was noted to have significantly improved during the PE1 study and the focus on STI has not diminished in the last three years. In fact, it has probably strengthened a little. However, there are still capacity and performance issues, as noted by the issues raised by interviewees and from recent data sources examined for this study update.

4.1 Recommendations for the STI actors in Ethiopia

Science Granting Council: MInT's Innovation and Research Affair's wing

MInT must ensure that the STI Policy revisions are completed and implemented. The lack of clear policy documents will hinder the movement towards improved productivity in the area of STI. Increasing funding for research must also be a priority.

Private sector actors

Ethiopia has vibrant export oriented agro-processing and manufacturing sectors, which benefit from many supportive government policies. The private sector must see value in research and innovation, and be provided sufficient incentives to work, for example, with universities.

Policymakers

Consideration of improved implementation of policies, as well as reducing staff turnover, will be imperative to build stakeholder trust in the organs of government. For example, the government could provide clearer guidance for foreign investors who might participate in STI activities.

References

AfDB (African Development Bank) (2019). Ethiopia Economic Outlook. Retrieved from https://www.afdb.org/en/countries/east-africa/ethiopia/ethiopia-economic-outlook

BBC (2019). The city where innovation is driven by necessity. Retrieved from https://www.bbc.com/worklife/article/20190318-addis-ababa-africas-most-exciting-city-of-innovators

CESTII (Centre for Science, Technology and Innovation Indicators) (2017). South African national survey of research and experimental development: Statistical report: 2015/16. Retrieved from http://www.hsrc.ac.za/uploads/pageContent/8753/SA%20R&D%20SURVEY%20STATISTICAL%20REPORT%20201516_WEB.pdf

Chataway, J., C. Dobson, C. Daniels, R. Byrne, A. Tigabu and R. Hanlin (2019). "Science Granting Councils in Sub-Saharan Africa: Trends and tensions." Science and Public Policy.

Chataway, J., C. Ochieng, R. Byrne, C. Daniels, C. Dobson, R. Hanlin and M. Hopkins (2017). Case Studies of the Political Economy of Science Granting Councils in Sub-Saharan Africa. Science Granting Councils Initiative, SPRU (Science Policy Research Unit) and ACTS (African Centre for Technology Studies).

Ethiopia Academy of Sciences (2019). Declaration launched to enable an equitable research system in Ethiopia. Website. Retrieved from https://www.eas-et.org/node/440

Food and Agriculture Organization of the United Nations Addis Ababa (2019). National gender profile of agriculture and rural livelihoods. Retrieved from http://www.fao.org/3/ca3224en/ca3224en.pdf

Gizaw, A.K. (2019). Ethiopia's STI Policy, Strategy and Updates. Retrieved from https://www.uneca.org/sites/default/files/uploadeddocuments/ARFSD/2019/ethiopia_sti_policy_and_strategy.pptx

Mouton, J. and Boshoff, N. (2006). The Federal Democratic Republic of Ethiopia. Retrieved from https://www.healthresearchweb.org/files/ETHIOPIASTsystem.pdf

Oqubay A. (2018). Industrial Policy and Late Industrialization in Ethiopia, Working Paper Series N° 303, African Development Bank, Abidjan, Côte d'Ivoire. Retrieved from https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/WPS_No_303__Industrial_PolIcy_and_Late_Industrialization_in_Ethiopia_B.pdf

Tamrat, W. (2018). Towards a national system of journal accreditation. University World News online. Retrieved from https://www.universityworldnews.com/post.php?story=20180303075443425

Technology and Innovation institute (2017).National Survey of Research and Experimental design, 2016/2017. TECHIN, Addis Ababa.

Technology and Innovation institute (2019a). Federal Government Expenditure on Scientific and Technological Activities. TECHIN, Addis Ababa.

Technology and Innovation institute (2019b). The Ethiopian Technology Balance of payments survey 2019. TECHIN, Addis Ababa.

Tigabu, A. (2017). Political economy of the Ethiopian Science Granting Council; National case study report: Ethiopia. Retrieved from https://idl-bnc-

idrc.dspacedirect.org/bitstream/handle/10625/56811/IDL-56811.pdf?sequence=2&isAllowed=y

Tralac (2019). Ethiopia: Ministry manoeuvres toward digital economy. Retrieved https://www.tralac.org/news/article/13847-ethiopia-ministry-manoeuvres-toward-digital-economy.html

UNCTAD (2017). The role of science, technology and innovation in ensuring food security by 2030. Retrieved from https://unctad.org/en/PublicationsLibrary/dtlstict2017d5_en.pdf.

UNIDO (2019). Supporting the improvement of the development strategy and policy for Ethiopia's technology-based chemical industry. Retrieved from https://open.unido.org/api/documents/14100685/download/UNIDO-Publication-2019-14100685

Woldegiyorgis, A. (2019). Improving Research Productivity in Ethiopia — Carrot or Stick? Website. Retrieved from https://www.insidehighered.com/blogs/world-view/improving-research-productivity-ethiopia-%E2%80%94-carrot-or-stick

Worldometers; Department of Economic and Social Affairs, Population Division. (2019). Retrieved from https://www.worldometers.info/world-population/ethiopia-population/

Annex: Interview details

Interviewee	**Interview mode**	**Interview date**
Ministry of Science and Technology staff	Phone	15 July 2019
Researcher at the University of Addis Ababa	Phone	1 August 2019
Ministry of innovation and Technology staff	In person	3 September 2019
Ethiopia textile Industry Development Institute staff	In person	3 September 2019
Research fellows at the Technology and innovation Institute (TECHIN)	In person	4 September 2019
Research fellow at the Addis Ababa University	In person	4 September 2019
Researcher at the Ethiopian Academy of Sciences (EAS)	In person	4 September 2019
Leather Industry Development Directorate, Senior Leather Technologist Leather Industry Development Institute staff	Phone	9 September 2019

National Case Study Report of

Kenya

Science Granting Council

1 Context of Kenya's STI System

The phase one political economy study of 2017 (Chataway et al., 2017) outlined how the role played by science, technology and innovation in catapulting Kenya into middle income country status has been recognized in the Kenya Vision 2030, the country's current national development plan. Furthermore, in the Kenyan constitution, science and indigenous technologies are seen to be crucial tools in national development. The Kenya Vision 2030 also outlined that the enactment of the STI Act in 2013 led to the realignment of STI programmes to the national agenda as well as strengthening of the national system of innovation (NSI). Through the STI policy, three organizations were established to coordinate national STI activities. These are the National Commission of Science, Technology and Innovation (NACOSTI), the Kenya National Innovation Agency (KeNIA) and the National Research Fund (NRF).

The 2017 report also outlined that the introduction of free primary education in 2003 and more recently free secondary education has impacted positively on the number of children now eligible for university places and the rise of university education in the country. Technical and vocational education and training (TVET) has, since 1967, had a role in the training landscape of Kenya, when the first TVET institution – Kenya Polytechnic – was established by the Ministry of Education. More technical colleges have been established since then due to the increased demand for technical skills (Mwatare & Mwami, 2019).

The main aim of this case study is to identify the different political, economic and social aspects affecting the performance of STI in the Kenya. Key informants from different sectors were interviewed either via Skype/phone or in person (see the Annex for interview information). Additional information was collected from secondary sources during a thorough literature review. This study was carried out between May and September 2019.

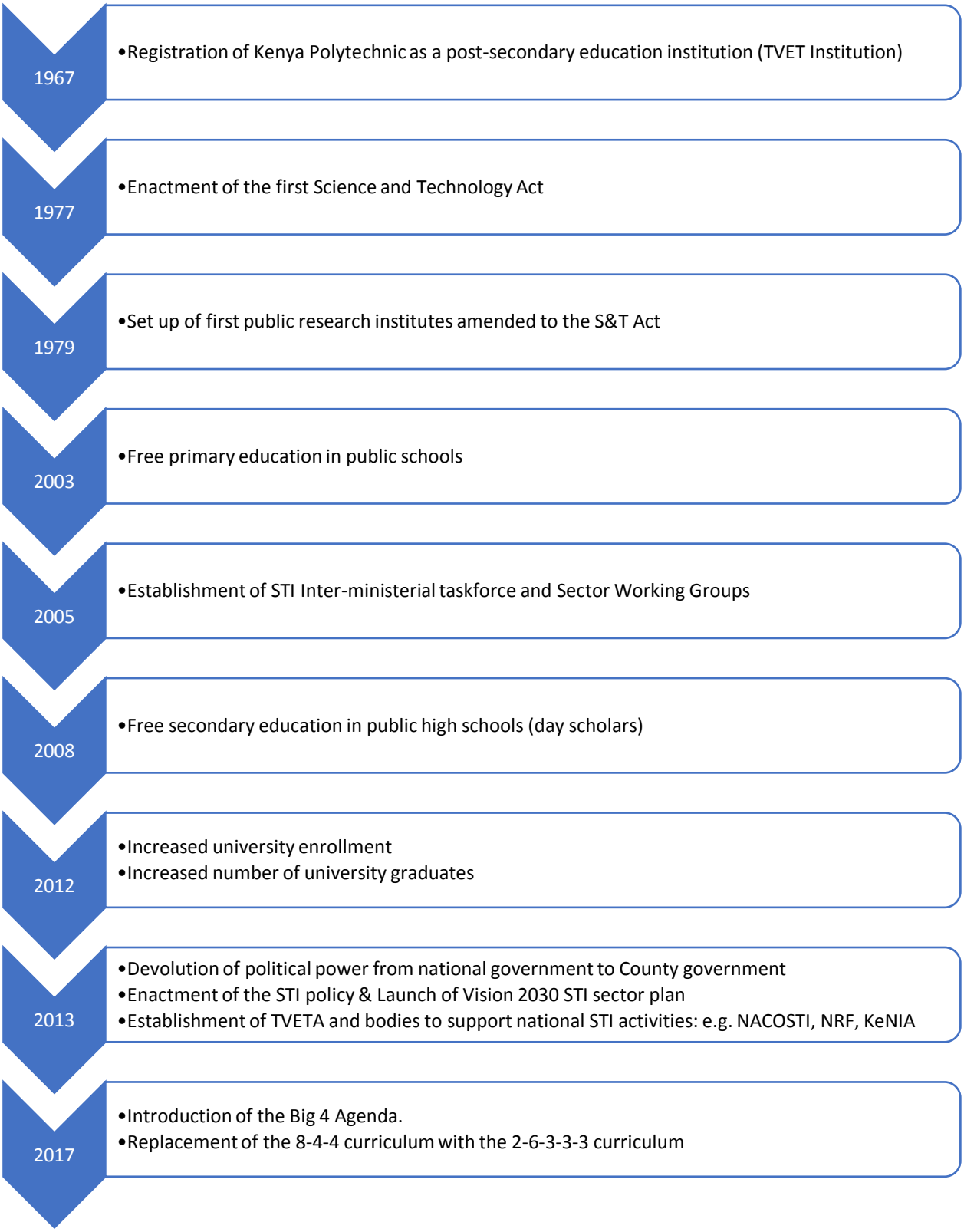
1.1 Contextual factors arising between 2017 and 2019

1.1.1 Political overview

Since the first study was conducted in 2017, Kenya's political landscape has been altered by the introduction of the Government of Kenya's "Big Four" initiative. This is a targeted approach to achieving Kenya's Vision 2030 through a focus on four key challenges: food security, affordable housing, manufacturing, and affordable healthcare. For example, Kenya Vision 2030's Third Medium Term Plan (MTP III) highlights major policies, programmes and reforms that are to be implemented between 2018 and 2022 and gives high priority to the Big Four initiatives (GoK, 2018). The MTP focusses on several foundations/enablers that will act as drivers towards national transformation of which Science, Technology and Innovation (STI) is one.

Noted in the first political economy study (Chataway et al., 2017), and still of importance, is the issue of devolution. In fact, according to the World Bank, devolution has been the greatest success from the August 2010 constitution. It piloted in a new system of political and economic governance. It has promoted greater grassroots investments, service delivery in the public sector and accountability (World Bank, 2019). Devolution has enabled decentralisation of fiscal resources from central government to county government and increased development of infrastructure at county level: e.g. hospitals/health centres, roads, etc. However, at the same time, it has been reported that devolution has potentially reignited land ownership issues and increased competition for resources, which in turn has increased corruption and ethnic politics (The Conversation, 2018).

Figure 1: Timeline showing major historical milestones affecting the national STI ecosystem



1.1.2 Economic overview

Over the last 10 years, Kenya has experienced a steady increase in economic growth, enabling it to move from low-income country to lower-middle income status. In 2018, the Real GDP grew an estimated 5.9% from the previous year's growth rate of 4.9% (ADB, 2019). This economic growth has been attributed to the recovery of the tourism sector, stability of the macroeconomic environment, development infrastructure and increased remittance inflows (World Bank, 2019).

In 2017, Kenya exported USD 6.17 billion and imported USD 17.1 billion, resulting in a negative trade balance of USD 11 billion. (OECD, 2019). Agriculture, fishing and forestry contributed 22% to GDP while manufacturing, education and financial and insurance activity contributed 11%, 7%, 8% and 6% respectively (Trading Economics, 2019).

That said, in 2018, the rate of unemployment among the youth was estimated to be about 11.4% (Ng'ethe, 2018). One of the reasons for unemployment is noted to be the lack of school leavers and graduates who have the skills required by the job market. The introduction in 2017 of a new curriculum that divides schooling into year classifications of 2-6-3-3-3 (as opposed to the previous 8-4-4 system), together with a new competency based curriculum in 2019, are efforts to address these challenges. For example, the 2-6-3-3-3 curriculum is promoted by the Government to meet one of the objectives in Vision 2030, which requires technical training in schools (Wanjala, 2017).

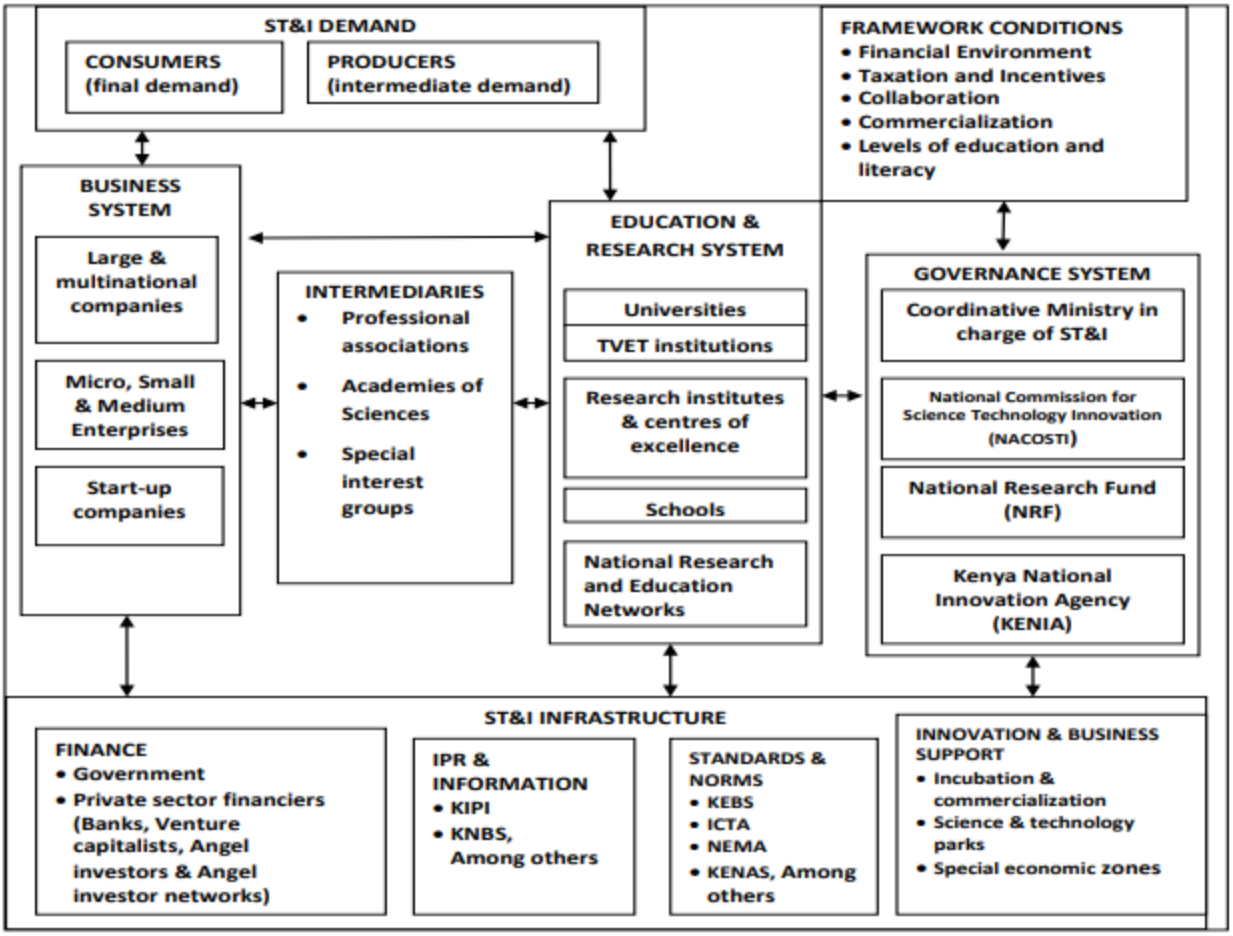
1.2 STI system overview in Kenya

Figure 2 below is an illustration of the major actors in STI and the national innovation system (NIS). As noted above, the implementation of the STI Act in 2013 led to the establishment of three major STI institutions: NACOSTI, NRF and KeNIA. The creation of these institutions led to enhanced governance in the National Innovation System. As noted in the first political economy study (Chataway et al., 2017), NACOSTI is mandated with coordination/regulation of STI activities in the Kenya. The NRF is responsible for mobilization and management of R&D funds, sector wide activities and development of infrastructure in research institutions and universities. KeNIA coordinates the activities of the national innovation system and enhances cooperation among major actors (government, industry and academia) (GoK, 2017).

STI in Kenya is housed within the Ministry of Education, Science and Technology (MoEST). MoEST is divided into four state departments, which coordinate the following areas: Technical and Vocational Education and Training (TVET); Post training and skills development; University Education and Research; and Early Learning and Basic Education. The State Department for University Education and Research is mandated to coordinate agencies, parastatals and institutions with responsibilities in R&D, and university education. The institutions/agencies in university education and R&D, including NRF, KeNIA and NACOSTI, report to the Directorate of Research, Science and Technology (DRST) within the Ministry.

The government has put in several strategies to ensure efficient coordination of national STI activities. These include development of legal frameworks to ensure synchrony between research activities and the NIS. Despite these efforts, the poor coordination of national STI activities remains a challenge due to the scattered distribution of research institutions across ministries (Ayisi et al., 2019). For example, health research institutes are under the Ministry of Health and agricultural research institutions are under the Ministry of Agriculture.

Figure 2: National Innovation System (NIS) and major actors in Kenya



Source: Ayisi et al. (2019)

Key: STI – Science Technology and Innovation; TVET – Technical, Vocational, Education and Training; NRF – National Research Fund; NACOSTI – National Commission for Science Technology and Innovation; KENIA – Kenya National Innovation Agency, IPR – Intellectual Property Rights; KIPI – Kenya Industrial Property Rights; KNBS – Kenya National Bureau of Statistics; ICTA – Information, Communication and Technology Authority; NEMA – National Environmental Management Authority; KENAS – Kenya National Academy of Sciences.

