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

FULL REPORT

To the International Development Research Centre (IDRC)

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List of Acronyms and Abbreviations

AESA	Alliance for Accelerating Excellence in Science in Africa
AHRI	Africa Health Research Institute
AOSTI	African Observatory of Science Technology and Innovation
AU	African Union
ASTII	Africa Science, Technology and Innovation Indicators initiative
BMGF	Bill and Melinda Gates Foundation
COMESA	Common Market for Eastern and Southern Africa
DfID	United Kingdom Department for International Development
EASTECO	East African Science and Technology Commission
ECOWAS	Economic Community of West African States
EDCTP	European & Developing Countries Clinical Trials Partnership
GERD	Gross Domestic Expenditure on Research and Development
IDRC	International Development Research Centre
IUCEA	Inter-University Council for East Africa
KEMRI	Kenya Medical Research Institute
KENIA	Kenya National Innovation Agency
NEPAD	New Partnership for Africa's Development
NIH	United States National Institutes of Health
NRF	Republic of South Africa National Research Foundation
OECD	Organisation for Economic Co-operation and Development
PASET	Partnership for Skills in Applied Sciences, Engineering and Technology
RCUK	Research Councils United Kingdom
SADC	Southern African Development Community
SGC	Science Granting Council
SGCI	Science Granting Councils Initiative
Sida	Swedish International Development Agency
SSA	Sub-Saharan Africa
STEM	Science, Technology, Engineering and Mathematics
STI	Science, technology and innovation
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USAID	United States Agency for International Development

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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.

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1 Research Problem and Objectives

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), set up to support Science Granting Councils (SGCs) in 14 countries[1] in sub-Saharan Africa (SSA). The research is based on an increasing recognition of the importance of generating evidence to support the SGCI by strengthening the SGCs for science, technology and innovation, taking into account political economy realities in the selected SGCI countries.

The backdrop to SGC strengthening includes the following factors:

- There are low or patchy levels of recognition from policymakers and other stakeholders for the importance of national research, as well as a lack of interest in science and technology (S&T) policy generally
- Local research funders and domestic researchers have difficulty obtaining recognition of work focussed on local issues and funding for research of domestic relevance. Research is often driven by external concerns and criteria for funding
- Decision making is fragmented and formal structures related to S&T funding bodies are relatively poorly developed. There is wide scope for increased partnership between public sector organisations, and between public and private sector organisations
- There are difficulties in marshalling domestic institutional capacity and capability to manage research

In response to the challenges outlined above, the SGCI aims to strengthen 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
- Establish partnerships among SGCs, and with other science system actors

In line with the above project aims, the SPRU and ACTS consortium was commissioned to carry out research with the following specific objectives:

4) 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
5) Through an understanding of this political and economic context, identify key considerations (e.g., opportunities, barriers and strengths) that can inform SGCI objectives
6) 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

[1] For the countries involved, see http://sgciafrica.org/en-za/the-initiative

The literature has used different terms to describe the organisations that we are referring to as Science Granting Councils. They have been referred to variously as funding agencies, research councils and other combinations of the words research, science, funding, agency and council. The common core definitional feature is that they are public or quasi-public organisations that grant state funding for science, including the social sciences and humanities. In this role, they sit in an intermediary space between the state and the research community defining and executing a significant part of the state's science policy (Braun 1998). We use the term Science Granting Council in this report, partly because it is used in SGCI but also to emphasise the central characteristic of making grants for science. SGCs may take on a range of additional functions such as advocacy and communication roles or information gathering, analysis and dissemination. But, by our definition, if they are not actively making grants for research then they would not count as an SGC. It is this science granting function that forms the core focus of this report.

In the next section, we describe the approach and methodology used in the study. Following this, in Section 3, we give a regional review of the political economy of SGCs. In Section 4, we provide an overview of the key themes emerging from the five country case studies. Finally, in Section 5, we discuss the main findings, issues, challenges and implications for the SGCI.

2 Approach and methodology

The broad aim of this study was to begin to build an understanding of how political economy factors are influencing the evolution of science funding in sub-Saharan Africa (SSA). The study spanned different types of research funders and used a mixed methodology rooted in an understanding of political economy that draws on analysis of institutions, interests and ideas. In this section, we discuss briefly our political economy conceptual framework and describe the methodology we have used to conduct the work.