2 STI ecosystem

In the first Political Economy Study (Chataway et al., 2017), it was observed that Kenya had taken the step of delineating responsibility of STI regulation and promotion across three different agencies. The issues facing these three agencies and other stakeholders highlighted in the PE1 study were:

- The role of policy instruments and political cycles
- The relative power and influence of different stakeholders
- Research quality and impact
- The relative merits of different funding types
- The availability of needed capability and skills

Several of these issues were raised in this follow-up study during interviews conducted for fieldwork and from the literature review. However, they have been discussed in rather different ways or from different perspectives. These are discussed below.

2.1 Evolution of STI ecosystem 2017 to 2019

2.1.1 Funding available for research, science, technology and innovation

Funds contributed by the national government remain low due to competition from priority sectors. It was acknowledged by a number of interviewees that government funds are currently directed towards supporting priority sectors in the Big Four agenda: i.e. health, food security, housing and manufacturing.

There was a consensus amongst all interviewees that there was insufficient funding for research and STI, and that funding was often given out in a patchy manner such that everyone competed for what scarce resources were available. Two interviewees called for a new financing model for STI and research funding; that funding for education and training was separated from that for research and STI. This is currently the case because the STI related organs of government (NRF, KeNIA and NACOSTI) report to the Ministry of Education, Science and Technology.

Perhaps unsurprisingly, one interviewee was in favour of a dedicated Ministry of Science and Technology (something Kenya has had before) while others noted the need for more support from high level leaders/organs of government (see below).

All interviewees noted that the scarcity of funds meant that everyone had to look for funds from a variety of sources, notably from foreign partners. It was also noted that there was extremely limited private sector funding of research and the little that was available was unevenly distributed. One interviewee highlighted how a research institution like the Kenya Medical Research Institute (KEMRI) receives large amounts of funding from the private sector but the research institute responsible for industrial research and development hardly has any private sector funding. He called for more effective implementation of private-public partnership frameworks to stimulate increased funding for R&D from the private sector.

There was disagreement amongst the interviewees on the level of private sector in-house R&D. While one interviewee argued many private sector players invested in R&D, another noted that most private sector players in Kenya are small and medium sized enterprises who cannot afford to conduct R&D. That said, a 2019 UNESCO report found that R&D funding from the local private sector remains low at 0.5% of revenue generated. It also found that the majority of the private sector have internal R&D, which they prefer funding as opposed to investing in R&D in universities and research institutions. The

report argued that this could be attributed to the high level of mistrust and prolonged timelines before delivery (UNESCO, 2019).

Interviewees continued to mention LIWA – an organisation tasked with linking industry with academia and mentioned in the original political economy study (Chataway et al., 2017) – as an organisation that is working to change the situation.

2.1.2 Weak interlinkages between universities, research institutes and industry

According to a report by UNESCO (2019), the absence of strong linkages between learning institutions, research institutions and the industry/private sector has been a recurrent problem over the years in Kenya. As a consequence, knowledge generated in universities and research institutes that could have great impact in industry/the private sector remains untapped, sitting instead in the form of publications (UNESCO, 2019).

Interviewees were in agreement that private section institutions did not invest often because they did not see the importance of research and, where they did, they kept it in-house; they rarely linked with universities or other research organisations. This is slightly at odds with the information above with regards to the fact some research organisations receive significant funds from the private sector. We assume that this difference is based on whether the private sector is a Kenyan organisation (as per the statements in this section) and the degree to which they are internationally based (in the previous section where international pharmaceutical companies pay for clinical trials research in Kenya).

As noted in the earlier report (Chataway et al., 2017) Linking Industry with Academia (LIWA) has been instrumental in encouraging collaborations between industries and academia. LIWA has created over 15 partnerships between major companies – e.g. Safaricom and Huawei – and universities. Kenya Education Network (KENET), a national research and education network, is another initiative by the government established to enhance knowledge sharing across universities. These collaborations have been beneficial in several aspects: curriculum review that ensures graduate skills are matched with industry needs, capacity building in innovation and technical skills, well-coordinated research agendas with no duplication, and encouraged private sector funding for R&D (UNESCO, 2019).

2.1.3 Level of skills and capacity for STI

The mismatch between graduate skills and industry requirement has been a major contributor to the high level of unemployment among the youth in Kenya. This is mainly attributed to weak linkages between universities and industries, poorly structured curricula, rapid conversion of technical learning institutions into universities and limited infrastructure (UNESCO, 2019). These arguments were mirrored in the interviewee comments we received. Specifically, interviewees commented that graduates of universities and technical colleges were often not ready for the job market when they completed, that there was significant lack of relevant technical skills and this was often due to the lack of relevant education/curriculum.

Kenya has continued to place an importance on TVET training over the last three years. Currently, there are 180,000 students enrolled in institutes of technical and vocational training. Technical vocational centres and national polytechnics have 98,000 and 82,000 enrolled students respectively (Ochunge, 2019). TVET graduates are expected to be equipped with practical knowledge and skills to contribute towards economic development in both formal and informal sectors. A high quality TVET education system is therefore crucial for national development and achievement of the national agenda (Mwatare & Mwami, 2019). This was reiterated by Mr. Kevit Desai, TVET Principal Secretary for Kenya, during the opening of the Kenya Association of Technical Training Institutions (Katti) in Western Kenya in

2019, “The government recognizes vocational training as the central pillar of youth employment and sustainable enterprise development needed to ensure Kenya becomes a middle-income earner by 2030.” There are plans by the government to provide scholarships and grants to innovators in TVET to support their innovations. The government also plans to assist the innovators to patent their products (Ochunge, 2019).

2.1.4 Unclear mechanisms for policy implementation, monitoring and evaluation

Kenya has been known to have the most progressive policies in Africa. However, the inefficient or lack of adoption of a rigorous development and implementation framework by policy makers has resulted in failed policy implementation (Machari, 2019). During a workshop in 2018, Prof Ndemo, an ICT expert, pointed out the absence of supportive institutional structures and mechanisms for top policy makers in the identification and use of evidence in decision making (AFIDEP, 2018). Again, these arguments were mirrored by our interviewees. They pointed to a need for alignment of policies rather than fragmentation of policies; clear implementation frameworks and stronger engagement by relevant stakeholders in government to push implementation forward.

One interviewee noted that NRF, KeNIA and NACOSTI were still in their infancy (in their new roles) and therefore were still “finding their feet” in terms of how to operate. Other interviewees noted that lack of staff in the NRF limited its ability to effectively achieve its mandate. Two interviewees noted that silos between ministries and lack of interaction between stakeholders more generally limited the ability for effective policy implementation. Furthermore, interviewees mentioned the lack of stakeholders’ engagement in policy formulation, review and evaluation processes.

2.1.5 Fit with development priorities

One of the reasons for the lack of implementation, put forward by at least two interviewees, was that the “common man” did not see the value of STI for their own benefit. Similarly, others argued – as noted above – that private sector actors also do not see the relevance of R&D when the majority of Kenyan businesses do not innovate beyond perhaps a small amount of incremental change to existing products and services. One of the reasons put forward for this was because of the lack of fit with developmental priorities. However, one interviewee noted that the STI Policy of Kenya was, in 2019, undergoing an alignment with the Sustainable Development Goals. In addition, as noted above, there was recognition that national level priorities, notably the Big Four agenda, was dominating all policy discussions, including funding of STI decisions.

2.1.6 Addendum: recognition of the issues facing STI implementation

It is important to note that some of the issues raised above – and in the first report (Chataway et al., 2017) – have been acknowledged as challenges by NACOSTI, Kenya’s National Commission for Science, Technology and Innovation, which is tasked with regulating and advocating for the sector. Specifically, it has identified the challenges outlined in Table 1.

Table 1: STI challenges and interventions in the national STI environment

S/No.	Challenges	Interventions
1.	Inadequate human capacity	Enhance human resource capacity
2.	Inadequate monitoring, evaluation and reporting system	Establishment of the Directorate of Strategy, Planning and Compliance
		Develop an effective monitoring, evaluation, reporting and learning system
3.	Inadequate Standards and Guidelines to operationalize the ST&I Regulations	Review regulations and develop relevant Standards and Guidelines
4.	Low public awareness on the Commissions mandate	Enhance public awareness
		Strengthen stakeholder engagement
5.	Challenges in operationalization of research advisory committees as provided for in the ST&I Act, 2013	Review of legislation
6.	Inadequate capacity in science communication	Develop capacity in science communication
7.	High dependency on GoK grants to finance the Commission's operations	Diversify sources of funding

Source: NACOSTI (2018)

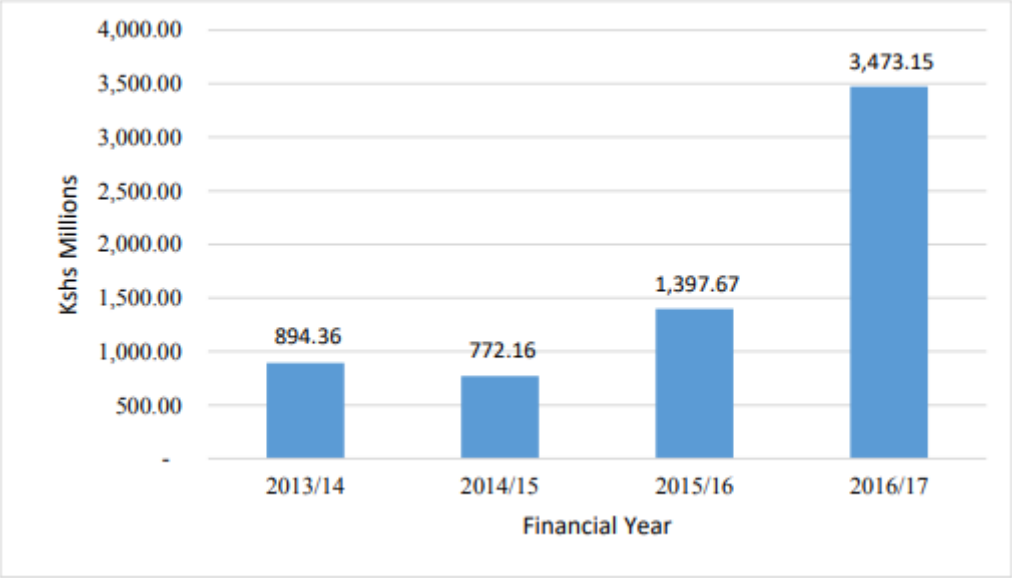
3 Research funding

3.1 Science funding

	2017	2019	Notes
R&D expenditure as % of GDP	0.79%	No update	UNESCO, 2015: Kenya 2010 data
Distance to national target of 2%	1.21%	No update	
Distance to regional target of 1%	0.21%	No update	
% from government	25.96%	No update	UNESCO, 2015: Kenya 2010 data
% from business enterprise	4.35%	No update	UNESCO, 2015: Kenya 2010 data
Role of foreign funders over the past five years	↑		No change since 2017 observed

Kenya's GERD/GDP ratio is one of the highest in Africa (Ndichu & Wacuka, 2017). The allocation of R&D funds from the government has tremendously increased from fiscal year 2015/16 to 2016/17, as shown in Figure 3 below.

Figure 3: R&D budget allocation (2013/14- 2016/17)



Source: GoK (2018)

Government funds for R&D are managed by the National Research Fund (NRF). There has been an increased funding for R&D from the government from USD 3.3 million to USD 5 million over the period 2008 to 2016. 1,816 STI related projects have been supported through these funds (UNESCO, 2019). It was noted that a large portion of funding for R&D is from foreign sources in the form of research grants from major organizations: e.g. World Bank, DFID, DANIDA and IDRC. Major

corporations like IBM, Google and Nokia are also funding R&D projects through universities. In most cases, research supported by donor funding is aimed towards achieving donor agendas and is not aligned to national priority areas (UNESCO, 2019). This supports the findings of the first case study and some interviewee comments in this current study.

The government has intensified efforts to support innovation in priority sectors through provision of funds by the Commission of Higher Education (CHE) via NACOSTI. The grant amount had increased from KES 250 million to KES 497 million in 2015/2016 fiscal year (NRF, 2019).

Table 3: Fund allocation per student by government to public universities (2017/18)

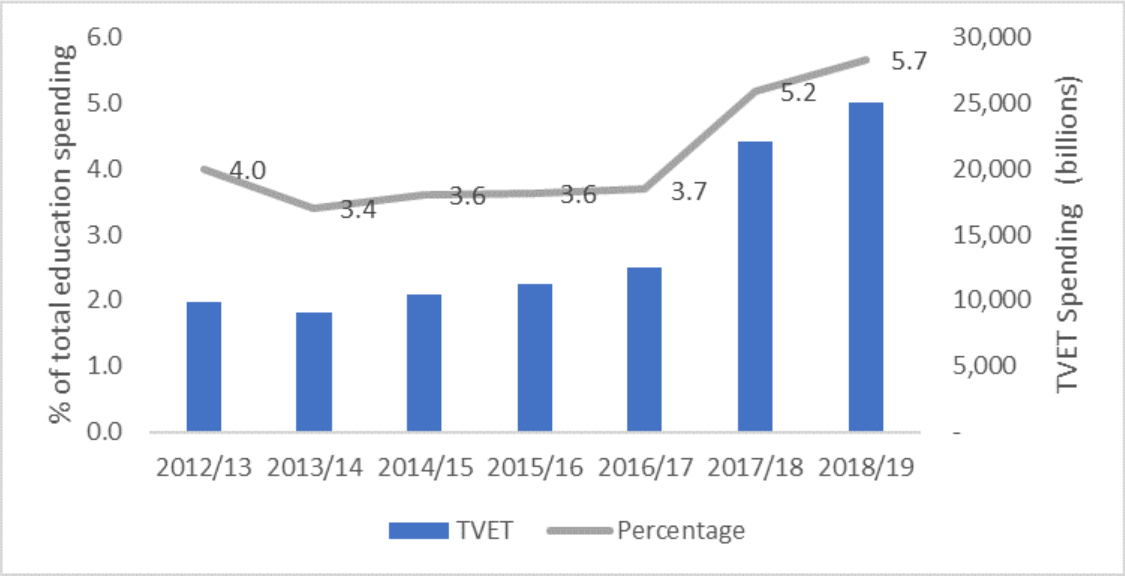
Universities	Enrollment	Government Budget (KES, millions)	Per-Student Subsidy (KES, thousands)
University of Nairobi	26,009	6,300	242
Egerton University	15,223	2,800	184
Kenyatta University	21,462	3,100	144
Jomo Kenyatta University of Agriculture and Technology	12,029	1,700	141
Technical University of Kenya	8,636	1,070	124
Technical University of Mombasa	4,520	770	170
University of Eldoret	14,275	1,100	77
Machakos University College	5,056	340	67

Source: World Bank (2019)

The University of Nairobi received the lion's share (KES 6300 million) of funding from the government while Machakos University College received the least amount of funding (KES 340 million), as shown in Table 3 above. The fund allocation was done in accordance to the enrolment/number of students received in the university.

From 2012/13 to 2018/19, the government increased financing to technical training and education to an average of 4.2% of the total education expenditure, as shown in Figure 4 below. The drastic increase in TVET financing 2017/18 to 2018/19 was aimed towards increasing training institutions, certification of Technical and Vocational Education and Training Authority (TVETA), curriculum development, staff recruitment and training. Students joining TVET through the Kenya Universities and Colleges Placement Service (KUCCPS) will be beneficiaries of an annual KES 30,000 bursary and KES 40,000 Higher Education Loans Board (HELB) loan to support in tuition fees and upkeep. The government has also reduced the TVET annual tuition fees by 30% from KES 92,000 to KES 56,420 (Mwatare & Mwami, 2019).

Figure 4: TVET financing from 2012-2018



Source: Mwatare & Mwami (2019)

At agency levels, NRF released grants worth KES 3 billion to a total of 411 researchers in institutions of higher education (218 PhD and 193 masters researchers). The PhD and masters researchers were granted KES 2 million and KES 0.5 million respectively (Oduor, 2017). KeNIA, on the other hand, provides grants to individual innovators. Approximately KES 5 million was disbursed in 2018 to support innovations, as pointed out by an informant from KeNIA. KeNIA also holds recognition awards where they reward KES 1 million to successful innovations.

3.2 Science impact

Interviewees in this study argued that there was both too much focus on applied as well as basic research. However, there are some signs of increasing focus on impact by government with regard to use of STI funds and resources. Notably:

1. The Kenyan and Japanese governments signed an MoU to extend the Pan-African University for Science, Technology and Innovation (PAUSTI) network project under JKUAT. The main aim of the project is to strengthen Science, Technology and Innovation Training in Africa. This will boost manufacturing and encourage economic growth across the continent (Tumo, 2019).
2. NACOSTI Research Manufacturing Chair is responsible for the coconut value addition strategies through which natural industrial products are manufactured from coconut husks and fibre. This contributes to the Big Four agenda. Other outcomes that are expected from the Manufacturing Research Chair include: value added food products to be sold in both local and foreign markets, and infrastructure development for SMEs within the coconut value chain (JKUAT, 2019).
3. There are plans by government, in collaboration with the private sector, to fund innovations from TVET institutes. This move is aimed towards boosting the manufacturing and agricultural sectors, which are vital in Vision 2030. Kenya has 230 technical and vocational colleges and 11 national polytechnics (Ochunge, 2019).

	2017	2019	Notes
Field of science receiving most R&D funds	Agricultural science		UNESCO Science report 2015
Place of STI on policy agenda over the past five years	↑↑↑	↑↑↑	
Importance of applied research over the past five years	↑	No change	
Importance of multidisciplinary research over the past five years	↑	No change	
Importance of user-integrated research over the past five years	No data	No change	

↑↑↑ high and increasingly on agenda; ↑ on agenda and slow increase in attention; --- no change

3.3 Science capacity

	2017	2019	Notes
Researchers in R&D (per million people)	230.73	No change	UNESCO, 2015: Kenya 2010 data
# of staff in SGC	3	No change	
- Distance to target	70	No change	
Improvement in science system to absorb funds in terms of researcher quality	No data	No change	
Improvement in science system to absorb funds in terms of fund manager quality	No data	No change	

According to one interviewee, there are plans to set up state-of-the-art research/scientific infrastructure in local institutions to attract and retain highly qualified human resources. This will enable research analysis within the country compared to outsourcing it to foreign institutions. There continue to be a low number of staff in NRF in 2019.

4 Conclusion and recommendations

4.1 Main findings and conclusion of the report

Since the last report, Kenya's policy landscape has been shaped by a move towards the "Big Four" agenda and a marked shift in emphasis on TVET and enhancing TVET opportunities in the country, including innovation through TVET colleges. This latter move is partly due to a continued recognition of the skills gap facing the country. More generally, with regards STI funding, this study has found that private sector funding remains low and there are calls for a new model for STI funding to be introduced. Specifically, there is a need to de-link education funding from funding for STI at Ministry level.

4.2 Recommendations for the STI actors in Kenya

Science Granting Council: NRF

The data available on the NRF website have improved in terms of lists of projects funded. However, there is still no clear public access to funding figures in terms of the amount of funding given. Having publicly available information on the demand and uptake of funding will provide significant support for increasing funding allocated to the agency.

Private sector actors

There is huge scope, with the focus on TVET, for a set of initiatives that increases innovation in SMEs and consideration of R&D outside of "the lab". Potentially, this is also important given the type of private sector actors working in Kenya, the majority of whom are not focussed on traditional R&D intensive sectors.

Policymakers

There are renewed efforts to align Kenya's STI activities with various agendas (Big Four, Vision 2030 and the SDGs). It will be necessary to ensure that there is coordination of these efforts to avoid duplication, overlap or contradiction.

On funding, it has been argued that introduction of tax incentives/waivers, recognition and award schemes could encourage financing of research activities from the private sector, development partners and philanthropists (Njau, 2018).

References

African Development Bank (2019). African Economic Outlook 2019. Retrieved from https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/2019AEO/AEO_2019-EN.pdf

African Institute for Development Policy (AFIDEP) (2018). What can African governments do to improve policy implementation? Retrieved from https://www.afidep.org/using-evidence-to-improve-policy-implementation-ample-lessons-in-first-day-of-nairobi-workshop/

Ayisi, J., Ndakala, F., Nyanga, R., Daniels, C., Owuor, R., Ting, B. and Wanyama, B. (2019). Assessing the Potential for Transformative Innovation Policy in Kenya. Retrieved from http://www.tipconsortium.net/wp-content/uploads/2019/07/Kenya-5-pager.pdf

GoK (Government of Kenya) (2014). R&D Survey 2013 – 2014. Nairobi, Ministry of Higher Education, Science and Technology.

GoK (2017). Implementation of the agenda 2030 for sustainable development in Kenya. Ministry of Devolution and Planning. Nairobi, Kenya

GoK (2018). Science, Technology and Innovation Policy; Revitalizing and Harnessing Science, Technology and Innovation in Kenya. Retrieved from https://www.nacosti.go.ke/images/docs/2018/november/news/DRAFT%20ST&I%20POLICY.pdf

Government of Kenya, (2018). Third Medium Term Plan 2018 – 2022. Retrieved from http://planning.go.ke/wp-content/uploads/2018/12/THIRD-MEDIUM-TERM-PLAN-2018-2022.pdf

Jomo Kenyatta University for Agriculture and Technology (2019). NACOSTI: Research Outputs Must Impact Kenyan Populace. JKUAT website. Retrieved from http://www.jkuat.ac.ke/nacosti-research-outputs-must-impact-kenyan-populace/

Kamau, S. (2018). Free primary education in Kenya: challenges and solutions. Tuko online. Retrieved from https://www.tuko.co.ke/269969-free-primary-education-kenya-challenges-solutions.html

Machari, M. (2019). Good policies fail if poorly implemented. Business Daily, online. Retrieved from https://www.businessdailyafrica.com/analysis/ideas/Good-policies-fail-if-poorly-implemented/4259414-5078304-10u4cfkz/index.html

Matwere, M & Mwami, M. (2019). Revitalizing Technical and Vocational Training in Kenya. Kenya institute for public policy research & analysis (KIPPRA) Blog post. Retrieved from https://kippra.or.ke/revitalizing-technical-and-vocational-training-in-kenya/

Muiruri, K. (2019). Kenya's economic growth up by 6.3%. Citizen digital. Retrieved from https://citizentv.co.ke/business/kenyas-economic-growth-up-by-6-3-242655/

NACOSTI (2015). Strategic Plan (2018 – 2022). Retrieved from https://www.nacosti.go.ke/images/docs/2019/Nacosti%20Strategic%20Plan%20EDITED%202nd%20april.pdf

Ndichu, S., & Wacuka, L. (2017). The Intensity of Knowledge Capital Investment in Kenya: Evidence from Manufacturing and Service Sectors. Canadian Center of Science and Education. International Journal of Economics and Finance; Vol. 9, No. 10; 2017.

Ngethe, V. (2018), ANALYSIS: How many young Kenyans are unemployed? A look at the numbers. Africa check. Retrieved from https://africacheck.org/2018/10/08/analysis-how-many-young-kenyans-are-unemployed-a-look-at-the-numbers/

Njau, M. (2018). Kenya mulls tax incentives to attract research funding. KenInvest website. Retrieved from http://www.invest.go.ke/kenya-mulls-tax-incentives-attract-research-funding/

Ochunge, N. (2019). Government to fund top innovators in TVET institutions. Standard digital, online. Retrieved from https://www.standardmedia.co.ke/article/2001315696/top-innovators-in-technical-colleges-to-secure-funding

Ochunge, N. (2019). Government to fund top innovators in TVET institutions. Standard Digital. Retrieved from https://www.standardmedia.co.ke/article/2001315696/top-innovators-in-technical-colleges-to-secure-funding

Oduor, N. (2017). Government releases Sh3 billion in research grants for higher education researchers. Retrieved from https://www.standardmedia.co.ke/article/2001263177/government-releases-sh3-billion-in-research-grants-for-higher-education-researchers

The Conversation. (2018). Kenya illustrates both the promise as well as the pitfalls of devolution. Retrieved from https://theconversation.com/kenya-illustrates-both-the-promise-as-well-as-the-pitfalls-of-devolution-96729

Top news (2018). Kenya's poverty rate drops sharply in 10 years -stats office. Retrieved from https://af.reuters.com/article/topNews/idAFKBN1GZ0TK-OZATP

Trading economics. (2019). Kenya GDP Annual Growth Rate. Retrieved from https://tradingeconomics.com/kenya/gdp-growth-annual

Tumo, R. (2019). Kenya and Japan Sign a MOU to extent the Pan-African University for Science Technology and Innovation. Retrieved from http://www.kassfm.co.ke/home/2019/01/30/kenya-and-japan-sign-a-mou-to-extent-the-pan-african-university-for-science-technology-and-innovation/

UNESCO (2019). Co-Designing Science in Africa; First steps in assessing the sustainability science approach on the ground. United Nations Educational, Scientific and Cultural Organization, pp. 124-125

Waruru, M. (2019). National Research Fund's unfunded mandate. University world news. Africa Edition. Retrieved from https://www.universityworldnews.com/post.php?story=20190305103801783

Waruru, M. (2019). National Research Fund's unfunded mandate. University world news. Africa Edition. Retrieved from https://www.universityworldnews.com/post.php?story=20190305103801783

World Bank (2019). improving higher education performance in Kenya: A policy report. The World Bank, pp. 40

World Bank (2019). The World Bank In Kenya; Overview. Retrieved from https://www.worldbank.org/en/country/kenya/overview

Annex: Interview details

Interviewee	Interview mode	Interview date
NACOSTI representative	Phone interview	25 June 2019
Academic at Egerton University	Phone interview	29 July 2019
LIWA representative	Phone interview	7 August 2019
Staff at Maseno University	Phone interview	8 August 2019
KENIA representative	Face to face	9 August 2019
Researcher at Kenyatta University	Face to face	14 August 2019
NRF representative	Phone interview	16 August 2019
Ministry of education representative	Face to face	16 August 2019
Researcher at KAM	Face to face	30 August 2019

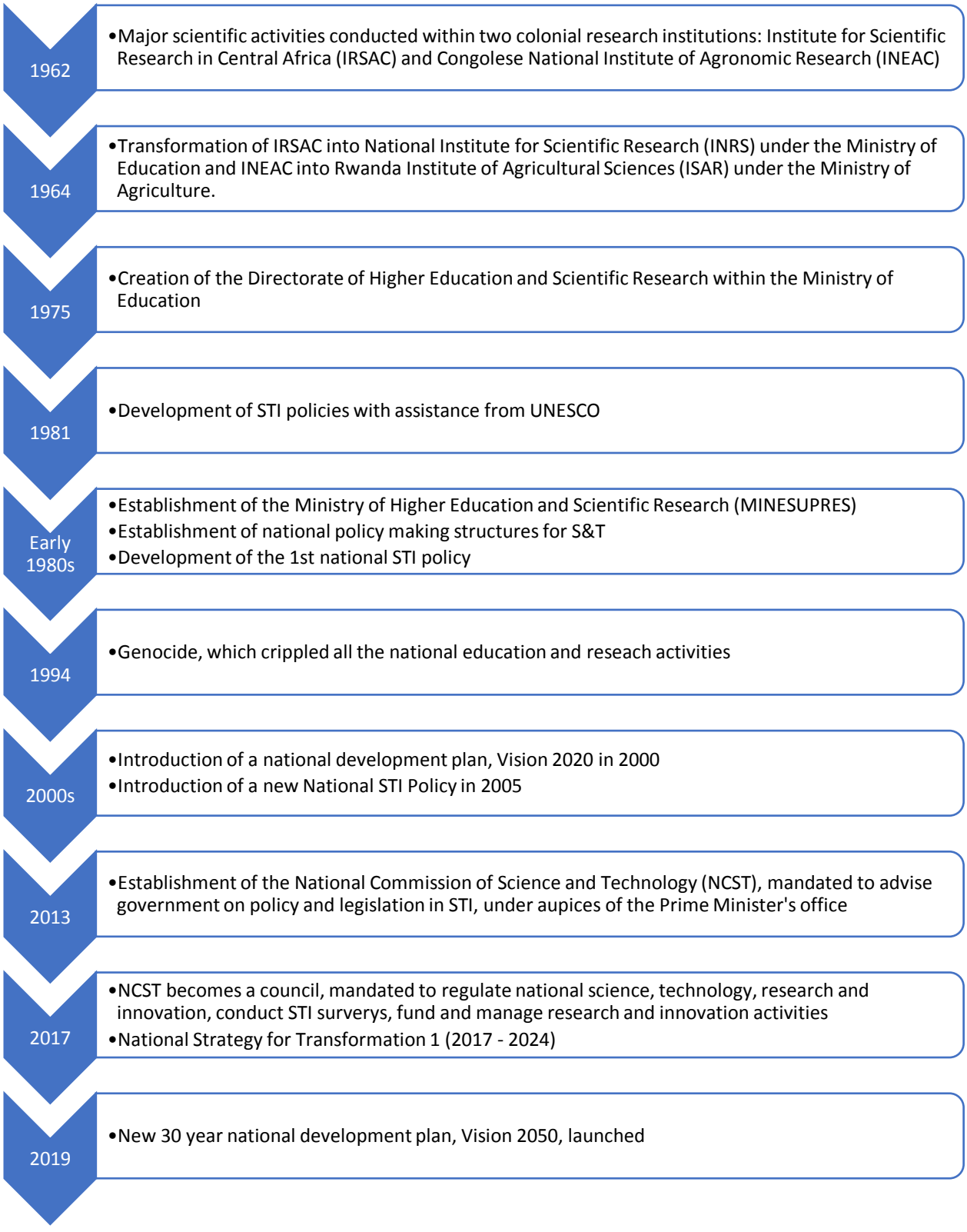
National Case Study Report of

Rwanda

Science Granting Council

1 Context of Rwanda's STI System

Figure 1: Historical milestones that have influenced the STI ecosystem in Rwanda



Rwanda, also known as "the Land of a 1000 hills", is located in the Central and East African region, bordered by Tanzania, Uganda, Burundi and the Democratic Republic of the Congo. Over recent years, Rwanda has experienced significant economic, infrastructural and social development under the leadership of the Rwandan Patriotic Front (RPF). The government has put in place strategies to strengthen the national education and research capacity through establishment of science and technology institutions. One of these bodies includes the National Commission of Science and Technology (NCST) which was established in 2013. Its main mandate was to advise government on policy and legislation in science, technology and innovation (STI) under the auspices of the office of the Prime Minister. NCST was restructured in 2016 into the National Council for Science and Technology with an additional mandate of regulating national science, technology, research and innovation activities, conducting R&D and innovation surveys, as well as funding and managing research and innovation activities in the country, under the auspices of the Office of the President of the Republic. In 2017, the NCST was further restructured to reframe its governance structure. The STI system in Rwanda has gone through tremendous changes over the years. Figure 1 above gives a brief summary of the historical milestones that have affected the STI system over the years. Limited resources have been a major hindrance to the Government's efforts to strengthen STI. In 2017, the World Bank reported that Rwanda has only 12 R&D researchers per million of the population.

The main aim of this case study is to identify the different political, economic and social aspects affecting the performance of STI in Rwanda. Key informants from different sectors were interviewed either via Skype/phone or in person (see the Annex for interview information). Additional information was collected from secondary sources during a thorough literature review. This study was carried out between May and September 2019.

1.1 Contextual factors arising between 2017 and 2019

1.1.1 Political overview

Currently, Rwanda enjoys political stability, economic growth and public safety (Congressional Research Service, 2019). 64% of the Parliamentary seats in Rwanda are filled by women. The Rwandan Patriotic Front (RPF) remains the majority ruling party. There are two opposition parties: Social Party Imberakuri and Democratic Green Party of Rwanda, each with two parliamentary seats (World Bank, 2019).

Civil society in Rwanda is highly underdeveloped due to several constraints. Normally, civil society organizations (CSOs) function in collaboration with the government's political and development plans. The CSOs who do not operate within this context are frustrated by the government. Despite the increased involvement of CSOs promoted by decentralization and new legislation, human rights work is highly politicized and under heavy scrutiny (ICNL, 2019).

In August 2018, President Paul Kagame was re-elected to a 7-year term. This decision was made after there was a constitutional amendment in December 2015 that allowed him an additional 3rd term in the Presidency (World Bank, 2019).

1.1.2 Economic overview

An annual economic growth rate of 4-9% has been observed over the past decade as a result of donor aid, political stability, reduced corruption and investor friendly policies (Congressional Research Service, 2019). Rwanda has one of the fastest growing economies in Africa. The Country's economy grew by 7% in 2018. This growth has been fueled by expansion of various sectors: e.g. agriculture, services and industry (ICNL, 2019). The agricultural sector experienced an 8% growth rate in financial

year 2017/2018 as a result of high productivity of food crops and livestock (Republic of Rwanda, 2019). In 2018, agriculture contributed 67% of the total job opportunities, whereas the services sector and industry contributed 25% and 8% of total employment respectively (FTF Council Analytical Unit, 2018).

It was noted by the International Monetary Fund (IMF) that, despite Rwanda's progress in economic growth, the country's economy remains vulnerable to fiscal risks and external shocks (Twagiramungu & Sebarenzi, 2018). Despite the tremendous progress that Rwanda has made in recent years, there are still some challenges that hinder the efficient functioning of some government entities. The challenges arise from the following areas:

a) Lack of effective coordination mechanism among government entities

b) Weak professional development plans, capacity building and rewarding mechanism in major government institutions

c) Centralised decision making and lack of far sightedness and innovation mind-set in local government

A case in point is the example of *imihigo* (performance contracts to a traditional practice of determining and accomplishing goals) (for more details, see World Bank, 2018). Performance monitoring among government entities has created a strong sense of competition that has hindered sharing of knowledge and collaboration among the government officials/institutions. To address this, the *imihigo* coordination unit is expected to conduct continuous monitoring of the planning and implementation of the *imihigo*. However, overlapping mandates between government entities (both local and national) have contributed towards increased competitiveness and mistrust among the entities thus weakening collaboration. In an effort to improve coordination between government entities, the Rwandan government launched a joint Imihigo, which required all entities to work together to accomplish the joint performance contract.

Furthermore, inadequate staff skills and numbers are other challenge in the country's public sector. Most of these public institutions, especially in the agriculture and energy sectors, are under-staffed compared to other agencies. This is mostly attributed to the absence of long-term skills/career progression plans (World Bank, 2018).

1.2 Science and Technology System overview of Rwanda

In 2019, the Ministry of Information and Communication Technology (ICT) and Innovation was formed. In addition, in 2018, there was appointment of the Director of Science, Technology, Innovation and Research (STIR) Unit, under the Department of Education Planning, in the Ministry of Education. This change was a result of the restructuring of the Ministry of Education that included the abolition of the former Directorate of Science Technology and Research (DSTR). Following the abolition of DSTR and the re-establishment of the National Council for Science and Technology (NCST), some of the major activities, including STI policy oversight, funding research and innovation (including the RIEF) and regulation of research, were transferred from the Ministry of Education to NCST.

The National Council for Science and Technology is the principle body mandated to coordinate and monitor national science, technology, research and innovation activities, although the coordination of innovation policy will have to be shifted to the newly formed Ministry of ICT and Innovation. The NCST is governed by the Council, co-chaired by the Minister of Education, which is mandated to set up a firm research and innovation system that ensures the alignment of STI with the national development goals (MINEDUC, 2018). Nonetheless, the NCST remains a semi-autonomous agency reporting directly to the Office of the President of the Republic.

That being said, one respondent did note that she felt that having NCST housed within a ministry of education did mean there was a sharp focus on universities and their role in STI production. Such a statement suggests insufficient emphasis on industrial partners and the private sector or community groups. Other interviewees confirmed this with all interviewees noting a lack of coordination between actors and insufficient linkages with the private sector. However, it was noted that the creation of the National Industrial Research and Development Agency (NIRDA) had the potential and mandate to change this.

The implementing agencies involved in STI and research activities in Rwanda were identified by an UNCTAD review in 2017. The list of implementing agencies and major funding mechanisms associated with these is outlined in Table 1.

Table 1: STI funding agencies, implementing agencies and purposes in Rwanda

Fund	Implementing agency	Purpose
Green Fund (National Climate and Environment Fund)	FONERWA - MINIRENA	Environment and climate change fund
REIF - Rwanda Innovation Endowment Fund	MINEDUC	R&D for innovation priority, economic and social areas
SDF - Skills Development Facility	Workforce Development Authority	Expanding the number of individuals with the relevant skills in critical sectors
RIF - Rwanda Innovation Fund	Rwanda Development Board	Funding of KIC related STI programmes
NRIF - National Research and Innovation Fund	NCST	Align research with national priorities
BDF	BDF	SME support credit guarantees, credit lines, matching grants, quasi-equity and advisory services
FAPSA - Fund for African Private Sector Assistance	AfDB	Untied grants for technical assistance and capacity-building
ICT-SME fund	MYICT and RDB	Public-private funding for job creation
NIRDA	NIRDA	R&D for industry needs
EGF - Export Growth Facility	Rwanda Development Bank	Investment catalyst, matching grants for market entry costs, export guarantee
SEEP III Fund	WDA - AfDB	Skills, entrepreneurship development and job creation programme

Source: UNCTAD (2017)

In the Phase I political economy study (Chataway et al., 2017), it was noted that the Ministry of Education (MINEDUC) provides funds through the Rwanda Innovation Endowment Fund (RIEF) with the main aim of funding innovation and other priority economic and social sectors (World Bank, 2018). However, this mandate was handed over to NCST in 2017 and launched the National Research and Innovation Fund (NRIF) in its place. The fund will facilitate the implementation of the national research and innovation agenda (Bizimungu, 2018). The Rwanda Development Board also funds STI activities in Rwanda through the Rwanda Innovation Fund (RIF).

NIRDA has a specific mandate to increase R&D funding with the private/industrial sector. There is a focus on funding commercialization and pre-commercialisation efforts. In 2018, NIRDA implemented its firm-level development strategies through the advertisement of open calls for support in business development, technology and management. This call was open for those involved in the garment and banana wine value chains. Through NIRDA's STEM (science, technology, engineering and mathematics) Lab, they are supporting applied research and development for other value chains through knowledge management and generation as well as provision of physical space. Their main focus area

is data analytics in industrial software systems, mechatronics and energetics. NIRDA plans to collaborate with various research organizations under this initiative (Shepherd & Twum, 2018).

The World Bank, for example, has noted that funding of innovation beyond start–ups would be instrumental in boosting the success of innovation in Rwanda (World Bank, 2018). The STI system and funding situation is governed within the framework of the current government funding modality of the medium-term expenditure framework (MTEF). This is based on the need for immediate outputs and returns to the economy. That being said, it has been noted that STI in Rwanda requires a different funding arrangement that entails sustained long-term financing commitments in order to realize its long-term contribution to GDP (GESCI, 2017).

1.3 Policies governing the Science Granting Council and R&D in Rwanda

Rwanda is still working towards its "Vision 2020" through implementation of consecutive medium term strategies. These strategies have included the Poverty Reduction Strategy Paper (PRSP I, 2002-2006), and the Economic Development and Poverty Reduction Strategies I (2007-2012) and II (2013-2018). The most recent strategy commenced in 2018. The National Strategy for Transformation (NST1) is meant to bridge the completion of the Vision 2020 and the commencement of the Vision 2050. Vision 2050 is Rwanda's guideline towards achieving high-income country status (UN, 2019).