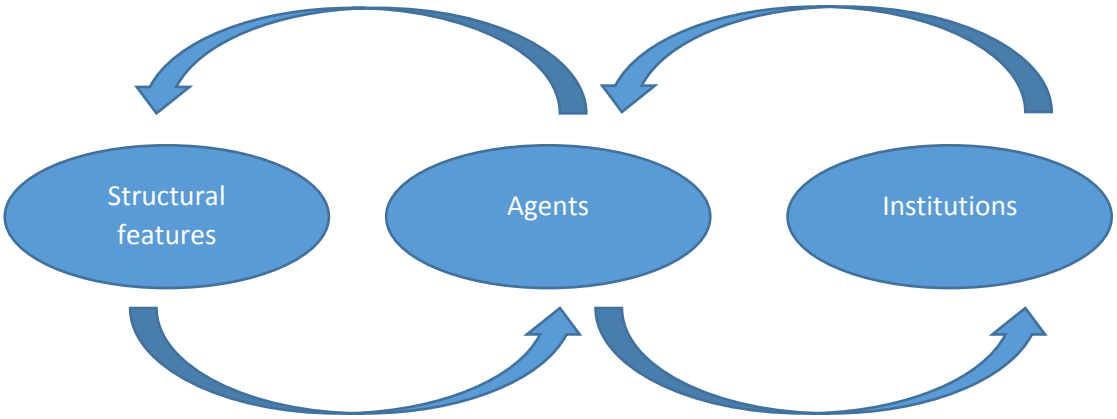
2.1 Conceptual framework

Political economy studies can be conceptualised and conducted in a variety of ways with emphasis on either qualitative or quantitative techniques. Our starting point in this study was with DfID's understanding of what constitutes political economy analysis:

Political economy analysis is concerned with interaction of political and economic processes in a society: the distribution of power and wealth between different groups and individuals, and the processes that create, sustain and transform these relationships over time (DfID 2009).

The diagram and box below outline the approach developed by DfID to understand how interactions between structures, agents and institutions influence the direction of change.

Figure 1 DfID's drivers of change conceptual model



Source: DfID (2004)

Working from this broad definition and understanding of political economy we developed an approach and methodology based on the need to analyse institutions, organisations and individual agents relevant to science granting councils (SGCs) and to develop an awareness of contextual factors and interpretations of the broader landscape.

Box 1

Agents, Structures and Institutions

Agents refers to individuals and organisations pursuing interests, including the political elite: civil servants; political parties; local government; the judiciary; the military; faith groups; trade unions; civil society groups; the media; the private sector; academics; donors

Structural features include the history of state formation, natural and human resources; economic and social structures; demographic change; regional influences and integration; globalisation; trade and investment; and urbanisation. They are deeply embedded and often slow to change

Institutions include the rules governing the behaviour of agents, such as political and public administration processes. They include the informal as well as formal rules. Institutions are more susceptible to change in the medium term than structural features

Source: DfID (2004)