The 2013 revised STI Policy is still the main policy document providing guidance for NCST and others in their efforts to promote the production and use of STI in Rwanda. Further review of the Rwandan STI policy was conducted by UNCTAD in 2018. The recommendations from this review include strengthening of policy synergies and identification of interrelationships and trade-offs among the goals. It also recommended that national STI policy should be formulated based on the national innovation system (NIS) conceptual framework (UN, 2018). The prolonged approval process of the revised STI policy hinders its implementation. The preparation of a National Research Agenda document by the NCST is still ongoing.

2 STI ecosystem

In the first Political Economy Study (Chataway et al., 2017), it was observed that Rwanda has a fledgling STI system that is coordinated by MINEDUC. The issues raised in the PE1 study were:

- High levels of expectations
- Legacies of historical past
- Absence of a central regulatory authority
- Limited interaction between research organisations
- Limited resources (financial and human) and incentive structures

The last two issues were raised in this study during interviews conducted for fieldwork and from the literature review, but they were joined by a number of other factors. These are discussed below.

2.1 Evolution of STI ecosystem 2017 to 2019

2.1.1 Lack of capacity of staff in STI institutions

Lack of expertise in STI was identified as a major challenge by several of the interviewees with whom we met during this follow-up study. This was noted to be a problem both within research institutions – e.g. universities – but also within the bodies responsible for regulating and promoting STI in the country. One interviewee focussed on the need to increase the opportunity for staff involved in these institutions to study at PhD level. However, he – and several others – also focussed on the need for more practical action through promoting more centres of excellence and innovation hubs. It was noted that the lack of infrastructure capacity within universities (e.g. laboratory facilities) was a hindrance in building STI researcher capacity.

That being said, the STI policy in Rwanda does recognise the need for STI related skills to be promoted. Specifically, it notes that, for Rwanda to be globally competitive in the production of goods and services, the country needs to build engineering, entrepreneurship and technical skills. In addition, it identified the following objectives to promote the creation of skills (GESCI, 2017):

1. Knowledge acquisition and deepening: reinforcement of STI teaching and resources in all stages of education
2. Creation of knowledge: development of research capacity in all the national priority areas
3. Transfer of knowledge: STI capacity reinforcement in economic priority areas
4. Creation of an innovation culture: encouragement of innovation at all levels to contribute towards economic growth

Furthermore, efforts are being made to increase training opportunities. The government has implemented a policy where 70% of university scholarships are awarded to students enrolled in STI related courses. In addition, an agreement between public universities and the Swedish International Development Agency (SIDA) targets to produce 1500 PhDs between 2012 and 2022 (GESCI, 2017).

2.1.2 Reliance on external actors for funding

While there was widespread recognition of the value of NIRDA's efforts to promote R&D within the industrial sector and that the NCST's launch of the National Research and Innovation Fund (NRIF) were important opportunities to increase funding available for STI, major issues remained. Notably, there was still an overreliance on external actors (especially international development partners) for funding. Interviewees outlined two efforts that were being made to start to reverse this trend. The first was that the Private Sector Foundation had revitalised its Research Centre. However, several interviewees noted that until the private sector recognized the value of investing in R&D – notably how they can realise profit maximization and return on their bottom line investments – they will be reluctant to invest in this area. The second activity was to focus on what was already there: i.e. to conduct frugal innovation, and use resources and traditional knowledge, to produce lab equipment and research infrastructure to enable world class research to take place, even if in resource poor environments.

2.1.3 Limited interactions between STI stakeholders

All of the interviewees highlighted the limited interaction between STI stakeholders (policy makers, universities, private sector, communities etc.). That said, a couple of interviewees acknowledged an increase in interaction between some elements of the private sector and universities, as a result of the initiatives outlined above. There was also some discussion by two interviewees (one from within the education sector and the other a policy maker) that more regional cooperation would be helpful to bridge gaps in interaction (especially where knowledge does not exist in country).

2.1.4 Improving research quality starting with the school curriculum and TVET

Recognition of the importance of increasing research quality starting from school age has increased in the last two years. The Ministry launched another phase of the "Quality Education Enhancement Awareness Campaign" in 2019. One of the main aims of the campaign is to emphasise the role of ICT in increasing the quality of education. The Ministry is also training teachers and head teachers on the use of the laptops, and it monitors the use of ICT equipment. Over the last few years, the initiative is championed with increasing the use of technology by students and teachers. Alongside this, the Rwanda Coding Academy was launched to build capacity in programming at the tertiary level of education.

Furthermore, a majority of interviewees focussed on the positive changes more broadly within the education and skills building arena in Rwanda: notably, a change to a competency-based curriculum across primary and secondary schools, and an increased focus on technical and vocational education and training (TVET) and the role of innovation outside of formal research environments within universities. Mention was also made of an AfDB initiative that was attempting to link industry and higher education establishments. That being said, there was recognition from at least one interviewee that the cost of education – fees for university in particular – limited the numbers who were able to access education and training; limiting the opportunities for young people to come into contact with innovation hubs and research activities.

2.1.5 Fit with development priorities

All interviewees stressed the need for STI and research activities to have a focus on developmental priorities. Some specifically focussed on the need for alignment with the SDGs; others focused on the need for prioritisation of community-based problems. Some recognised the importance of looking at the latest cutting-edge research and STI areas (notably the 4th industrial revolution) for solutions.

3 Progress against indicators

Limited documentation and access to records of R&D activity in Rwanda were seen to be of major concern by interviewees and came out in the literature review. A recent report on STI activity in Rwanda noted that the most accurate way of assessing success in STI is through outcomes and not through the inputs to STI (UNCTAD, 2017). Unfortunately, this follow-up review found no improvement in the collection and analysis of STI related indicator data.

In this section we outline the data tables that were reported in the original study and update were possible. We then provide some additional narrative comments on the status of these indicators, where new data are available.

3.1 Science funding

	2017	2019	Comments
R&D expenditure as % of GDP	0.17%	No new data	Rwanda self-reported data in 2017
- Distance to national target of 0.5%	0.33%	No new data	
- Distance to regional target of 1%	0.83%	No new data	
- % from government	No data	No data	
- % from business enterprise	No data	No data	
Role of foreign funders over the past five years	↑	↑↑	

↑↑↑ high and increasingly on agenda; ↑ on agenda and slow increase in attention; --- no change.

There are no new national figures available related to routine science funding indicators since the last study report was developed in 2017. Another version of the National R&D Survey had been conducted since the first political economy report was published; however, the final version had not been cleared for distribution and publication at the time of this study.

In 2017, 0.17% of GDP was spent on R&D as opposed to the target 0.5% (Chataway et al., 2019). However, as reported above, the National Research and Innovation Fund (NRIF) was recently launched. Specifically, it was launched in March 2018 through a loan (US$30 million) from the African Development Bank (AfDB). The main objective of the loan was to resolve the issue of insufficient funding for supporting young entrepreneurs and new ventures. The fund will provide capacity building, business planning and management for technology entrepreneurs. NRIF aims to support research and innovation and create employment opportunities for aspiring innovators. Science and technology institutions including National Industrial Research and Development Agency (NIRDA), Rwanda Agriculture Board (RAB) and University of Rwanda will also be supported through this fund. The fund aims to provide 2000 direct jobs, 6000 indirect jobs and support approximately 170 companies (Hall, 2018).

A review of news reports found that, in 2019, it was announced that the Rwandan Government had awarded 9,968 scholarships to study STEM subjects at university in 2019-2020 academic year (Ashimwe, 2019). During the literature search, it was also found that the African Center of Excellence

in Energy for Sustainable Development (ACEESD) based in the University of Rwanda recently received a grant worth USD 250,000 from the World Bank as part of the Africa Centers of Excellence for East and Southern Africa Project (ACE II). The ACEII project is supported by the Inter-University Council for East Africa (IUCEA), a Regional Facilitation Unit for the World Bank (East African Community, 2019).

3.2 Science impact

	2017	2019	Comments
Field of science receiving most R&D funds	No data	No data	
Place of STI on policy agenda over the past five years	↑↑↑	-	No change observed
Importance of applied research over the past five years	↑	-	No change observed
Importance of multidisciplinary research over the past five years	↑	No data	No interviewee mentioned this
Importance of user-integrated research over the past five years	No data	No data	No interviewee mentioned this

↑↑↑ high and increasingly on agenda; ↑ on agenda and slow increase in attention; --- no change.

Again, no updated figures with regard to science impact were found during the literature review or fieldwork for this follow-up political economy study. That said, this study did find that the National Research and Innovation Fund (NRIF) granted RWF 50 million to business in the banana value chain to improve technologies and production quality. Some of these funds were allocated to NIRDA to facilitate implementation of the project "Enhancement of processing technologies, quality and competitiveness among banana beverages in Rwanda" (Nkurunziza, 2019). The fund also awarded a total of RWF 550 million to the Excellent Research Grant initiative. In September 2019, the Excellent Research Grant initiative awarded funding to 11 beneficiaries[8].

[8] https://twitter.com/hashtag/ExcellentResearchGrant?src=hash, accessed 08/10/19

3.3 Science capacity

	2017	2019	Comments
Researchers in R&D (per million people)	12.29	No new data	UNESCO, 2015: Rwanda 2009 data
# of staff in SGC	13	No new data	
- Distance to target	No data	No new data	
Improvement in science system to absorb funds in terms of researcher quality	No data	No data	Difficulty assessing this in follow up when no reliable funding figures
Improvement in science system to absorb funds in terms of fund manager quality	No data	No data	Difficulty assessing this in follow up when no reliable funding figures

There is low adoption and integration of STI due to lack of qualified human resources. However, efforts have been put in place to enhance capacity building in STI (GESCI, 2017). The shortage of qualified human resource has been identified as a major challenge across various sectors in Rwanda in STI policy reviews. Different recommendations have been received from different agencies: e.g. UNEP, WIPO, UNCTAD, etc.

The enrolment rate in tertiary education institutions remains low but has been increasing at a high rate. In 2015, only 8% of the youth enrolled for tertiary education. Very few complete their tertiary education. The government had taken steps towards the improvement of tertiary education in the country through consolidation of public universities into the University of Rwanda. This move was aimed at improving governance of the tertiary education system. Tertiary education institutions have been seen to be innovation hubs in Rwanda. The number of patents and publications has been gradually increasing but remains low. Enrolment rates in science and engineering have also been low compared to social sciences and law. In 2017, social sciences, health, engineering and sciences had 45%, 9%, 6% and 9% enrolment rates respectively (World Bank 2018). There have been other important changes and progress in the Rwandan STI system. For example, the Rwandan Government in collaboration with the African Development Bank launched a new campus of Carnegie Mellon University as a regional ICT hub with the aim of addressing regional development challenges and enhancing research capacity in the country and in the region. This initiative is part of the African Higher Education Centers of Excellence project funded by the World Bank (Simpkin et al., 2019).

4 Conclusion and recommendations

4.1 Main findings and conclusion of the report

This update to the first round of the political economy case study of Rwanda's STI system has highlighted a number of new funding initiatives being rolled out by the National Council of Science and Technology in Rwanda and efforts being made to enhance the sustainability of research activities in the country through a focus on STEM across the education sector. However, the lack of a clear overview of funding that has been granted, and the status of STI in the form of indicators, makes it difficult to assess the impact of the STI system. The consolidation of research within a single university (University of Rwanda) is a major effort by the Rwandan government to focus research efforts. The success or otherwise of this initiative is yet to be seen and should be evaluated as it is a very different approach to the neighbouring countries.

4.2 Recommendations for the STI actors in Rwanda

Science Granting Council: NCST

A revision of the website to provide a clear and transparent overview of the grant process and available funding schemes would provide an incentive to researchers to apply for grants and enable more effective grant management.

Education providers

A review of the decision to consolidate research into a single university will be needed in the coming years. A thorough review of all efforts to stimulate STI and research is also needed. There appear to be many different initiatives at different levels from clusters work and innovation hubs through to PhD studies. A review of the indicators of successful STI is also required to ensure that the focus is not simply on patents and publications as the efforts being made are now greater than this.

Private sector actors

Efforts of the Private Sector Foundation and those working with universities are to be commended. More, however, needs to be done. Those representing the private sector must find ways of making the arguments for R&D investment and for making STI attractive to those in business. More recognition of the different types of business and the need for innovative action at all levels of business (not just formal manufacturing of products) would also be beneficial. The current focus on TVET education is a an opportunity for in-roads in this area to be made.

Policymakers

All interviewees noted the difficulty of implementing the STI Policy due to the fact it has not been ratified as yet. Furthermore, all interviewees noted the need to make the public aware of the STI policy and for its promotion through a clear implementation plan, where progress of the plan is monitored on a regular basis.

References

Ashimwe, E. (2019). Participants hail government's efforts in promoting sciences. Retrieved from https://www.newtimes.co.rw/lifestyle/participants-hail-governments-efforts-promoting-sciences

Bertelsmann Stiftung's Transformation Index (BTI) (2018). Country Report; Rwanda. Retrieved from https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2018/pdf/BTI_2018_Rwanda.pdf

Bizimungu, J. (2018). Rwanda launches research and innovation fund. The New Times. Retrieved from https://www.newtimes.co.rw/rwanda/rwanda-launches-research-and-innovation-fund#.WySksIFleCE.twitter

Congressional Research Service (2019). Rwanda: In Brief. Retrieved from https://fas.org/sgp/crs/row/R44402.pdf

East African Community (EAC) (2019). IUCEA awards US$1 million to establish incubation centers at Africa Centers of Excellence. Retrieved from https://www.eac.int/press-releases/138-education,-science-technology-news/1453-iucea-awards-us$1-million-to-establish-incubation-centers-at-africa-centers-of-excellence.

FTF Council Analytical Unit (2018). Labor Market Profile. Retrieved from http://www.ulandssekretariatet.dk/sites/default/files/uploads/public/PDF/LMP/LMP2018/lmp_rwanda_2018_final3.pdf

GESCI (2017), Assessment of Knowledge Society Development in Rwanda June 2017 African Leadership in ICT (ALICT), Retrieved from https://gesci.org/fileadmin/user_upload/Assessment_of_Knowledge_Society_Development_in_Rwanda.pdf

Hall, A. (2018). Rwanda ploughs US$30 million into innovation. Extensia online. Retrieved from http://extensia-ltd.com/rwanda-ploughs-us30-million-innovation/

ICNL (2019). Civic Freedom Monitor: Rwanda. Retrieved from http://www.icnl.org/research/monitor/rwanda.html

Minecofin (2018). Key statistics on Rwanda. Retrieved from http://www.minecofin.gov.rw/fileadmin/user_upload/Key_statistics_on_Rwanda_Oct_23rd.pdf

MINEDUC (2006). The Republic of Rwanda's Policy on Science, Technology and Innovation. Retrieved from

MINEDUC (2017). Science & Technology in Rwanda. Retrieved from http://mineduc.gov.rw/fileadmin/user_upload/pdf_files/STI_in_Rwanda_Booklet_prepared_for_TWAS27th_Annual_Meeting_Final-1.pdf

Nkurunziza, M. (2019). Banana processing industries get boost from research, innovation fund. The New times online. Retrieved from https://www.newtimes.co.rw/business/banana-processing-industries-get-boost-research-innovation-fund

Republic of Rwanda (2019). Ministry of Finance and Economic Planning; Annual economic report Fiscal year 2017/2018. Retrieved from

http://www.minecofin.gov.rw/fileadmin/templates/documents/Reports/Annual_Economic_Reports_web/AER_FY2017-18_Final.pdf

Shepherd, B. & Twum, A. (2018). Review of industrial policy in Rwanda Data review, comparative assessment, and discussion points F-38426-RWA-1. Retrieved from https://www.theigc.org/wp-content/uploads/2018/11/Shepherd-Twum-2018-Final-report.pdf

Simpkin V, Namubiru-Mwaura E, Clarke L. (2019). Investing in health R&D: where we are, what limits us, and how to make progress in Africa. BMJ Glob Health 2019; 4:e001047. doi: 10.1136/bmjgh-2018-001047. Retrieved from https://gh.bmj.com/content/bmjgh/4/2/e001047.full.pdf

The World Bank (2019). The World Bank in Rwanda: Overview. Retrieved from https://www.worldbank.org/en/country/rwanda/overview

Twagiramungu, N. & Sebarenzi, J. (2019). Rwanda's economic growth could be derailed by its autocratic regime. The conversation *online*. Retrieved from https://theconversation.com/rwandas-economic-growth-could-be-derailed-by-its-autocratic-regime-114649

UNCTAD (2017). Science Technology and Innovation policy review: Rwanda. Retrieved from https://unctad.org/en/PublicationsLibrary/dtlstict2017d8_en.pdf

UNESCO. (2017). Country profile – Rwanda. Retrieved from http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/FEI_Country_profile_Rwanda.pdf

United Nations (2018). IATT Background Paper; Science, Technology and Innovation for SDGs Roadmaps. Retrieved from https://sustainabledevelopment.un.org/content/documents/19009STI_Roadmap_Background_Paper_pre_STI_Forum_Final_Draft.pdf

United Nations (2019). 2019 Rwanda Voluntary National Review (VNR) Report; Sustainable Development Goals. Retrieved from https://sustainabledevelopment.un.org/content/documents/23432Rwanda_2019_VNR_Final_Draft 17_06_2019.pdf

United Nations University; Institute of Advanced Studies (2006), The Republic of Rwanda's Policy on Science, Technology and Innovation. Retrieved from http://www.mineduc.gov.rw/fileadmin/user_upload/Rwanda_National_STI_Policy_01.pdf

World Bank (2018). Rwanda. Retrieved from http://pubdocs.worldbank.org/en/366631492188168425/mpo-rwa.pdf

World Bank (2018[2]). Future Drivers of Growth in Rwanda. Retrieved from http://documents.worldbank.org/curated/en/522801541618364833/pdf/131875-V1-WP-PUBLIC-Disclosed-11-9-2018.pdf

Annex: Interview details

Interviewee	Interview mode	Interview date
Research fellow at the Ministry of education	Skype	11 July 2019
Researcher at University of Rwanda	Skype	19 July 2019
Management staff at EASTECO	Skype	24 July 2019
Management staff at the Ministry of education	Skype	5 September 2019
Student at University of Rwanda College of Science and Technology	Face to face	5 September 2019
Research consultant	Face to face	5 September 2019
Researcher at Private Sector Federation	Face to face	6 September 2019
Researcher at University of Rwanda	Face to face	6 September 2019

National Case Study Report of

Senegal

Science Granting Council

1 Context of Senegal's STI System

1.1 Recap of contextual factors identified in PE1

The Republic of Senegal has been among Africa's most stable countries, with three major peaceful political transitions since independence in 1960. The country is also the second fastest growing economy in West Africa. Economic growth has been above 6% since 2014. Agriculture and fisheries are the mainstay of the economy although services provide more than half of total GDP. Poverty remains a major challenge in Senegal. It affects almost half of the population (46.7%), which could potentially intensify with the focus on capital-intensive exports, limiting the creation of new jobs. There are also important geographic inequality divides with two out of three residents considered poor in rural areas, especially in the South, compared to one in four in Dakar (the capital city of Senegal).

In 2014, President Macky Sall launched the Plan Senegal Emergent (PSE, Emergent Senegal Plan). The objective of PSE is for Senegal to become an "emerging market" by 2035. In order to achieve this, it elaborates a long-term development strategy for Senegal, including a series of flagship large-scale infrastructure projects such as a dry port and the development of a Special Economic Zone.