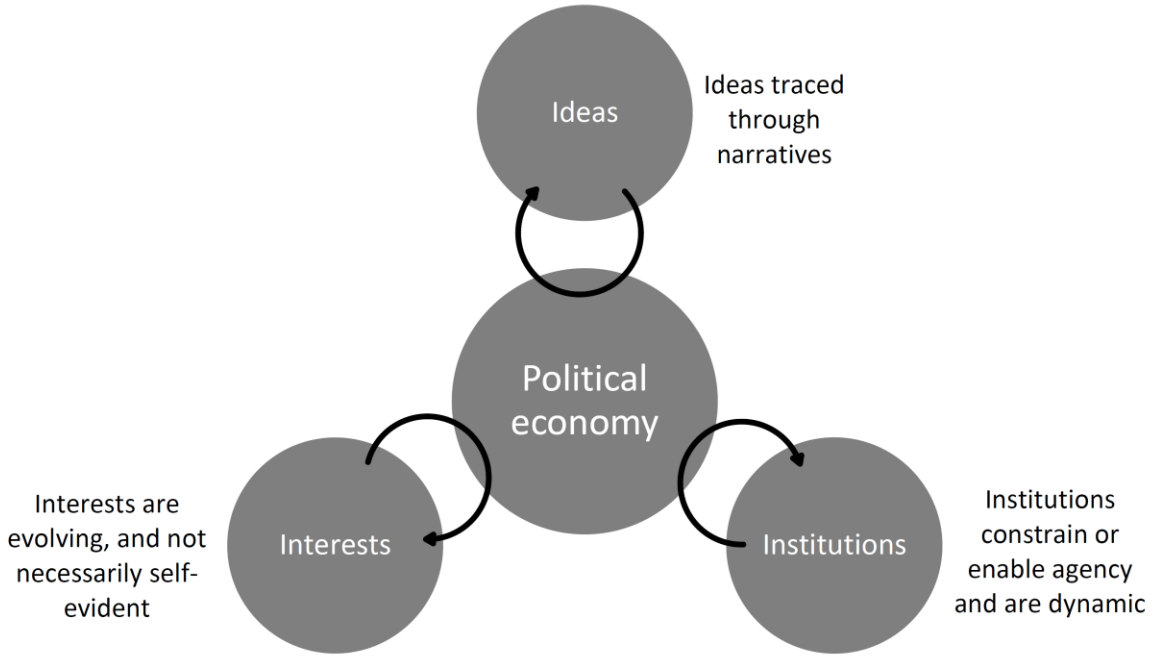
Analysis by Hudson and Leftwich (2014) of the historical development of different phases of political economy, and conceptual work done in the context of a recent study by Byrne and Mbeva (2017), then led us to refine our analytical lens further. Hudson and Leftwich's critique of an approach that looks at political economy as simply an analysis of the "economics of politics" supports the idea of retaining, at the heart of political economy analysis, a focus on political interests as being complex and multifaceted. This approach recognises that actors hold interests but rejects the simplifying idea of agents as rational utility maximisers who respond mechanically to institutional incentives, and instead advocates for a more contextual analysis. Byrne and Mbeva (2017) concur with this:

In classic political economy, actors are assumed to be personal-utility maximisers but this assumption is critiqued on the basis that it assumes actors pursue rationally their known (to themselves) interests. According to this critique, actors do not always know what their interests are, especially in contexts characterised by complexity and uncertainty ... In such contexts, actors construct their interests along with constructing meaning from the various dynamics at play within a discourse …, and the opportunities for, and constraints to, their action. This does not preclude actors having particular knowable (by themselves and others) material interests, but it may not be clear how these will feature in any potentially realised … future and, therefore, whether actors will continue to see these as their interests. The point here is that we need to be attuned to the way interests themselves evolve in tandem with evolutions in narratives, institutions, materiality and context.

Byrne and Mbeva develop an analytical framework based on analysing ideas, institutions and interests.

Figure 2 provides an overview of the approach.

Figure 2 A political economy analytical framework



Source: Byrne and Mbeva (2017)

In reflection of this understanding of how political economy is constituted and recognising the time and budget limitations of the study, we have worked to compile and analyse relevant data on financial support to science organisations in SSA to reveal material interests and realities. We have looked at peer reviewed and grey literature and conducted a limited number of semi-structured interviews to gain insight into agents' (actors') ideas and narratives and their understanding of their own and other's activities and roles in the context of structural factors. Finally, to the extent possible, we researched and analysed institutions to understand how institutions set routines and patterns that enable or constrain agency.

Political economy is an approach to understanding change in organisations and institutions. In this way it can constitute an important component of monitoring and evaluation research. Our overall aim here was to use political economy to inform our understanding of trends in funding and influence and the way in which diverse factors relate more broadly to the evolution of research funding and science granting councils in SSA. The study was conceived of as an innovative baseline against which future trends and developments can be assessed.

2.2 Methodology

The study is comprised of three main components.

- 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
- National case studies involving analysis of grey literature and key informant interviews

2.2.1 The literature and data review

There is very little academic literature on research funding in SSA but we identified existing literature and complemented this with a targeted search for relevant literature focussed on national contexts (see country case studies in Annexes 1-5). A grey literature search of websites, annual reports and policy documents was synthesised into an additional review which can be found in Annex 7. The web search used the Google search engine and was based on the following keywords: "capacity strengthening", "research", "science", "Africa", "science and technology" and "funding".