The country has had a long history of scientific research since independence. Research, innovation, science and technology activities have been under the Ministry of Higher Education and Research (MESR) or its equivalent since 1983. MESR is tasked with priority setting and the coordination of policy formulation. In Senegal, research grants have been disbursed at an institutional level since 1973 (Mouton et al., 2015). The country has a well-established education system, being one of the three countries in Africa that devotes more than 1% of GDP to education (UNESCO, 2016). However, the higher education sector is predominantly teaching focussed with a low researcher density (Diallo, 2013). Despite this, Senegal is one of the few Francophone countries that have dedicated science funding systems. The Finance Directorate, which is responsible for the various funding platforms available for scientists and researchers in Senegal, is considered to be the equivalent to the SGC in the country.

A significant push towards promoting research, innovation, science and technology started in 2013. One outcome of the PSE is a series of 11 Presidential Decisions on Higher Education and Research adopted by Macky Sall in 2013 to change the organisation of, and funding for, higher education in Senegal. The PSE also places a strong emphasis on tertiary education and STI and building up further education institutions in the country, including a plan for a second university in Dakar to focus, among other things, on science and technology.

1.2 Contextual factors arising between 2017 and 2019

1.2.1 Political overview

The February 2019 re-election of Macky Sall for a five-year second term presents an opportunity to ensure continuity in the long-term national strategy and continued investments under the PSE. The PSE has three main axes: structural transformation of the economy, promotion of human capital, and governance and rule of law. Government ministries are working towards achieving development priorities set in the Plan and defining the country's long-term development strategy (PSE, 2014) as laid out in their respective Sectoral Development Policy Letter (LPSD). Of particular relevance is the current Presidency's focus on "Education and Hydrocarbons, as the new driving force in Senegal's development" (Presidency of Senegal, 2018). The two key topics championed by President Macky Sall are (1) the distribution of oil and gas revenues and allocation to various extraction actors as well as (2) contributions towards future generations, education and sustainable development. Oil and gas revenues

are expected to strengthen the State budget, contribute to its commitment to develop human capital outlined in the PSE, and accelerate the structural transformation of Senegalese public education and the move towards universal schooling (Presidency of Senegal, 2018). There are ongoing efforts to finalise, by 2022, several texts and measures towards the organisation and funding of higher education, research, and innovation, in line with the 11 Presidential Decisions.

1.2.2 Economic context

Economic performance has remained strong over the past three years, notably boosted by the implementation of the country's PSE. The economic growth momentum recorded since 2015 remained strong in 2018, with an estimated real GDP of 7.0%, down slightly from 7.2% in 2017 (World Bank, 2019). The primary sector expanded by 7.8% in 2018, driven by agriculture and related activities. The secondary sector recorded 6.9% growth, driven mainly by mining subsectors, agrofood, and construction while the tertiary sector saw 6.7% growth, reflecting strong performance by the retail segment. While all sectors recorded growth in 2018, agriculture performed particularly well due to support programmes, robust external demand, and large infrastructure investments in the context of the PSE (World Bank 2019). In the energy sector, various reforms and investments have doubled installed capacity in six years to 1,250 MW in 2018. The energy mix plan has increased production and lowered the price of electricity by 10%. The economic growth momentum is expected to continue in 2019 and 2020 and above 6% in the coming years due to continued public investment under the PSE (AFDB, 2020; World Bank, 2019). Forecasts for economic growth remain optimistic with the production of oil and gas expected in 2022.

1.2.3 Science and technology system overview

There has been an increased awareness towards STI in Senegal over the past few years although the country does not yet have an explicit policy for the sector. The Senegalese government's stated aim to "fully invest in research development" (MESRI, 2018, p.28) and Axe 2 of the PSE on human capital, places high expectations for STI to contribute to the country's structural transformation and objective of becoming an emerging economy. As well as the higher education reforms, MESRI is seeking to align its strategy with the PSE, particularly Axe 2 on Human Capital, Social Protection and Sustainable Development. MESRI has seen the first year of implementation of its Sectoral Development Policy Letter (LPSD), aligning its objectives with the Senegal Emergence Plan for the 2018-2022 period (MESRI, 2018).

The ongoing implementation of higher education reforms has led to procedural, organisational and structural changes within the STI system. The adoption of a new framework law under the 11 Presidential Decisions has expanded the Ministry's remit to include innovation and responsibilities for two new missions: universities' contributions to community services and graduates' access to employment (MESRI, 2018). The Ministry, now renamed as the Ministry for Higher Education, Research and Innovation (MESRI), is responsible for implementing the reforms and has oversight for STI activities in Senegal. More specifically, its responsibilities include higher education, research and innovation, and student social and welfare issues. MESRI has also adopted several texts towards the implementation of the reforms.

Internal changes within the Ministry have led to the creation of the General Directorate for Research and Innovation (DGRI) to implement policies for research and innovation, ensure the coordination and harmonisation of related activities and resources pooling. Its responsibilities include strengthening the different components of the national research system to enable synergies, promoting the diffusion of research results and their valorisation, implementing a funding system for research activities and

diversification of funding sources, and developing a scientific and technical culture. In order to achieve this, the DGRI's responsibilities are split between four distinct directorates with respective responsibilities for research strategies planning; innovation, intellectual property and technology transfer; scientific research and technological development financing; and the promotion of scientific culture.

While MESRI has overall responsibility for leading STI developments, research activities are fragmented between institutions under the supervision of different ministries. For example, the Institute for Food Technology (*Institut de Technologie Alimentaire*, ITA) comes under the responsibility of the Ministry of Industry, while the Senegalese Institute for Agricultural Research (*Institut Sénégalais de Recherche Agricole*, ISRA) is attached to the Ministry of Agriculture. As a result, research and innovation, and associated funding streams, are dispersed and fragmented with multiplication and superposition of priorities, leading to lack of visibility and synergies between actors (Cissé et al., 2019).

1.2.4 Science and Technology indicators overview

Current STI indicators are sporadic pending a planned survey to provide exhaustive official data. MESRI is working with the National Agency for Statistics and Demography (ANSD) towards a survey, with the objective of providing official and reliable data on STI. The operationalisation of the survey has been delayed. Nevertheless, the Ministry has provided a series of indicators as part of its 2018 Annual Report (MESRI, 2019). These update previously available data as provided by UNESCO (2016) based on 2010 indicators. The lack of a specific target before activities, and the lack of some indicators, prevents an in-depth analysis for research and innovation. Consequently, some indicators are partially informed (for example in 2018, see Table 1 below). Furthermore, several research and innovation initiatives designed to strengthen the STI system are taken by different actors to research and innovation, making it difficult to assemble relevant data and information under one source, using the same indicators.

Table 1: Senegal STI indicators

	2017	2018	2022 (target)
Number of researchers[9]	14335	22185	
Researcher density	956	1411	1850
Female researchers	29%	No data available	32%
Scientific publications		7197	
R&D spending (percentage of GDP)	0.75%	No data available	

Source: MESRI (2019)

[9] This includes 56.63% research masters, 33.18% PhD students, 9.98% lecturer-researchers and 0.21% researchers.

1.2.5 Science Granting Council (SGC) in Senegal

There is no dedicated formal SGC in Senegal. MESRI's Scientific Research and Technological Development Financing Directorate (DFRSTD), which is in charge of various funding platforms available for scientists and researchers in the country, carries out the functions of the SGC. The responsibilities of DFRSTD include implementing the national budget for scientific research and technological development, monitoring and controlling the use of funds, implementing management procedures, preparing and organising sessions for the National Council of Higher Education, Research, Innovation, Science and Technology, and implementing measures to increase participation of the national scientific community (MESRI, 2019).

Over recent years, the Senegalese SGC has benefited from the SGCI's activities to help in strengthening its capacities for STI policy. These have included training sessions and capacity building in surveys and STI indicators, and interactions and engagement with its peers within regional platforms. The embeddedness of the SGC within MESRI ensures that individuals are able to participate in training activities, depending on topics covered. While moving MESRI's DFRSTD towards a formal SGC status may not necessarily change how the financing directorate operates, further efforts towards harmonisation and adoption of a common language may be needed within the SGCI to enable mutual understanding across the SGC's different contexts and clarity over expectations and objectives among its members.

Funding provided by the SGCI towards collaborative projects between Burkina Faso and Senegal has also enabled the SGC to identify a community of high-level researchers in health and agriculture, which both countries agree are priority sectors. The DFRSTD received a total of 17 research proposals co-written by teams including three researchers for each country. Based on the SGCI funding available, two out of the 17 projects – one for each sector – were selected, totalling FCFA 50,897,200 (USD 87,528).

Providing adequate resources for research projects and infrastructure to develop researchers' capacities and having the organisational capacities to address STI issues are key challenges for the Senegalese SGC. As MESRI's funding directorate body, the DFRSTD plays a key role in interacting with researchers but faces challenges in meeting their expectations. Low budgets mean it is not able to meet local research needs. For example, while all researchers involved in the SGCI-funded call for proposals for cooperative projects with Burkina Faso welcomed the opportunity to work together, availability of funding for only two projects meant that the SGC could not meet researchers' expectations, which can stifle their motivation.

Although there is potential for elections to slow down activities in the country, political constraints are limited given Senegal's stability. Nevertheless, processes within MESRI, and the duration and bureaucracy associated with funding disbursement, can raise trust issues between the SGC and funding beneficiaries. While the SGC interacts directly with researchers, manages funding and conducts evaluations, disbursement of funding comes from another structure. This generates trust issues between the SGC and researchers, who do not understand why their applications are dealt with by another body. Project monitoring and evaluation (M&E) is also a challenge, which training and capacity building activities can help to address.

1.2.6 Research funding of the Science Granting Council

As it stands, the main source of funding for the Senegalese SGC comes from the government, which contributes 80% of project funding. Nevertheless, there is a funding deficit for high level STI research at the local level. For example, the SGC has been able to cover only 10% of the research projects it

would like to fund under the Impulse Fund for Scientific and Technical Research (*Fonds d'Impulsion pour la Recherche Scientifique et Technique*, FIRST) funding stream. The funding deficit also impacts negatively on researchers' capability development and investment in infrastructure to conduct local research, which are not up to the level of what is needed.

The SGC's main objective is to contribute to research that focusses on priority areas and is looking for further support to increase funding available for research. In order to increase financial resources, the SGC is seeking to develop partnerships with domestic and international actors and would welcome further support to establish such links. Another approach that the SGC adopts is to develop partnerships with industries, private sector (national or international) and engage in private-public partnership (PPP) initiatives. Furthermore, efforts to increase sources of funding include the management and securing of additional partners with financial capacity for research funding. Financial capacity from partners is needed as well as finding partners for financing and developing additional resources and funds.

Pending an exhaustive STI survey in Senegal, there are no exact figures on sectoral allocation for research budgets. However, agriculture, health, and energy are likely to dominate, considering limited resources and the need to align state funding with national priorities. The share allocated to Information and Communication Technologies (ICTs) is likely to be on the rise in the distribution of funding allocation, given the emphasis on the sector in the national development strategy. Bearing in mind the fragmentation of research and innovation activities and associated funding, other sectors may also receive support through private institutions.

1.2.7 Policies governing the Science Granting Council and R&D in Senegal

In the absence of a dedicated STI policy, sectoral measures related to higher education reforms and the PSE guide the SGC's funding and R&D, and MESRI's activities on STI. The 11 Presidential Decisions and associated directives provide a roadmap for the SGC to follow and objectives to be achieved by 2022. These objectives include expanding higher education institutions to the entire country and diversifying the university map, developing Science, Technology, Engineering and Mathematics (STEM), and promoting the use of ICTs for teaching and research, as a way of increasing students' access to professional work. The reforms aim to increase investment in higher education and research. One way to achieve this objective is to increase training of human resources and create the necessary knowledge towards emergence, placing a specific emphasis on research and innovation. For example, Decision 8 outlines measures to "provide a fresh impetus to research and innovation" in Senegal, including identifying the country's main research priorities as they relate to its socio-economic development ambitions and implementing an appropriate system of performance indicators to evaluate national policy for STI.

The PSE also provides the direction for development of STI activities in Senegal. The Plan places an emphasis on tertiary education and building further education institutions. In addition, the PSE emphasises the need to increase access to education for a larger number of people and from a wider range of socio-economic and marginalised groups. Furthermore, the plan allocates funding to the creation of a second University of Dakar (with a focus on S&T), the creation of the City of Knowledge – creating higher education, research, and business, a Network of higher education and training institutes, and University residences for over 40,000 students. The City of Knowledge in Diamniadio is also expected to host a dedicated space for governance and evaluation, as well as specific spaces for research and innovation, learning, and the promotion of scientific culture. Implementation of the PSE started in 2016 and the Ministry of Economy is expected to publish its LPSD at the end of 2019. Lastly, the government reform agenda and the PSE place specific emphasis on the development of ICTs to promote access to higher education and STI.

2 Senegal science, technology, and innovation system

2.1 Recap of STI ecosystem in Senegal

Senegal has a number of well-established universities and research institutes. MESRI's mandate covers all higher education institutions, including universities and higher institutes of vocational training (ISEP) as well as the Senegal Virtual University (*Université Virtuelle du Sénégal*, UVS). The 2013 President Decision mandated the creation of a virtual university and 50 Digital Open Spaces or ENOs, with at least one in each government department across the country. Research institutes fall under the remit of sector Ministries. The most well-known of these is the Senegalese Institute for Agricultural Research (ISRA). In total Senegal had 16 functional research centres and test centres in 2015, up from 9 in 2014. The aim of the government was to have 33 functional centres by 2018.

MESRI is supported by a National Council of Higher Education, Research, Innovation, Science and Technology, established in 2015[10]. The council acts as a consultative mechanism to the Minister of Higher Education and Research (UNESCO, 2016). MESRI is also supported by a number of other allied agencies who promote research activities in the country. In addition, there are several other private research organisations operating out of Senegal as either Senegalese non-profits or as international organisations, including the National Academy for Science and Technology of Senegal (ANSTS), the National Agency for Applied Scientific Research (ANRSA), and the Senegalese Agency for Industrial Property and Technological Innovation (ASPIT). International organisations include l'Institut Pasteur de Dakar, Institute of Research for Development (IRD), the Council for the Development of Social Science Research in Africa, and the African Institute of Mathematical Sciences.

There have also been efforts to strengthen cooperation between universities and the domestic private sector, which remains low. Relatedly, there have been efforts towards the establishment of innovation hubs and incubators such as the creation of CTIC Dakar in 2011, Ker-thiossane Defkoakniep founded in 2014, and Yessali Agrihub founded in 2016. As part of the Presidential reforms, the government announced that it would reform university administration boards and at least 50% of board members would come from outside academia or the "socio-professional world of work". Finally, the construction of Senegal's first planetarium and mini astronomical observatory "could also be a sign of a growing science culture" (UNESCO, 2016, p.494).

2.2 Evolution of STI ecosystem 2017-2019

2.2.1 Higher education

To reiterate, the Ministry for Higher Education, Research and Innovation (MESRI), is responsible for all aspects of higher education, including university and vocational training. It has oversight for Senegal's eight public universities, six of which are operational, one polytechnic and one higher institute for vocational training (ISEP), which provides short two-year graduate training post-*Baccalaureate* (MESRI, 2019). Two new universities are being built: UAM (*Université Amadou Mahtar Mbow*), specialised in science and technology, and USSEIN (*Université Sine Saloum El Hadji Ibrahima Niasse*), specialised in agricultural activities. A network of institutes for vocational training organised around socio-economic potentials of the country's regions is being developed with four new institutes for vocational training. There has also been an increase in private higher education over recent years, which now trains around a quarter of Senegalese students.

[10] A government official noted that this is a project. A relevant draft document has been in existence since 2015/2016, but not yet acted upon.

2.2.2 University Access

Increasing university access and reducing urban-rural discrepancies are major challenges in Senegal, where only a small minority of the population (around 10%) have access to higher education. There were about 190,145 students in 2018 compared to 174,674 in 2017 (MESRI, 2019). This translates to a density of 1209 students per 100,000 inhabitants, which is still below the 1414 target and the 2000 international norm (MESRI 2019). Out of these, about 114,100 are male and 76,135 are female[11], providing a 0.67 parity rate, and 6% are PhD students compared to 4% in 2017. Most of higher education comes from the public sector with 123,281 students but there has been an increase in private sector education which now has 66,864 students.

The government efforts towards more inclusive higher education are twofold: expanding the university map and the geographical location of higher education institutions, and increasing access in terms of origin of the students. This aims to overcome the concentration of universities in large cities on the coastline, which raises geographical and distributional issues in terms of access and the need for dissemination of universities in landlocked areas where there is far less urbanisation. This is important not only because education is centralised but also because there are socio-economic barriers to its access. Concentration in urban centres means that access is very expensive for people from disadvantaged areas. Transport and accommodation are expensive, raising questions around the potential for success in such socio-economic conditions. Gender equality in access to higher education is also an issue. While, generally, there are as many female as male secondary school leavers, only 30% of higher education students are female. The retention rate is weak because of social, cultural and economic factors such as parents' reticence in sending their daughters to large cities and associated living conditions as well as difficulties in attending studies for women who are wives and/or mothers.

In order to diversify the university map, the government has planned a vast programme towards the creation of new institutions and rehabilitation of existing universities. Despite delays in the execution, extension work was finalised in three universities (UCAD, UADB and UGB) and eight new digital spaces (ENOs) were created in 2018 (MESRI, 2019). The Thies vocational training centre also became operational, although there have been delays with the other expected ISEPs.

As part of the drive to increase inclusive access to higher education, the reforms have also introduced measures to promote the development of digital activities and enhance distance learning. One notable effort is the opportunity provided by the Senegal Virtual University (UVS). There has been a significant increase in students' participation in online courses for higher education, quickly catching up with traditional physical structures. UVS has become the second university in Senegal for the last two years, increasing its number of students from 2000 five years ago to almost 30,000 in 2019. The promotion of distance learning is also supported by the creation of open digital spaces (ENOs) throughout the country, providing physical facilities with internet connections that enable interactions between students and teaching staff and secure spaces for exams. Students taking this mode of learning receive a free computer. There are currently 13 ENOs in Senegal, but this is expected to increase to 50 within the next few years.

2.2.3 STI courses in higher education

Senegal has recorded an increase in the availability of STEM and STI courses in higher education over recent years. As part of its emphasis on tertiary education, the PSE has set a target for 50% of students to follow STI disciplines. The future Dakar University and City of Knowledge, which are both under

[11] The total is now expected to be more than 190,145.

construction, are to offer new STI courses and training opportunities. Efforts towards revising or creating available training have increased the number of curricula dedicated to STI and STEM to 342 compared to 253 in 2017 (MESRI, 2019).

Of particular interest is the emphasis on promoting ICTs in higher education, both for online learning and as a growing sector. Integration of ICTs into teaching and learning strategies has seen an increase of online courses from public higher education institutions from 943 in 2017 to 1605 in 2018, as well as further developments of the "one computer for each student" programme to strengthen digital activities with 10,053 beneficiaries. There are also incentives such as competitions, prizes and awards to direct students towards the field.

Recent developments have also seen the creation of a new training centre to provide postgraduate training to develop skills in oil and gas. Following oil and gas discoveries between 2014 and 2016, and with production expected to start from 2021, a Senegalese State decree adopted on 27 December 2017 established the National Oil and Gas Institute (*Institut National du Pétrole et du Gaz*, INPG[12]). It aims to develop national expertise and contribute to employment and job creation for Senegalese women and men in the oil and gas sectors. INPG aims to train human resources to take charge of the multisectoral dynamics emerging from exploitation, production and management of oil and gas resources. The first cohort for this specialised masters started in October 2018. Entry is very selective and open only to students from scientific backgrounds, not social sciences or humanities.

Despite delays in the developments of the new ISEP centres, there are also increasing incentives for young people to follow higher education vocational training instead of going to universities. Students can already specialise in vocational training for their Baccalaureate. After this they have the option to do an internship in a company and, following two years' training, create their own companies or become operational and join the job market.

2.2.4 University-private sector linkages

Despite attempts to strengthen university linkages with the private sector, progress has been slow. According to an interview respondent, only two universities have implemented measures to change administrative boards' composition to include 50% of representatives from outside academia or the "socio-professional world of work". Measures to promote young people's access to employment have enabled 2248 students to be supported within public university incubators and 2453 in the PSE-J (MESRI, 2019). A total of 120 projects were incubated and 19 enterprises created in public universities in 2018. The PSE-J has supported 298 incubators and enabled the creation of 106 enterprises, creating 1936 jobs.

2.3 STI for socio-economic development

2.3.1 Human resources and skills for socio-economic transformation

The PSE's emphasis on STI also calls for attention to human resources and skills needed to achieve structural economic transformation and the role of tertiary education in the process. While the Plan sets a target for 50% students in STI disciplines, challenges exist at the university entry level where 80% come from a Baccalaureate specialising in literary studies. One of the challenges in teaching STEM relates to students' profiles, most of who come from a literary background. Senegal has inherited from

[12] Institut National du Pétrole et du Gaz (INPG) (2019): National Oil and Gas Institute, https://www.inpg.sn/ (accessed August 2019)

the French secondary education system whereby college pupils specialise in literary, scientific, or technical studies for their Baccalaureat (A-level equivalent). Most students, however, have a literary background, which is not directly applied to provide jobs and/or deliver value-added products from agricultural raw materials or extractive and agricultural activities that require transformation in order to add value to the raw products. Furthermore, the supply of secondary education vocational studies remains low. The Ministry is planning to introduce a vocational training college in each of the 45 departments with specialisations in line with the local economy. For example, a college located in an area relying strongly on agriculture could specialise in agrarian studies.

As such, the challenge remains on training and education to adapt to the needs of the economy and deliver qualified human resources for economic transformation. Such developments may require a nomenclature to define the boundaries of the STI field. While indicators exist for scientists within each school, innovation may relate to technological innovation, management innovation and organisational innovation. In the context of oil and gas, for example, innovations could extend from exploration and exploitation platforms, and engineering disciplines, to considering ancillary activities and related sectors that involve other types of technologies for the transformation of oil and gas. An important point to consider is whose responsibility it is to foster innovations in these areas. The national private sector and higher education would need to work together to create jobs that do not yet exist in Senegal but are already in other oil producing countries. The ability to create such jobs could boost Senegal's socio-economic prospects and ambitions.

In that context, there are ongoing discussions to further articulate the link between STI and the needs of the economy. The Ministry of Economy is in dialogue with the private sector to discuss innovation challenges and opportunities from the perspective of the economy and the role of universities in the innovation process. Furthermore, ongoing talks are taking place with the Korean Development Institute to learn from the country's experience in articulated skills and training demand for specific sectors. The aim is to map the number of skilled labour personnel needed for each sector and devise what kind of engineering training and teaching staff will be needed to support the sector. While there is a list of established activities and sectors, the question is how to direct vocational training to meet this demand, in collaboration with the private sector, which can provide technical teaching, including higher education.

2.3.2 A system-wide approach to education

A broader understanding of increasing the role of STI for socio-economic development also requires a systemic approach to education, starting from primary school all the way up to higher education. A key question is how to simplify teaching so children understand from an early stage opportunities provided by STI. At the secondary level, this includes increasing the number of students' specialisation towards scientific studies so they can follow up in higher education. Transition from secondary school to college is also a challenge as the number of pupils specialising in scientific studies stagnates or decreases. As a result, it is essential to develop a strategy for education and a pedagogic approach to STI teaching that helps to overcome social barriers and mental blocks from pupils' subconsciousness, both in primary and secondary schools. An interview respondent summarised it thus:

> If we want 50% of students in STI disciplines, we need to start from the base and start from primary school and acquisition of scientific knowledge through secondary school and vocational training all the way to higher education.

Aligning with the PSE objectives for STI also requires a cross-sectoral understanding of education policy as a whole to find synergies for engaging young people. Such a systemic approach necessitates further interactions between the three ministries responsible for education in Senegal: MESRI, the

National Education Ministry (*Ministère de l'Education Nationale*) and the Ministry for Labour, Vocational Training, and Craftsmanship (MEFPA). While the three ministries have worked together at a high-level towards planning of the report for the general education policy, further participation of those directly involved in teaching, higher education, research and innovation such as teachers, professors, research staff, students and basic education specialists, is needed. Interactions between specialists in national education, vocational, and higher education would help in defining a strategy for the realisation of STI training in education. Teachers are the bridge to ensure there is no discrepancy between knowledge acquired from primary to secondary and from secondary to higher education, and to ensure a smooth transition across different stages.

2.3.3 Gender considerations in STI

Promoting STI in Senegal through an inclusive approach also requires taking into account gender considerations – as girls and women are under-represented in the STI field. This means raising their awareness – prior to university, from an early age and through secondary school – that there are career opportunities for women in the STI field in Senegal. This should aim to overcome socio-political barriers and provide support to remove the stumbling blocks facing young girls and parents towards the STI and STEM fields. Attention to representation in decision-making bodies is also a key point, as lack of gender considerations within processes of institutional transformations and political decisions could add further stumbling blocks. Following the 2010 Parity Law, Senegal is one of the few governments to take into account women's representation with an important percentage of women at the National Assembly and within government bodies. Stumbling blocks, however, remain in the way of effective implementation of STI strategies for girls and women. Increasing the number of women in higher education and decision-making, and improving implementation of development strategies, could increase the space for advocacy and gender-aware solutions that help address gender-related STI issues.

2.3.4 Regional and national governance of STI and research initiatives

Regional initiatives have helped to raise awareness of STI in Senegal. The African Union Development Agency (AUDA, formerly NEPAD), for instance, has provided technical and financial incentives to support Africa Union (AU) member countries. The support has helped to create partnerships, thereby contributing to the development of a common governance framework. Regional initiatives from AUDA and the AU, therefore, provide references (in terms of documents and institutions) with which stakeholders and national governments can align, in line with national development agendas of individual country's needs. One research participant deplored the lack of financing behind regional initiatives:

> There are declarations at high level, which are in line with national policies, but no follow-up on ground. Even if resources are agreed, they do not trickle down to the institutional level. Decision makers need to provide concrete facts/evidence with funds/financing – we see in documents that funds are available – we really need them. This aligns with our STI policy: we have reference documents, and we have Presidential decisions and directives in is our policy environment.

Participants also raised concerns of a disjuncture between high-level political discourses at the national level compared to the lack of the necessary funding allocated to these activities for concrete actions on the ground. Further high-level support from executive and legislative powers and associated funding is also needed. However, more engagement by the Presidency and politicians would provide a strong sense and clarity that STI is a priority for national socio-economic development and job creation.

2.3.5 Pending STI Policy

Unlike Anglophone countries, Senegal is still lacking a dedicated STI policy. This is a stumbling block. Despite institutional and organisational changes within MESRI, implementing the Presidential Decisions towards research and innovation, progress towards a fully-fledged STI policy framework has been slower than expected. For example, the STI survey to provide robust indicators and a dedicated STI policy are still pending. While the creation of the General Directorate for Research and Innovation (DGRI) and new developments for STI are positive, concrete actions on the ground remain to be seen. A research participant emphasised:

> With STI, there is a long way to go. It is there in discourse but this negligible when it comes to practices.

Having an explicit STI policy in place may not address all the challenges in the sector. However, it would enable the actors to see a roadmap for STI and clarify lines of responsibilities. The lack of a national framework and STI policy is particularly problematic as there is no clear roadmap towards activities and prioritisation of STI in the country. A formalisation of STI activities in policy instruments would enable Senegal to articulate the main drivers to conduct specific activities.

2.3.6 Fragmentation and weak coordination

Governance of all STI and actors also remains a challenge. Although MESRI has improved some of its governance capacities in the field of research with new texts for executions in the STI field and policy documents, as outlined in its LPSD (MESRI, 2019; MESRI, 2018), there is also the need to gather and coordinate the range of actors involved in STI. Actors include MESRI itself, research labs, universities, and private enterprises, the National Agency for Statistics and Demography (ANSD), research think-tanks, NGOs and other research structures, and foreign countries. There have been prior attempts to improve coordination. However, these attempts have been carried out at thematic levels with specific topics rather than addressing governance across the STI field. As one research participant pointed out:

> Each actor is huddled up on itself. Actors have kept on asking for more action. MESRI has tried to respond and provide more stability with the creation of the General Directorate to improve governance and provide texts. [But] creating a directorate in charge of governing is not enough, you also need implementation.

The coordination challenge highlights the need for a dialogue framework as well as guidance towards establishing targets and an implementation plan for the directorate within a national framework. Although there are plans to develop a national framework for STI, this has not yet happened. Discussions on how to develop the strategic plan have been ongoing since 2018, with a national framework expected within the next two years. As a result, it is possible that many relevant STI activities are not necessarily captured.

Furthermore, there is lack of clarity, common understanding, and discrepancies around the role of what constitutes "research excellence" and its contributions to local needs and socio-economic development. As one interviewee put it, "If there is no agreed definition, each strategy adopts a different understanding and there is a cacophony of definitions and criteria that vary from one structure to another as there is no governance towards harmonisation".

3 Progress against indicators

3.1 Science and research funding

Pending the STI survey, detailed data on research funding are scarce. While more than 1% of the country's GDP is devoted to education, higher education is predominantly focussed on teaching. There is not much funding for research in the university budget: about 90% of the budget goes to, for example, salaries, administration and teaching-related functions. Universities continue to focus heavily on teaching compared to research. Inadequate government funding for scientific research means that, even if the State allocates funds to research activities, oftentimes there is no clear budget line for research at universities. There are also instances where individual allowances are managed by universities but no research funding.

The predominance of education is reflected in expected spending for the reforms, most of which is allocated to higher education. A total of FCFA 302 billion is planned for the reform, 78% of which has been allocated to increasing capacities for students in higher education and diversifying the university map while the remaining share is split between governance and research (MESRI, 2013). Research and innovation accounted for 2% of the budget in 2018 (MESRI, 2019) compared to student's welfare and social issues (49%), higher education (46%), and control programmes (3%). There are no details of how this breaks down although previous data from UNESCO state that 41% of GERD was from foreign sources compared to 48% from government and 4% from the private sector. The majority of GERD (52%) went to government institutions or higher education (31.4%).

A total of 0.75% of the country's GDP is allocated to R&D (MESRI, 2019). Most R&D funding comes from the State through grants to various research structures, including universities, public scientific institutions, and high schools as well as through postgraduate scholarships and competitive funds (Cissé et al., 2019). MESRI operates different funding streams for which it has oversight. These include:

- **FIRST/FNRI**: Impulse Fund for Scientific and Technical Research, which has now become the National Fund for Research and Innovation (FNRI)[13]. MESRI received a total of 85 applications for project funding under the FIRST stream in 2017, 50 of which were selected for potential funding. A final decision allocated funding to 13 projects, totalling FCFA 254,253,150 but no disbursement for these projects or others had taken place in 2018 (MESRI, 2019).
- **Funds for Female Researchers and Lecturers in Senegal (*Projet d'Appui à la Promotion des Enseignantes-chercheures du Sénégal*, PAPES)**: PAPES provides opportunities for female researchers and teachers to apply to a dedicated fund to support costs for further education in Senegal or abroad, publishing costs, and costs to attend conferences to present papers. It can also provide up to half of the funding for the publications in international journals and scientific books. So far, PAPES has provided funding to 107 research activities from female academics, including 72 lecturers and 35 PhD candidates, for a total amount of FCFA 287,642,773 (EUR 438,507) (MESRI, 2019c). A total of 32 female PhD students received funding under the PAPES scheme in 2017 (MESRI, 2019).

There were no funding streams in 2018 for either PAPES or FIRST as the year was spent evaluating projects submitted in 2017.

The fragmentation of the research system in Senegal also means that research institutes fall under the remit of sector ministries and not MESRI or under the scope of the SGC. As reported in the first PE

[13] The Act is not yet adopted.

report (Chataway et al., 2017), Senegal had 16 functional research centres and test centres in 2015, up from 9 in 2014. There are plans to establish more research centres. Funding systems promoting agricultural research have been recently established. For example, the FNRAA, a sectoral fund for agriculture and food research (set up in 1999), is hosted within the Ministry in charge of the economy. While MESRI and its finance directorate have oversight for research, specific sectoral ministries also allocate research funding as well as the private sector. In general, funds for research and innovation activities are made up of the totality of State subsidies and funding from international donors or "technical and financial partners". Some of the funds from international donors come in the form of international calls for proposals/research projects and others through direct donor funding (Cissé et al., 2019).

Beyond specific funds administered by MESRI and other research funds under different ministries, different reward schemes have been put in place to support "excellence". These include:

- The Presidential Award for Innovation
- The Presidential Award for Science and Technology (*The Grand Prix du Président de la République pour les Sciences et la Technologie*, GPRST): a national distinction whose objective is to reward the researchers who have particularly distinguished themselves by their creativity, the importance or the originality of their works
- An African exhibition of Research and Innovation in Senegal (SARIS), which is regularly organized by the *Agence Nationale de la Recherche Scientifique Appliquée* (ANRSA) in partnership with all national components of research and innovation (Cissé et al., 2019).

While funding streams under MESRI have been successful so far, low public funding is an issue for both research and infrastructure, resulting in weak capacities in labs and research units across the country.

3.1.1 Private sector funding

Despite the public rhetoric on research-business linkages and recognition that enterprises could be key actors, domestic private sector funding plays a minor role in R&D in Senegal. In Senegal's economic fabric, whereby around 12,000 companies are in the modern sector and 97% of activities are in the informal sector, the perception is that R&D is still an activity predominantly reserved for the academic world. Besides the contribution of few telecommunications companies, private sector funding of research and innovation is small in Senegal (Cissé et al., 2019). Due to paucity of data, a gap which the pending STI survey would seek to fill, the private sector's role in the funding of research and innovation is considered to be marginal. Nevertheless, some initiatives are taken up by international private sector actors, either on an individual basis such as MasterCard or the Bill & Melinda Gates Foundation, or through partnership with the government.

3.1.2 External funding

International donors play significant roles in financing research in different forms. According to UNESCO, 50% of research funding comes from external sources. This raises questions of whether research is addressing Senegal's development issues (see, for example, the PE1 report, Chataway et al., 2017). As discussed earlier, some of this external funding comes from technical and financial partners, who play a key role in supporting MESRI's activities. In order to diversify and strengthen funding for research, Senegal, through MESRI, has joined different partnerships, notably between Europe and Africa (MESRI, 2019). These include:

- **Leap Agri** (Long term European African Partnership for food security in Africa, previously ERA-Net Cofund): 27 projects have been selected for funding, 6 of which involve Senegalese researchers. Senegal's participation also enables the country to fund four projects, while two projects are funded by a top-up from the European Union and the *Agence Française de Dévelopment* (AFD). The total budget for the 27 projects is EUR 22.7 million. This is the first time Senegal has participated in co-financing the Leap Agri programme. The programme has enabled MESRI to organise researchers from several institutions in multidisciplinary teams working in priority fields. Furthermore, through the programme, researchers are able to develop partnerships at national, regional and international levels, and acquire additional sources to fund research.
- **SGCI** (cf above): collaborative project with Burkina Faso (FCFA 24,750,000 for health project and FCFA 26,147,200 for agriculture project). Implementation of the projects started in September 2018.
- Application for **Leap4FNSSA**: AU-EU partnership for food security and sustainable agriculture. The aim is to establish a platform for research and innovation partnership between the African Union and the European Union (AU-EU).

In line with Senegal's past, the country has maintained close research links with France. The French have, through some of its institutions – for example, Institute Pasteur (CNRS) in April 2019 – launched a call for proposals to support joint France-Senegal research. The objective of the programme is to initiate or develop scientific cooperation between research centres and universities in both countries, through support for joint research excellence, involving the mobility of researchers. The programme promotes a multidisciplinary research approach, the emergence of new Franco-Senegalese collaborations (thematic and/or institutional) and favours the participation of young researchers (MESRI, 2019). According to UNESCO (2016), there had been 1009 co-publications between Senegalese and French researchers between 2008 and 2014, compared to 403 with the USA, 186 with the UK, and 139 with Belgium.

Recently, the World Bank has opened two new higher education African Centres of Excellence (ACEs) in Senegal in the fields of STEM (mathematics and ICTs) and health (child and maternal health). This brings the total number of World Bank ACEs in Senegal to four:

- African Center of Excellence in Mathematics and ICT (CEA MITIC), Gaston Berger University, **Senegal**
- *CEA pour la Sante de la Mere et de L'enfant* (CEA-SAMEF), Cheikh Anta Diop University, **Senegal** (CEA-SAMEF in Maternal and Child Health, Universite Cheikh Anta Diop, UCAD)
- *CEA: Agir en Environnement et Sante*, Cheikh Anta Diop University, **Senegal**
- *CEA: Agriculture pour la Securite Alimentaire et Nutritionnelle* (CEA AGRISAN), Cheikh Anta Diop University, **Senegal**

The four new centres are part of the World Bank's wider network of collaboration with West and Central African countries, which aims to strengthen the capacities of participating universities to deliver high quality training and applied research[14].

[14] For more on this, visit https://ace.aau.org/about/

3.2 Science impact

Senegal had the 3rd highest publication rate (338 journal publications in 2014) in West Africa after Nigeria (1961) and Ghana (579). The majority of scientific papers published by researchers between 2008 and 2014 were in the field of biological or medical sciences (1037) as opposed to agriculture (118 papers) (Chataway et al., 2017).

3.3 Science capacity

Table 2: Research capacities in Senegal

	2017	2018	2022 (target)
Number of researchers	14,335	22,185	
Researcher density	956	1411	1850
Female researchers	29%	No data available	32%
Number of lecturer- researchers	No data	2214	
Number of full-time researchers (UCAD)	No data	46	
Number of researchers at PhD level	6013	7361	
Number of submitted PhD theses	158	287	
Number of researchers Master 2 (research Master)	10,824	12,564	
Number of technicians	No data	21	

Source: MESRI (2019)

The government of Senegal has made efforts to strengthen human resources for R&D. Although the number of researchers has increased to 22,185 compared to 14,335 in 2017 (see Table 2), the number of full-time researchers remains small. Out of all researchers, 56.63% are research masters, 33.18% PhD students, 9.98% lecturer-researchers and 0.21% researchers (MESRI, 2019). Furthermore, there is a shortage of laboratory technicians (MESRI, 2019). Establishing research teams and having the necessary human resources to support them is also a challenge. While there are individual researchers, their actions are not adequately coordinated at the national level and are often not tailored towards national needs. Furthermore, there is a lack of administrative staff to provide support for research activities.

3.4 Infrastructure

Despite some investment in infrastructure, often supported by international donor financing or private sector partnerships, the necessary physical environment and equipment to conduct high-quality research in Senegal remains a challenge. The lack of adequate infrastructure can lead to brain drain as researchers move abroad. Concerted efforts are being made to improve the situation. While not yet operational, the *Cité du Savoir* (Knowledge City) includes laboratories, spaces for shared working and equipment. The recent acquisition of the supercomputer equipment to strengthen research structures with support of ATOS, is another example. And there are plans to establish a molecular genetics platform as part of the City of Knowledge (MESRI, 2019). As a multi-partnership, the platform will include genopole from the University of Evry (France) and the Institute for Advanced Sciences and Techniques (*Institut des Sciences Techniques Avancés*, ISTA), which hosts the National Centre for Scientific Calculation (*Centre National de Calcul Scientifique*). The platform will offer masters courses in strategic scientific fields, knowledge exchanges, training and acquisition of material towards a vegetal biotechnology platform that will be hosted at ISTA (MESRI, 2019, p 45).