Using data from OECD, World Bank, UNESCO and other relevant reports containing funding data we put together a spreadsheet with information about funding for science and research from key international donors and funding bodies. This was complemented by analysis of funding trends; a higher-level analysis of the data identified in the various reports. These can be found in Annex 6.

2.2.2 Regional interviews

We conducted 16 semi-structured interviews on regional issues. Interviewees were either chosen for their knowledge as members of staff at SSA and sub-regional science funding and policy bodies, and relevant international and multilateral science funding and policy organisations, or were chosen because of their positions as analysts or experts. We recognise the pitfalls of relying on individual interpretations from small numbers of individuals to represent complex and multifaceted organisations. In the context of this study, however, and within the limited time and resources available, it was necessary to use this approach. Despite their limitations these interviews provide valuable insights and raise questions for further study.

The interviewees were purposively sampled using the following methods:

- Landscape scan to identify prominent organisations and individuals working in science funding
- Consultation with our advisory group[2]
- Suggestions from IDRC
- Snowballing from people interviewed

The protocol for the regional interviews can be found in Annex 9. We tested the protocol on a member of our advisory group and made some revisions before using the revised version as the basis of interviews with other contacts. While the interviews give us rich data, they form a small sample and

[2] Our advisory group was made up of five senior academics with experience of working with science funders and granting councils across Africa.

so are far from representative of all key stakeholders. Therefore, the interview data should be treated with an awareness that they are incomplete.

2.2.3 National case studies

At the national level, we conducted five case studies. Four of these were in East Africa (Ethiopia, Kenya, Rwanda and Tanzania) and one "light-touch" case study was completed in Senegal. Sub-Saharan Africa is a large and diverse region of the world. The sub-regional concentration on East Africa reflects a decision to use limited resources to build up a more in-depth understanding of one context rather than try and spread a small study across the whole SSA region. Senegal was included to give limited insight into a Francophone rather than Anglophone context and, specifically, because it has a long history of experience with science funding and policy.

We interviewed between 8 and 15 people in each country. Interviewees included policy analysts and other relevant experts and senior managers from government ministries, science granting councils, non-governmental and private sector bodies. The interviewees were purposively sampled using the following methods:

- Landscape scan to identify established and/or prominent organisations working in the science funding area in each country
- Validation of the identified organisations with regional experts
- Identification of senior management in each organisation to be asked for an interview
- Snowballing on the basis of suggested additional interviewees with appropriate profiles

2.2.4 Data analysis and report writing

Analysis of relevant data and literature was designed to give contextual detail and complement the interviews. Some regional and national interviews were recorded but the majority were not. Where recording was not possible due to technical issues or was not welcomed by interviewees, detailed notes were taken and interview notes were written up after the interview was complete. All interviewees agreed to speak to us on the basis of confidentiality and anonymity. Notes from each interview were written up and shared amongst the study team but not beyond. Themes from the regional interviews were written up into a separate document; themes from the national interviews were analysed in the context of report writing.

This report itself is partially the product of a three-day "write-shop" held in Brighton on 17-19 June 2017 and attended by seven members of the research team.

2.2.5 Limitations and terminology

The evolution of science and research funding and science, technology and innovation policy more broadly, is fast-moving in SSA. It is full of complexity and uncertainty. As science becomes more central to political agendas and narratives in SSA, different interests and perspectives will realign. Given our limited resources and the short time period over which this research took place, this report should be taken as a partial snapshot of a broad and varied landscape. Recommendations are made with recognition of these limitations.

One of the challenges that we encountered during the study was a confusion in the way that interviewees used the language of "science funding". For most, the term science funding seemed to

include social science and was equivalent to research funding more broadly. However, some interviewees were clearly more focussed on natural science rather than social science even though they might have used both science and research funding in their interviews.

An interesting confusion lay in the varied ways in which people used science funding as including or not including innovation. Some used the terms science and innovation interchangeably and others saw a distinction between the two. Later in this report we suggest that this confusion may be significant as an indicator of the assumptions that are made by some about the value of investing in science and the relationship between science and innovation. It could be that the linguistic muddle reflects a deeper confusion about different agendas and frameworks for thinking about funding of and investment in science, what outcomes should be expected, and what constitute markers of success. Our suggestions about possible significance are made tentatively but could be useful as issues to be considered in future research and policy work. Rather than "correct" this ambiguous use when reporting the responses of interviewees or the content of relevant documents, we retain it so as to help reveal how this ambiguity is playing out in science funding narratives, policy and action.