4 Conclusion and recommendations

4.1 Main findings and conclusion of the report

This report has highlighted some issues in Senegal. These include the welcoming of STI references in the national policy agenda as part of a key contributor to socio-economic development. However, efforts are needed in articulating specific goals and allocation of funding. As it stands, the majority of funding for research (STI and R&D) is from the government. This source, and share, of funding is still small, and needs to be increased significantly.

4.2 Recommendations for the STI actors in Senegal

i. There needs to be recognition at a high level (Presidency and parliamentarians) on the importance to increase efforts towards more interactions between all actors in the STI system.

ii. It is important for policy makers and politicians (led by the Presidency) to complete the formulation and adoption of the anticipated national STI policy, and further emphasise the role of STI for socio-economic development and transformation.

iii. Address the challenges in (STEM) education and gender participation in research and STI. Actions in this regard must take a systems approach and cover primary and secondary education as well as access to higher education, and review the roles of researchers and teachers.

iv. Funding for research remains a major challenge in Senegal. Greater efforts need to be made in this regard. Policy interventions must, as in the recommendations above, take a systems approach that involves a broad spectrum of actors – public and private sector funders, development partners, SMEs and actors considered to be in the informal economy.

v. Improve the availability of data on STI, alongside data transparency.

References

AfDB (African Development Bank) (2020). Senegal Economic Outlook, https://www.afdb.org/en/countries/west-africa/senegal/senegal-economic-outlook

Chataway, J., C. Ochieng, R. Byrne, C. Daniels, C. Dobson, R. Hanlin and M. Hopkins (2017). Case Studies of the Political Economy of Science Granting Councils in Sub-Saharan Africa. Science Granting Councils Initiative, SPRU (Science Policy Research Unit) and ACTS (African Centre for Technology Studies).

Cissé *et al* (2019) Developing a Transformative Innovation Policy Approach: the case of Senegal, Transformative Innovation Policy, Africa Hub, Universite Cheickh Anta Diop de Dakar, TIP Consortium available at: https://www.tipconsortium.net/wp-content/uploads/2019/07/Senegal-5-pager.pdf

Government of Senegal (2019) Plan Senegal Emergent, Dakar, https://www.sec.gouv.sn/dossiers/plan-s%C3%A9n%C3%A9gal-emergent-pse

Iizuka. M. and Mawoko, P. (2018) Innovation for Development in West Africa: Challenges for Promoting ST&I Policy, United Nations University, UNU-Merit, Netherlands, available at: https://www.merit.unu.edu/partnerships-the-key-to-progress-in-west-africa-deip-cote-divoire-2017

MESR (2013a) Décisions Présidentielles relatives à l'Enseignement supérieur et de la recherche, available at: http://www.mesr.gouv.sn/decisions-presidentielles-relatives-a-lenseignement-superieur-et-de-la-recherche-pdf/

MESR (2018b) Performances 2017 de l'enseignement supérieur: Le ratio d'étudiants pour 100.000 habitants passe de 1.071 à 1.099 http://www.mesr.gouv.sn/atelier-de-partage-de-la-revue-annuelle-de-performance-2017-du-mesri/

MESR (2019) France- Senegal – joint call for proposal - http://www.mesr.gouv.sn/wp-content/uploads/2019/03/appel-a-projet.pdf (in French); see also, http://www.mesr.gouv.sn/appel-a-projet-appui-a-la-recherche-france-senegal/

MESRI (2013b) La reforme en 10 points, Ministère de l'Enseignement Supérieur et de la Recherche, Dakar, avalaible at: http://www.mesr.gouv.sn/enseignement-superieur-la-reforme-en-10-points-pdf/

MESRI (2018) Lettre de politique sectorielle de développement de l'enseignement supérieur, de la recherche et de l'innovation LPSD/MESRI 2018-2022, Dakar

MESRI (2019a) Rapport Annuel de Performance 2018, Coordination Cellule des Etudes et de la Planification, CEP-MESRI, Dakar

MESRI (2019c), Enseignement supérieur: Rapport d'activités 2012 – 2019 available at: http://www.mesr.gouv.sn/enseignement-superieur-rapport-dactivites-2012-2019-pdf/

Presidency of Senegal (2018) , Nationwide dialogue: Education and Hydrocarbons, new driving forces in Senegal's development, Dakar , 5 June 2018, available at : http://www.presidence.sn/en/newsroom/the-presidency-answers-your-questions-nationwide-dialogue-education-and-hydrocarbons-new-driving-forces-in-senegals-development_1306

Senegal Presidency (2014) Plan Senegal Emergent: https://www.sec.gouv.sn/sites/default/files/Plan%20Senegal%20Emergent_0.pdf

Senegal Presidency (2019)' Plan Senegal Emergent, Dakar, http://www.presidence.sn/pse (last accessed August 2019)

UNESCO (2013). Towards a better governance of science, technology and innovation (STI): tools for analysing and monitoring policies and instruments, STI Workshop, 12-14 March 2013, Dakar, Senegal. http://www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/global-observatory-of-policy-instruments/workshop-seti/

UNESCO (no date). STI Policy Development, Senegal. http://www.unesco.org/new/en/natural-sciences/science-technology/sti-systems-and-governance/sti-policy-development/africa/senegal/

World Bank (2019). The World Bank In Senegal https://www.worldbank.org/en/country/senegal/overview

Annex: Interview details

Interviewee	**Interview Mode**	**Interview Date**
Representative, MESRI, Scientific Research and Technological Development Financing Directorate (DFRSTD)	WhatsApp	14 June 2019
Representative, MESRI, Study and planning unit	WhatsApp	11 July 2019
Representative, MESRI, Strategies and Research Planning	WhatsApp	11 July 2019
Representative, MESRI, General Directorate of Research and Innovation	WhatsApp	16 July 2019
Representative, Planning Direction of the Ministry of Economy (DGPPE)	WhatsApp	14 August 2019
Professor, University of Alioune Diop of Bambey (UADB)	WhatsApp	13 August 2019
Professor, Université Virtuelle du Sénégal (UVS)/Senegal Virtual University	WhatsApp	23 August and 13 September 2019
Representative, AFSTech/Sénégal (Women in Science Association)	WhatsApp	29 August 2019

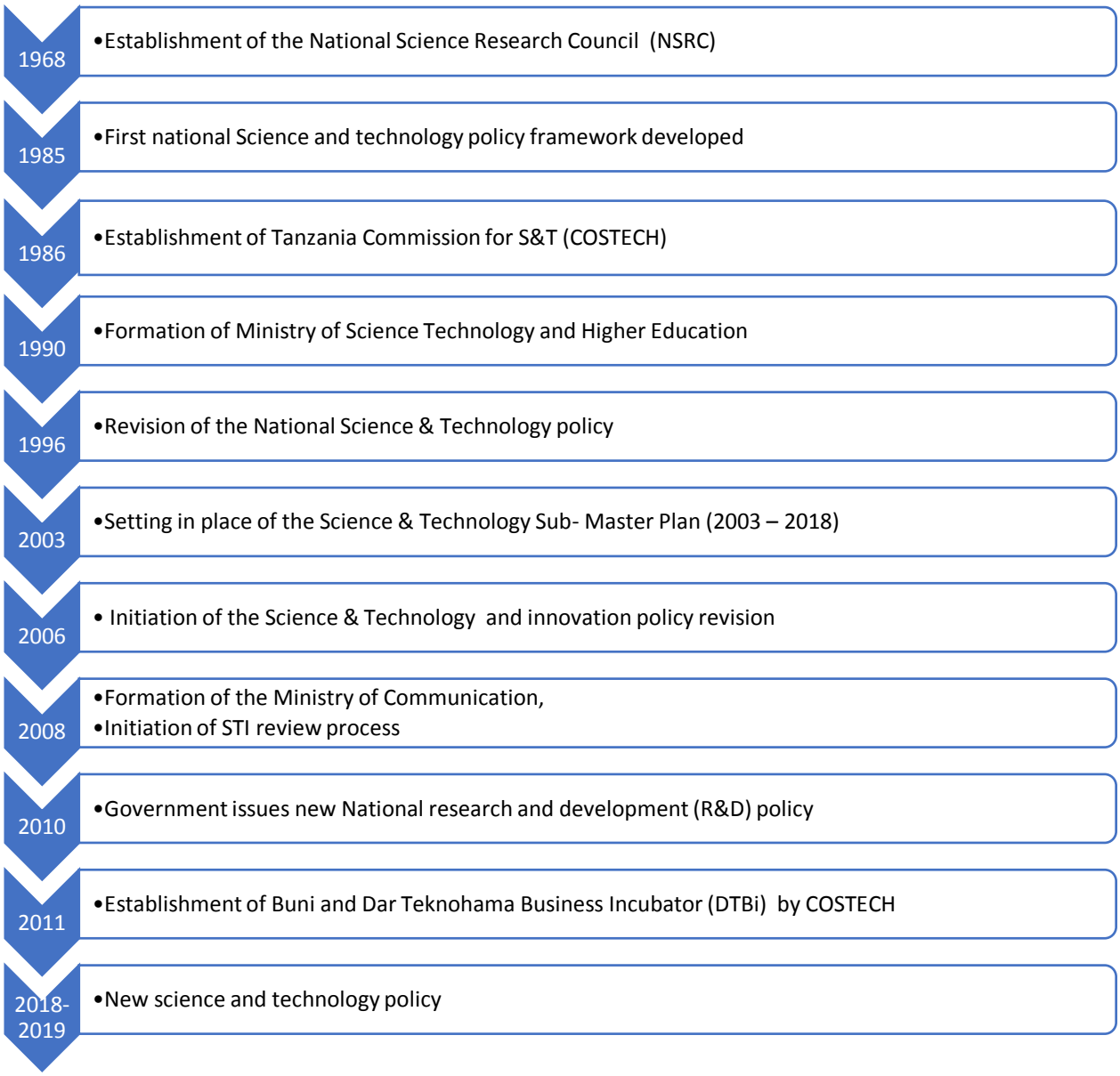
National Case Study Report of

Tanzania

Science Granting Council

1 Context of Tanzania's STI System

Figure 1: Historical milestones that have influenced the STI system in Tanzania.



Over the years, the Tanzanian government has made strides to ensure the growth and development of the national STI system, as shown in Figure 1. In 1986, COSTECH was established as a successor of the Tanzania National Scientific Research Council (NSRC) better known as "UTAFITI" (COSTECH, 2019). COSTECH was established with the main mandate of coordination and promotion of research and technology development activities in the country. The aim of this case study is to identify the different political, economic and social aspects affecting the performance of STI in Tanzania. Key informants from different sectors were interviewed either via Skype/phone or in person (see the Annex for interview information). Additional information was collected from secondary sources during a thorough literature review. This study was carried out between May and November 2019.

1.1 Contextual factors arising between 2017 and 2019

1.1.1 Political overview

Since the first study (Chataway et al., 2017; see also Chataway et al., 2019), there have been few political changes that have influenced the STI landscape in Tanzania. The country is still presided over by the 5th President of the United Republic of Tanzania, John Pombe Magufuli. Improved management of public resources, public administration and eradication of corruption have been priorities in Magufuli's government since his appointment in 2015. Notably, he has taken a strong stance on corruption, which has been curbed during this period (World Bank, 2019).

1.1.2 Economic overview

In 2018, Tanzania's GDP growth rate decreased to 6.7% from 7.1% (AfDB, 2019). The increased volume of imports in 2018 due to importation of equipment and construction material for large government projects – e.g. Standard Gauge Railway – and depreciation of the Tanzanian shilling may have contributed to a decrease in the GDP growth rate. However, the level of inflation decreased to 3.5% due to a surplus in food supply (AfDB, 2019). According to the Bank of Tanzania, the government contributed USD 271,005,000 out of USD 271,048,000 for development activities. Only a small portion was received from donors (USD 43,353) (Karashani, 2019). The main contributor to GDP was the service sector (39.3%).

There was seen to be more flexibility in the monetary policy in 2018 compared to 2017. This reduced the borrowing rate resulting in increased private credit supply (AfDB, 2019). Dependency on donor funding has slightly reduced due to increased domestic revenue (partially from taxes) and economic growth. Nevertheless, up to a third of government expenditure is financed by donor funds[15]. Tanzania's reliance on donor funding may significantly decrease in the near future due to increased revenue from natural gas and economic growth (AfDB, 2019).

Tanzania did not receive any external funding for its 2018/19 budget due to governance issues. In 2018, the government only received 0.016% of the funds required for government projects. The government had to fund the projects through alternative funding sources (Karashani, 2019). The majority of development partners are withdrawing financial aid due to the government's strict stance on issues like gay rights. However, the government claims that there are contributing factors to donor support including strict conditions, delayed implementation of projects and prolonged negotiation periods. Only 54% (USD 315.5 million) of the pledged amount (USD 1.157 billion) of funds was received from development partners in 2018 (Karashani, 2019).

Despite the decrease in poverty in Tanzania, a large portion of the population remains poor. This may be due to the growth rate of the population (World Bank, 2019). Approximately 47% of the population is living below the poverty line. The latest World Bank report (2019) ranks Tanzania at 144 out of 190 economies at ease of doing business. This shows a decrease in ranking from the previous 137/190 in 2018 (Trading Economics, 2019). According to the Ministry of Industry, Trade and Investment, the decrease in rank is due to enforcement of new regulations aimed at curbing misconduct in business. These regulations are aimed at improving the business sector in the future. The new rules include mandatory vehicle checks to reduce arms/human trafficking and permit fees for all businesses including those in the informal sector (Brewin, 2019).

[15] Note that this is direct to projects as opposed to the USD 43 thousand, which is direct to government support and only that which was captured by reporting.

On the economic front, overreliance on hydropower for electricity production has been seen to be one of the bottlenecks to sustainable economic development in the country. Low rainfall and depletion of water reservoirs are the main contributing factors to insufficient electricity production in Tanzania. This rainfall deficit has also had a tremendous toll on the agriculture sector, thus also having a negative impact on economic development (Ministry of Foreign Affairs of Denmark, 2019). Tanzania has recorded an increased efficiency of resource use. Targeted funding from donors has been seen to have a major impact, especially in the service sector. The government has used donor funds, alongside use of its own resources, to improve vital sectors in the SDGs. The Tanzania Development Vision 2025 promotes the use of ICTs and suitable capabilities to encourage sustainable development (Barakabitze, 2019).

1.2 Science and Technology System overview of Tanzania

In late 2017, Amos Nungu was appointed the new Director General for COSTECH. He was previously the Assistant Director – Directorate of Science, Technology and Innovation at the Ministry of Education, Science and Technology. COSTECH is the main regulatory body for all STI related activities in Tanzania. The responsibilities of the commission include coordination and monitoring of scientific research, innovation and technology development related activities; registration of research institutions within the country; provision of advice to the government in regard to STI related issues, allocation of research and development (R&D) funds; generation and dissemination of research output; preparation and review of national STI programmes; and enhancement of technology transfer (COSTECH, 2018).

Despite the magnitude of its mandates, it has been noted that COSTECH does not have enough resources to efficiently execute its duties. At the same time, coordination of COSTECH with other government bodies has been frustrated by the insufficient resources (Salam et al., 2018).

COSTECH has set priority research areas in STI to enhance national socio-economic transformation, mainly through industrialization. This is in line with the Tanzania Development Vision 2025 (TDV 2025) to promote technology transfer and innovation. The main aim of the vision is to shift the country from agrarian-led growth into an industrial and service-led economy. STI will play a crucial role in this transformation through the embedding of research in all sectors of the economy (Tawiri, 2016).

Tanzania has experienced tremendous growth in the innovation system over the past 5 years. This has been evident from the increased number of individuals and institutions actively involved in innovation activities. In 2018, the country's ranking in the Global Innovation Index 4 improved, moving up 27 positions to 92 from the previous recorded rank of 123 in 2013. This rise in rank is commendable due to the favourable innovation environment in the country. An increased awareness of the importance of innovation as a tool to address societal issues has been noted. Despite this, innovation in Tanzania is still in its infant stages due to limited resources and support (HDIF, 2018).

1.3 Policies governing the Science Granting Council and R&D in Tanzania

The National R&D Policy issued by the government in 2010 emphasizes the need for establishment and regular review of priority areas in research. The policy also emphasized the importance of identifying research areas that contribute to economic development and address societal needs (de Haan, 2015). During the 6th national annual STI conference and exhibition held in 2018, the Deputy Permanent Secretary in the of the Ministry of Education, Science, Technology and Vocational Training, Prof Mdoe, spoke on the drawbacks of the current STI policy. He pointed out that the existing policy does not have the capacity to address the issues within the current STI system. Preparation of a new STI policy is in progress and the policy was supposed to be published between 2018/2019. The new policy will be

formulated to address the current issues within STI. Prof Mdoe further emphasized the role the new policy will play in attaining national economic growth through STI (Abdu, 2018).

2 STI system

In the first Political Economy Study, PE1, it was observed that Tanzania was doing well relative to other countries in terms of gaining funding from the private sector but that changes in policy and emphasis by donors and the government were negatively impacting the STI system (Chataway et al., 2017). The issues facing COSTECH and other stakeholders highlighted in the PE1 study were:

- Changes in policy towards industrialisation
- Overlaps in roles/responsibilities and lack of autonomy of certain actors
- Changes in donor support and priorities
- Private sector funding for STI which was ring-fenced
- Increased focus on impact of funding

Very few of these issues were raised during interviews and the literature review in this round of analysis, with the exception of the influence of funders' priorities in research undertaken. The issues raised during this second political economy study are outlined below.

2.1 Evolution of STI system 2017 to 2019

2.1.1 Low expertise and motivation

Lack of skilled/highly knowledgeable human resources in innovation and development was noted by one respondent from the research sector. The respondent pointed out that the low number of senior researchers with PhDs in research institutions has been strenuous in the resource mobilization activities. She further added that, in the past, co-grants ensured that the private research organizations had enough funds to sustain themselves. Co-grants no longer exist, and the organizations have to ensure that the money raised from projects covers all expenses. In addition, other respondents noted that university research staff are not exclusivity engaged in research/product development on a full time basis. They are also obligated to be involved in teaching, administration and other community services (often while also working on paid research projects). Thus, the research output may be compromised in terms of quality and quantity. The result is a lack of incentives to motivate researchers in Tanzania to be fully focussed on research. Instead, they often end up searching for alternative sources of income rather than focussing on research.

The skills issue was also raised with regard to other areas of academia. Several respondents interviewed during the study pointed out that there are few people equipped with the technical skills required by industry. The majority of technical colleges have been upgraded to universities. It was noted by one respondent that "the job market is flooded with experts and engineers and very few technicians who are the major sources of innovation". It was argued that there needs to be a balance between highly trained personnel with university degrees and artisans and technicians from polytechnics. The rate of unemployment among Tanzanian youth remains high, mostly because the graduates are not equipped with skills required by employers (HDIF, 2018).

2.1.2 Research funding priorities

Funding is crucial in sustaining researchers and research activities. Insufficient funding reduces the quality of the research output. According to one of the researchers we interviewed, available donor funding can only be accessed through competitive calls. These funds can only be used in line with the research to which it is attached, thus researchers are not able to implement research projects of their

choice. Interviewees also noted that investments in research require long-term horizons but that the government and private sector expect investments with immediate returns. One interviewee stated that priority areas for funding in the Ministry of Education, Science, Technology and Innovation can, at times, be politically influenced and gave the example of school infrastructure funding. A key respondent from one of the local universities pointed out that the majority of the research funded by COSTECH is in public research institutions. Private research institutions rarely receive any funding from COSTECH. However, they argued that the government needs to support research activities in private institutions even if it is in the form of subsidies.