Another area of linguistic ambiguity is in the use of the terms "basic" and "applied" science. Many interviewees made statements in favour of the latter but it is not clear that all interviewees were referring to the same characteristics in science and research when they used these terms. Problems associated with potential confusion arising from the use of these terms and the pitfalls in assuming "applied" approaches are more productive are of course not new[3]. In this limited study, we were not able to interrogate the meanings and assumptions behind the use of these terms. This may be something useful to do in the future. It would also be useful to explore the meanings behind the use of the term "impact", which is becoming more prominent in narratives and may overcome some of the more traditional issues associated with "basic" and "applied" classifications.

[3] There are of course also well-known and numerous critiques of assumptions about a linear relationship between basic and applied science. A recent study of research councils in South Africa adds to the literature on the pitfalls of taking for granted that applied science, and applied science institutes, will be more productive in relation to social and economic outcomes from research (Kruss, Haupt et al. 2016). And Calvert (2006) argues that the term "basic research" is deployed politically by researchers seeking to maintain their interests.

3 Regional review

In this section, we provide a review of the material we gathered for the regional-level study. This includes some attention to sub-regional similarities and differences, but it also includes some reference to national-level dynamics. However, deeper national-level insights are provided in the summary of the national case studies, given in Section 4.

For the regional level, in general, there is increasing recognition that science, technology and innovation (STI) are important for achieving economic growth and development in SSA. This can be seen in a widening range of countries adopting STI agendas as well as a growing number of donors providing support for STI initiatives of various kinds. Some countries and sub-regions are strengthening their capabilities to implement STI policies by establishing institutions and targeting funds for STI activities. However, there appear to be different understandings of what STI is and what it means to promote STI for economic growth and development. The specifics of the agendas being adopted vary according to these different understandings and which actors appear to be influencing them. In some cases, policy rhetoric and ambitions are translating into support for individual scientists and research projects, while in other cases there are attempts to strengthen systems, whether seen narrowly as science (research) systems or more broadly as STI systems.

There are differences across SSA, whether by sub-region or country, the reasons for which are many. What emerges overall is a complex and rapidly-evolving array of actors and initiatives, something our study could only begin to map. However, it is clear that international donors of various kinds have been, and continue to be, hugely important actors and funders. There are moves to change the nature of donor involvement but they are in general still nascent.

We begin the discussion of these findings with a summary of the key actors and initiatives our study has revealed are operating across SSA. Many of the key actors are international donors, as we noted, and so their activities and the level of funds they are providing dominate the discussion in this section. Much of this discussion is based on a review of the literature and the limited data that are available on funds flowing for SGC and STI support, but includes information gathered through the interviews. The rest of the section, which forms the bulk of the discussion, examines several emerging themes we identify from the regional-level interviews, bolstered with reference to the literature wherever possible. These emerging themes are explored under two main areas: evolving STI agendas, and the notion of “ownership” of those agendas and their implementation.

3.1 Key international donors and initiatives across sub-Saharan Africa

The number and variety of initiatives by international actors to support scientific research and training in Africa has grown significantly over the last two decades, alongside an increasing number and types of actors (Hydén 2017). As Figure 4 shows, there is now a complicated landscape of actors and initiatives so we are unable to describe them all here. Instead, based on our interviews with key regional actors and a review of grey literature, we sketch the variety of types of initiatives and the key actors involved in them by highlighting some examples. To make some sense of this variety it is helpful to broadly classify the initiatives. This we do following an approach that has been used by the Overseas Development Institute (ODI) and in two reports by the UK Collaborative on Development Sciences (UKCDS) (Jones, Bailey et al. 2007, Enoch 2015, Enoch 2015). These suggest activities can be classified according to three levels. First, training and research initiatives can be aimed at the level of individuals and teams. Second, initiatives can be aimed at developing capacity at the organisational level including research departments, centres, institutes, think tanks and others. Third, they can be aimed at the environmental "rules of the game" level addressing incentive structures, the political and regulatory context, and the building of institutions to manage and distribute research funds.

We discuss in turn examples of the various initiatives that fall into these categories and add a discussion of initiatives that work at more than one level. Then we provide a brief discussion of some sub-regional level differences, before finishing with some observations on how the focus of research strengthening may be changing. The diagram in Figure 4 attempts to capture the complicated landscape of international STI support in SSA. For further detail on the various initiatives depicted in Figure 4, see Annex 6.

3.1.1 Individual level

At the individual level, scholarships for students remain a widespread mode of support amongst donor countries, many of which have longstanding schemes. France and Germany stand out for the size of the programmes they run, supporting African students at different levels to study in the French and German university systems. In total, France is reported to have spent USD 3.4 billion in scholarships over the period 2010-2015. For Germany the figure is USD 1.1 billion over the same period[4]. Scholarships are also widely used by international organisations and private foundations. The MasterCard Foundation scholarship scheme for African students is significant both in its size, projected to disburse a total of USD 700 million over the lifetime of the scheme (MasterCard Foundation 2016), and also because it provides scholarships to a number of leading African universities as well as worldwide[5].

The majority of scholarships fund study in donor nations, as with the French and German schemes detailed above, but schemes like the MasterCard one show that there are some signs of change. Support for individual researchers beyond postgraduate level is also common. For example, the World Bank runs the Robert S. McNamara Fellowship Program, which provides funds for young researchers to spend time in another World Bank country (Hydén 2017).

The other common form of individual level support is funding of research teams to carry out specified programmes of research. The main funders of this type of support are donor-country research

[4] Data were accessed through OECD Query Wizard for International Development Statistics https://stats.oecd.org/qwids/ on 20 May 2017. These figures are current prices USD in Net Disbursements for Scholarships and student costs in donor countries for the period 2010-2015.

[5] The figure is from the MasterCard website accessed on 14 May 2017 http://www.mastercardfdn.org/the-mastercard-foundation-scholars-program/

councils, such as National Institutes of Health (NIH) in the US and the Medical Research Council (MRC) in the UK, and foundations such as the Wellcome Trust and the Bill and Melinda Gates Foundation (BMGF). Funding is either provided directly to African research institutions or in collaboration with a lead institution in the donor country.

There are also new actors emerging at the continental level funding research projects. Notable recent schemes include the African Union (AU) Grants Programme, which has supported multiple calls since 2011 covering mainly environmental and food related research topics[6], and the Alliance for Accelerating Excellence in Science in Africa (AESA, covered in more detail below). Although there are aspirations at the national level in SSA countries to fund individual research projects themselves, apart from a few notable exceptions such as South Africa, there is little evidence to suggest much funding has materialised.

3.1.2 Organisational level

Core funding of key research organisations has been a longstanding strategy of Western donors and foundations. For example, Sida has followed a long-term strategy of providing core and project funding to a small number of selected universities in Ethiopia, Mozambique, Rwanda, Tanzania and Uganda. Other notable examples include the network of research institutes funded by Institut Pasteur in French-speaking Africa; the long-term funding of high-profile and large-scale MRC research centres in Gambia (70 years old) and Uganda (established for three decades); and the Wellcome Trust Major Overseas Programme which funds three centres in Africa: the KEMRI-Wellcome Trust Research Programme (KWTRP), Malawi-Liverpool-Wellcome Trust Clinical Research Programme (MLW) and the Africa Health Research Institute (AHRI) in South Africa[7].

Beyond organisations focussed on "purely" scientific research, since 2008, a six-donor[8] partnership has provided more than USD 200 million in funding for the Think Tank Initiative (TTI), which provides core funding to organisations in Africa, Latin America and South Asia engaged in policy-relevant research (IDRC 2014). In SSA, TTI has been supporting 20 organisations in 10 countries[9] across East and West Africa, providing general support funding, and access to training and technical assistance to help the organizations improve their research quality, performance and policy impact (Young, Hauck et al. 2013). The programme is scheduled to end in 2019.

A more recent development is that China has been funding the building of new universities and training colleges oriented to applied sciences: for example, the Ethio-China Polytechnic College in Addis Ababa and the Malawi University of Science and Technology (King 2014).