2.1.3 Poor policy implementation

A respondent pointed out that the weaknesses in formulation of policies have serious implications for implementation, and that policy formulation can be politically influenced and non-objective. It was also noted that knowledge of the STI field was often limited as most policy makers have limited understanding of the STI concept. A related argument made by respondents concerns the limited awareness of the general public with regard to organisations like COSTECH. It was noted that the fact that COSTECH only has one office in the capital, lacking regional/zonal offices, limits its ability to serve the entire country.

2.1.4 The quality of the national innovation system

A respondent from academia mentioned that the national innovation system (NIS) is still at its infant stage and is not well developed, noting that challenges to the NIS include difficulties with infrastructure and poor linkages between key actors. It was pointed that there are often silo operations among the different sectors and associated ministries. Another respondent from the private sector pointed out that there are several ministries dealing with STI in the country but that they often operate independently from each other. He stressed the importance for sectors/ministries working together to enhance knowledge and skills sharing.

3 Progress against indicators

3.1 Science funding

	2017	2019	Notes
R&D expenditure as % of GDP	0.53%	No data	UNESCO, 2015: Tanzania 2013 data
- Distance to national target of 1%	0.47%	No data	
- Distance to regional target of 1%	0.47%	No data	
- % from government	57.53%	No data	UNESCO, 2015: Tanzania 2013 data
- % from business enterprise	0.08%	No data	UNESCO, 2015: Tanzania 2013 data
Role of foreign funders over the past five years	↑	↓	

↑↑↑ high and increasingly; ↑ low; --- no change; ↓ decreasing

The main national funding organ for STI remains the National Fund for the Advancement of Science and Technology (NFAST), as outlined in the first round of this study. The majority of the funding received by NFAST is from donor organizations. The major drawback of this is that most of the research projects funded by donor organizations have to be in line with the donor's agenda. Another drawback, as noted by interviewees and by other writers (see for example, Atela et al., 2018) is that researchers do not have the flexibility to address their own research interest or national development/social needs. Insufficient resources are a major hindrance to the progress of R&D in Tanzania. R&D funding is primarily dependent on government and foreign donor organisations, as noted above, and donor funding has been reducing.

3.2 STI impact

There has been some recognition of the impact of innovation on society in Tanzania since the first study was completed in 2017. HDIF (2018) has noted that innovation has had numerous beneficial effects on society over the years including job creation, access to clean water, and capacity building. One of the innovations that are mentioned is the Gongali Model, which is an affordable water purification system invented by a Tanzanian Chemical Engineer, Dr Askwar Hilonga. It is argued that Dr Hilonga has created numerous job opportunities for underprivileged women and enhanced their skills in entrepreneurship and other life skills. Another example of an innovation that was given is SIGMA, which is a company that constructs efficient biogas systems for schools. SIGMA is also involved in capacity building of local entrepreneurs in construction and maintenance of the systems.

	2017	2019	Notes
Field of science receiving most R&D funds	No data	No data	UNESCO Science report 2015
Place of STI on policy agenda over the past five years	↑	No change	
Importance of applied research over the past five years	↑	No data	
Importance of multidisciplinary research over the past five years	↑	No data	
Importance of user-integrated research over the past five years	No data	No data	

3.3 Science capacity

	2017	2019	Notes
Researchers in R&D (per million people)	18.49	No data	UNESCO, 2015: Tanzania 2013 data
# of staff in SGC	No data	No data	
- Distance to target	No data	No data	
Improvement in science system to absorb funds in terms of researcher quality	No data	No data	
Improvement in science system to absorb funds in terms of fund manager quality	No data	No data	

No data can be found to be able to effectively comment on the issue of science capacity in the period between 2017 and 2019 in Tanzania.

4 Conclusion and recommendations

4.1 Main findings and conclusion of the report

Since the last report, Tanzania's ranking in the Global Innovation Index 4 improved, rising 27 positions to 92 from the previous recorded rank of 123 in 2013. This is despite the findings of this report that highlight a significantly unfavourable environment for research and STI. That being said, the efforts of the country to work towards sustainable industrialization place a focus squarely on the importance of STI and research. The revision of the STI policy that is ongoing at the end of 2019 will be important in this respect. The key finding in this follow-on review is that the successful implementation of any revised STI policy is likely to only be possible if the bottlenecks relating to the policy environment (notably the resourcing of COSTECH and its autonomy) are fully addressed.

4.2 Recommendations for the STI actors in Kenya

Science Granting Council: COSTECH

COSTECH needs to cement its place within the STI system in Tanzania. If it can enhance its position so as to become the effective "go-to" place for anything relating to research and STI, it will be able to leverage increased numbers of collaborations which, in turn, will strengthen the STI system. This may involve moving its location to within the Office of the President, as other countries have done.

There is a need for enhanced collaboration between COSTECH and appropriate ministries in order to work towards industrialization. In addition to this, donor requirements for multi-disciplinary teams could encourage these collaborations.

Private sector

The private sector needs to increase their support for research and development through funding. Those involved in R&D need to continue advocating for the government and private sector to understand the importance of research, and the importance of collaborations between these two groups of actors.

Policymakers

There is a need to enhance capacity building to ensure that the policies developed can be easily implemented, starting with the revised STI policy. An enhanced focus on the influencing factors during the policy formulation, implementation and evaluation processes is essential, together with development of corresponding mitigation strategies.

References

AfDB (African Development Bank Group) (2019). Tanzania Economic Outlook. Retrieved from https://www.afdb.org/en/countries/east-africa/tanzania/

Atela, J., Marshall, F., Ndege, N., Chataway, J., & Frost and Hall, A. (2018). Unpacking Knowledge Systems for sustainable development in East Africa: Practical perspectives from Kenya, Rwanda and Tanzania. Retrieved from https://www.ash-net.org/how-can-knowledge-systems-in-east-africa-contribute-to-sustainable-development/

Barakabitze,A.A., Lazaro, A. W., Ainea, N., Mkwizu, M.H., Maziku, H., Matofali, A. X., Iddi, A., & Sanga, C. (2019). Transforming African Education Systems in Science, Technology, Engineering, and Mathematics (STEM) Using ICTs: Challenges and Opportunities. Retrieved from https://www.hindawi.com/journals/edri/2019/6946809/

Brewin, D. (2019). Tanzanian Affairs, Archive for Business & the Economy. Retrieved from https://www.tzaffairs.org/category/business-the-economy/

Chataway, J., C. Dobson, C. Daniels, R. Byrne, A. Tigabu and R. Hanlin (2019). "Science Granting Councils in Sub-Saharan Africa: Trends and tensions." Science and Public Policy.

Chataway, J., C. Ochieng, R. Byrne, C. Daniels, C. Dobson, R. Hanlin and M. Hopkins (2017). Case Studies of the Political Economy of Science Granting Councils in Sub-Saharan Africa. Science Granting Councils Initiative, SPRU (Science Policy Research Unit) and ACTS (African Centre for Technology Studies).

COSTECH website (2019). Tanzania Commission for Science and Technology. Retrieved from http://www.costech.or.tz/establishment

de Haan, S., Kingamkono, R., Tindamanyire, N., Mshinda, H., Makandi, H., Tibazarwa, F., Kubata, B., & Montorzi, G. (2015). Setting research priorities across science, technology, and health sectors: the Tanzania experience. Health Research Policy and Systems (2015) 13:14 DOI 10.1186/s12961-015-0002-2. Retrieved from https://www.researchgate.net/publication/273777396_Setting_research_priorities_across_science_technology_and_health_sectors_The_Tanzania_experience

Domasa, S. (2018). Tanzania: Education Budget Up By 5pc to 1.4 Trillion. Tanzania Daily News (Dar es Salaam). Retrieved from https://allafrica.com/stories/201805010077.html/

Human Development Innovation Fund (HDIF) (2018). Investing in Social Innovation and Technology in Tanzania HDIF's Reflections and Recommendations 2013-2018. Retrieved from http://www.hdif-tz.org/wp-content/uploads/sites/11/2018/12/HDIF_Reflection_Report.pdf

Karashani, B. (2019). Tanzania now forced to fund its budget as donor aid freeze bites. Retrieved from https://www.theeastafrican.co.ke/business/Tanzania-now-forced-to-fund-its-budget-as-donor-aid-freeze-bites/2560-4944588-133qq4tz/index.html

Ministry of Foreign Affairs of Denmark (2019). Current and future challenges and opportunities in Tanzania. Retrieved from http://um.dk/en/danida-en/strategies%20and%20priorities/country-policies/tanzania/current-and-future-challenges-and-opportunities-in-tanzania/

Salam, U., Lee, S., Fullerton, V., Yusuf, Y., Krantz, S., & Henstridge, M. (2018). Tanzania Case Study: Rapid Technological Change - Challenges and Opportunities. Retrieved from https://pathwayscommission.bsg.ox.ac.uk/sites/default/files/2019-09/tanzania_case_study_rapid_technological_change.pdf

Tawiri (2016). Research priorities for Tanzania 2015 -2020. Retrieved from http://tawiri.or.tz/wp-content/uploads/2017/06/Tanzania-Research-Pririties-from-COSTECH.pdf

Trading Economics (2019). Ease of Doing Business in Tanzania. Retrieved from https://tradingeconomics.com/tanzania/ease-of-doing-business

University of Dar Es Salaam. 2018. University of Dar Es Salaam Research Agenda. Retrieved from https://www.udsm.ac.tz/upload/20190815_091105_University%20of%20Dar%20es%20Salaam%20Research%20Agenda%202018_19%20-%202027_28.pdf

World Bank (2019). The World Bank in Tanzania. Retrieved from https://www.worldbank.org/en/country/tanzania/overview

Annex: Interview details

Interviewee	**Interview mode**	**Interview date**
Researcher, Science Technology & Innovation Policy Research Organization (STIPRO)	Skype	11 July 2019
Professor, Tanzania Academy of Sciences (TAAS)	Phone call	19 July 2019
Staff member, Confederation of the Tanzanian Industries (CTI)	Phone call	29 July 2019
Lecturer, University of Dar es Salaam (UDSM)	In person	23 October 2019
2 staff members, Tanzania Chamber of Commerce, Industry and Agriculture (TCCIA)	In person	24 October 2019
Staff member, COSTECH	Phone call	18 November 2019
Director, private company	Questionnaire	20 November 2019

Annex 6: PE2 Interview protocol

The interview explored changes in the landscape for STI support (research funding, policy support, skills availability etc.) over the last few years. The questions focussed on:

1. The challenges that organisations face
2. What is behind the challenges and the organisation's ability to overcome the challenges
3. Other challenges that might be facing the actors working in the STI space

INTERVIEW GUIDE

NB: If an interviewee was unfamiliar with STI as a phrase the researchers considered using the term R&D. However, R&D is highly limiting. Therefore, R&D was used with care.

Part A: Challenges faced

Preamble, in the lines of:

As you may know, innovation (or the search and subsequent utilisation of new ideas, products or ways of working) and its related areas of research, science and technology, are seen as extremely important mechanisms through which a country can develop economically. Examples are often given of Korea that successfully utilised the latest science and technology to transform its manufacturing sector and became a high income country within a couple of decades. In Africa, examples of Mpesa in Kenya and biotechnology in South Africa are often given as similar (albeit smaller scale) examples. Within this context…

1. What are the main challenges within the national science, technology, and innovation (STI) or research and development (R&D) environment that your organisation is trying to address? Why are these challenges important?
2. What are the main challenges within the national STI or research environment generally? – *For those who are being interviewed for their more general/overarching understanding of the environment*
3. What is the most important of these challenges to your organisation? Why?
4. How does your organisation address [this main STI/ R&D challenge]?
    a. Do you think this approach works well? If not, why not?
5. How do you evaluate the success of your activities? Specifically, how do you know if your approach to addressing this [main STI/R&D challenge] has worked?

Part B: Interrogation of the key challenge

6. Who are the main actors involved in this [main STI//R&D challenge]?
    a. What roles have key actors played, or been unable to play, in this problematic STI situation?
    b. Who is benefiting from the current problematic STI//R&D situation and who is not benefiting?
    c. What needs to change and why?
    d. What has changed over the past two years?
7. Does the structure of your organisation, or that of any other organisation or institution, impact positively or negatively on your ability to address this [main STI//R&D challenge]?
    a. What are the constraints arising from the country's natural-resource endowments (or other natural and geographic conditions), and its economic, political and social structures that are causing this problematic STI/R&D situation?
    b. What changes are needed and why?
    c. What has changed over the past two years?

8. In what ways has the policy environment at the national level (and above) caused or neglected this problematic STI/R&D situation?
    a. What needs to change and why?
    b. What has changed over the past two years?
    c. What roles have political, organisational, social and cultural practices played in this problematic STI/R&D situation?

Part C: Other challenges

9. In an earlier study, we found that there were three major challenges impacting STI activity in [Kenya/ Tanzania/ Rwanda/ Ethiopia/ Senegal]. You [have/ have not] already mentioned [one/ two] of these:

    a. Private funding

    At the national and regional level there is reference to the important role that the private sector could play. However, private sector funding is low and engagement is patchy across countries. Has the situation changed?

    b. Sector funding distribution or allocation (e.g. health, agriculture, water, energy, etc.)

    Health and agriculture are the sectors which receive most resource in the SSA region but this may change over the coming years. Has the situation changed?

    c. Research excellence

    There are different views about what constitutes scientific excellence and the criteria for funding. National funders express a desire to build capacity and address national issues while some regional funders have distinct strategies for building the scientific profile and presence in the region. Has the situation changed?

10. For the [one/two issues] you haven't mentioned, why do you not see them as important barriers to STI activity?

    a. [If interviewed before] Was your view different in 2017? i.e. do you think it is no longer an issue? If so, why? (has something else become a more important issue?)

11. Is there anything else you expected us to ask you about but which we have not? If so, what was it?

Annex 7: List of kick-off workshop participants held in Nairobi on 27-28 March 2019

First name	Family name	Organisation
Ann	Kingiri	ACTS
Ann	Numi	ACTS
Aschalew	Tigabu	ACTS
Boniface	Wanyama	NACOSTI
Chux	Daniels	SPRU, University of Sussex
Diakalia	Sanogo	IDRC
Donnelly	Mwachi	MEL Consultant
Ellie	Osir	IDRC
Loise	Ochanda	IDRC
Mary	Muthoni	ACTS
Rebecca	Hanlin	ACTS
Rob	Byrne	SPRU, University of Sussex
Ruth	Oriama	ATPS
Sandra	Pointel	SPRU, University of Sussex
Winnie	Khaemba	ACTS

Besides Professor John Mugabe (Kenya and South Africa), Professor Mamadou Sy (Senegal) and Professor Joanna Chataway (UK), the remainder of the Advisory Board members were drawn from the list of participants given above

Annex 8: Executive Summary of Political Economy Study (Phase 1)

Executive Summary

This study supports the Canadian International Development Research Centre (IDRC), the UK Department for International Development (DfID) and South Africa's National Research Foundation (NRF) Science Granting Councils Initiative (SGCI). The SGCI aims to strengthen Science Granting Councils (SGCs) in 14 countries in sub-Saharan Africa (SSA).

The SGCI aims to reinforce the ability of SGCs to: manage research; design and monitor research programmes based on the use of robust science, technology and innovation (STI) indicators; support exchange of knowledge with the private sector; and establish partnerships among SGCs, and with other science system actors. In line with these aims, the SPRU and ACTS consortium was commissioned to carry out research with the following specific objectives:

1) Advance existing knowledge on the political and economic context of SGCs in selected countries/regions, including the role and influence of key institutions, agents and structures

2) Through an understanding of this political and economic context, identify key considerations (e.g., opportunities, barriers, strengths) that can inform SGCI objectives

3) Provide baseline information to inform the overall evaluation of the SGCI, including recommendations for ongoing monitoring or *ex post* assessment (via a second series of case studies) to gauge the impact of SGCI activities

In order to characterise and understand the political and economic context of SGCs, the research team developed a conceptual approach to political economy that included structures, agents, institutions and ideas. Drawing on mixed methods, the study incorporates:

- A literature review, including a review of regional-level data
- Semi-structured interviews with representatives from regional and sub-regional science and policy funding bodies
- Five national case studies (Ethiopia, Kenya, Rwanda, Senegal and Tanzania) involving analysis of grey literature and key informant interviews

Key study findings

Although there are many emerging issues discussed in the report, we summarise here six key findings and the implications these have for the SGCI.

1. All case study countries are committed to increasing funding for science but overall levels of funding are still low.

National level SGCs are established or emerging in all countries and they are playing an increasingly prominent role in setting research agendas. Funding for SGCs, and the cost and effectiveness implications of different institutional configurations, could be tracked. SGC governance arrangements and spending on administration could also be monitored to enable analysis and comparison.

2. At the national and regional level there is reference to the important role that the private sector could play. However, private sector funding is low and engagement is patchy across countries.

Greater involvement from the private sector will take dedicated effort and there is a need for greater communication between private and public sectors about the value of different types of research.

SGCI may consider whether more resources need to be allocated to private sector engagement activities. The role of other civil society actors could also be explored.

3. There is increasing activity at the regional level and interest in supporting programmes that shift ownership to Africa.

Alongside increasing national funding, there are new regional level research funding and support actors emerging. SGCs can continue to leverage international funds. However, careful thought should be given to which international funders to prioritise in co-funding arrangements, and also what possible effects there may be on the level of national ownership. It is important for major regional funders to discuss between themselves and with national SGCs how best to reduce overlap in funding initiatives or conflicting goals of funding activity between regional and national efforts.

4. There are divergent agendas at national and regional levels.
SGCI could consider promoting discussion on the impact of various regional funders on national level SGCs. Alignment of agendas and a common understanding of "excellence" and criteria for funding cannot be assumed. Sub-regional bodies may play a role here in creating more specific agendas aligned with goals in East, South and West Africa and establishing locally relevant criteria.

5. There is no clear narrative about relative strengths of East, South and West Africa sub-regions.
There is a potential issue for SGCI in monitoring whether regional initiatives have an equalising effect. The issue is compounded by a lack of consensus about existing strengths and weaknesses in sub-regions. National, sub-regional and regional bodies will all have important roles to play in monitoring and evaluating the impact of funding. There may also be ways in which particular strengths emerge in different regions and if monitoring and evaluation capture these changes then this can be a source of learning.

6. Health and agriculture are the sectors which receive most resource in the SSA region but this may change over the coming years.

The traditional sector focus of research in SSA (health and agriculture) is likely to be complemented over the coming years by research in a variety of new areas. It will be important to build capacity amongst researchers and funders to fund science over these wider areas. New international funders may become more significant in relation to funding and influence. Early discussions about their interests and plans may be important. Looking for ways in which to build capacity across sectors in a way that makes research initiatives broadly relevant could be an important avenue to explore.

Recommendations for further research

The study highlights a number of areas where more research would be beneficial and would contribute further knowledge for the SGCI, the SGCs themselves and relevant funding agencies. In this summary we refer only to areas of future research that we consider essential.

Essential areas for further study

Funding numbers: Further work on the baseline indicators recommended in this study would be useful to fully interrogate their relevance, but work is also needed to significantly improve the collection and availability of data on regional funding activity and national level impacts. Indicators need to reflect regional realities and, for example, thinking is needed about how to incorporate indicators relating to

research and innovation in the informal sector. New indicators could be developed to reflect regional concerns with human and social development. This is urgently needed.

Further case studies: This study only considers five countries. If a full baseline is required as the SGCI takes off then further in-depth case studies of a larger number of countries across the continent are urgently required. This may involve additional resource and funds.

Further analysis of SGCs as policy advice agents and mediators of different science policy tensions: In this study, we only concentrate on the main political economy dynamics of the SGC landscape. But it is clear that SGCs play, or could play, many different roles. Understanding these different roles, and the possible diversity of models already in use, and the way in which they might interact with each other, is urgently needed as this has a significant bearing on the work of SGCs across the continent.