3.1.3 Environmental level

The question of how to support the improvement of the research environment in which organisations and individuals operate has become the focus of an increasing number of actors. These initiatives often involve efforts to improve the ability of actors to coordinate action and cooperate through the systematic gathering and dissemination of information. For example, Sida has been providing some of

[6] See the African Union Research Grant website https://au.int/aurg (accessed 13 March 2017).
[7] See the Wellcome Trust website https://wellcome.ac.uk/what-we-do/our-work/funding-and-supporting-research-africa-and-asia (accessed 30 May 2017).
[8] The donors are IDRC, DfID, William and Flora Hewlett Foundation, BMGF, Netherlands Directorate-General for International Cooperation (DGIS) and the Norwegian Agency for Development Cooperation (Norad): see http://www.thinktankinitiative.org/program/donors (accessed 14 August 2017).
[9] The countries are: Ethiopia, Kenya, Rwanda, Tanzania and Uganda in East Africa; and Benin, Burkina Faso, Ghana, Nigeria and Senegal in West Africa.

the funding for NEPAD's initiative to develop and use science indicators: the Africa Science, Technology and Innovation Indicators (ASTII) initiative. Another strategy has been to implement initiatives that raise, measure and maintain standards of training, scientific practice or grant management. Examples include the African Academy of Sciences (AAS) implementing a programme of harmonisation, standardisation and web-based platform building for research grant management, called Good Financial Grant Practice. The European Commission is also funding harmonisation and quality assurance schemes, such as the African Higher Education Harmonisation and Tuning, and the AU Higher Education Harmonization and Quality Assurance initiatives.

A further strategy that appears to be having a level of resurgence is funding for the development of SGCs at both the national and regional level. The most notable recent development has been the creation of AESA by the AAS and funded by DfID, the Wellcome Trust and BMGF. AESA is a funding platform based in Nairobi to administer grants competitively across the continent. Since launching in 2015, AESA has established itself as a key player by developing a number of major programmes such as the Developing Excellence in Research Training and Science in Africa (DELTaS) programme with an initial budget of USD 100 million for the period 2015-2020[10]. At the national level, there also appears to be some renewed interest in working with and funding SGCs. For example, DfID, the Wellcome Trust and IDRC co-funded a GBP 10 million programme to support the National Research Council of Malawi to develop its capacity to manage grant-making processes for health research[11]. Another notable example is the programme that has funded the study reported here: the Science Granting Councils Initiative (SGCI)[12] funded by IDRC, DfID and the South African National Research Foundation (NRF). SGCI aims to strengthen the ability of science granting councils (SGCs) to manage research, monitor programmes and conduct knowledge exchange and partnership activities.

3.1.4 Initiatives that combine levels of support

Although the classification of individual, organisational and environmental level support is useful for providing a characterisation of the types of initiatives donors are funding, there are many programmes that encompass elements that cross these levels. For example, many initiatives encompass organisational level support but also include a significant individual training goal or requirement. The widely-adopted Centres of Excellence (COEs) model, for instance, is aimed at organisational level support but often has a major focus on the training of individual researchers. And the funding of partnerships between universities in donor countries and African universities is another popular mode of intervention that will often include individual training as well as organisational support.

On COEs, the World Bank, for example, began implementation of the African Higher Education Centers of Excellence (ACE I) project in 2014 in West and Central Africa. Running until the end of 2019, ACE I will disburse a total of USD 164 million intended to strengthen or establish 19 centres of excellence in disciplines related to science, technology, engineering and mathematics (STEM), and agriculture and health (World Bank 2014, World Bank 2017). ACE I is being implemented together with the Association of African Universities (AAU) and, amongst others, has end-of-project targets of 15,600 students enrolled (short courses, master's and PhDs), as well as targets for faculty training, partnership agreements between ACEs, new or revised curricula, and so on (see pages 24-31 of World Bank 2014 for details).

[10] See African Academy of Sciences website http://aasciences.ac.ke/aas/en/academy/academy-pages/deltas-africa-grantees/ (accessed on 13 March 2017)

[11] See http://www.lstmed.ac.uk/consultancy/past-consultancy-projects/health-research-capacity-strengthening-initiative

[12] See http://www.sgciafrica.org/index.php/about-us

During 2016, the World Bank began implementing ACE II, which is focussed on Eastern and Southern Africa, working along similar lines to ACE I but providing USD 148 million to support 24 centres of excellence in fields related to industry, agriculture, health, education and statistics (World Bank 2016). ACE II will run until 2021 and is being administered through the East African Community's Inter-University Council for East Africa (IUCEA)[13]. The project is expected to train over 3,500 postgraduates, more than 700 of whom are anticipated to be PhDs (see pages 29-32 World Bank 2016 for details of the specific indicators).

Another initiative using a COE model is the African Institute for Mathematical Sciences (AIMS), which began in South Africa in 2003 but has expanded to currently six countries[14] across SSA, with ambitions to establish a total of 15 AIMS COEs by 2023 (AIMS 2015, Technopolis 2015). Whilst it is primarily focussed on training African students to master's level (reporting[15] that 960 have so far graduated), AIMS has components for research, organisational development, public engagement and industry links. Since the Canadian government, through IDRC, began contributing funds in 2010 (Technopolis 2015), the number of funders has expanded to eight[16]. It is unclear how much funding AIMS will receive but it is at least[17] USD 80 million.

There have also been recent initiatives that have encompassed and linked all three levels of support in complex programmes. A good example is the large-scale European & Developing Countries Clinical Trials Partnership (EDCTP) scheme scheduled to receive EUR 2 billion from the European Commission for its second phase. This scheme combines a focus on strengthening ethical and regulatory frameworks, funding networks of excellence, supporting research projects and training cohorts of scientists[18].

[13] See the World Bank press release 14th April 2014 (accessed on 13 March 2017): http://www.worldbank.org/en/news/press-release/2014/04/15/world-bank-centers-excellence-science-technology-education-africa

[14] The countries are: South Africa (2003), Sénégal (2011), Ghana (2012), Cameroon (2013), Tanzania (2014) and Rwanda (2016). See https://www.nexteinstein.org/locations/aims-centres/?lang=en (accessed 13 August 2017).

[15] The figure is given on the AIMS website: see https://www.nexteinstein.org/impact/?lang=en (accessed 13 August 2017).

[16] The funding partners are listed as IDRC, MasterCard Foundation, DfID, German Federal Ministry of Education and Research, Alexander von Humboldt Foundation, DAAD, Google and Robert Bosch Stiftung: see https://www.nexteinstein.org/our-partners/?lang=en (accessed 13 August 2017).

[17] This is calculated from figures reported in Technopolis (2015).

[18] See the European Commission website (accessed on 7 May 2017) http://ec.europa.eu/research/iscp/index.cfm?pg=africa

Figure 3 Donor-funded health research centres in SSA (2012-2015)

Source: https://worldreport.nih.gov/ (accessed 18 May 2017)

3.1.5 Sub-regional differences

There are significant sub-regional differences in SSA in terms of the level of activity of donors in funding science and capacity building. The World RePORT[19] data enable analysis of these differences with regard to health funding over the period 2012-2015. Although limited to health funding and to research projects, and so excluding some of the initiatives that are focussed on organisational and environmental level factors, the data still clearly point to significant differences.

Figure 3 shows the number of research centres per country that have received funding during the period 2012-15 from the main funders[20] of health research in Africa. The map clearly shows the dominance of South Africa, East Africa and to a lesser extent West Africa, in particular Nigeria, Ghana, Cameroon, Cote d'Ivoire and Burkina Faso. What is most striking is the limited number of research centres that have received funding in the central African countries of the Democratic Republic of Congo, Central African Republic and Chad. In total, there have been 22 research centres receiving funding in these countries across these periods compared to 129 for Kenya and 260 for South Africa alone during the same period. This issue is further explored in the next section which includes a discussion of explanations from our interviewees of regional differences in agenda-setting.

[19] World RePORT data are available at (accessed 18 May 2017) https://worldreport.nih.gov/app/#!/

[20] The funders included are Bill and Melinda Gates Foundation, Canadian Institutes of Health Research, European Commission, EDCTP, Institut national de la sante et de la recherche medicale, Max-Planch-Gesellschaft, Medical Research Council, National Institutes of Health, Institut Pasteur, Sida, Swedish Research Council, Wellcome Trust.

3.1.6 A shifting pattern of STI support?

Based on our literature review, there appears to be a shift from a more singular focus on producing scientists and research to also considering what factors need to be put in place to support research organisations. An interviewee concurred, saying, "*So the difference here is that there is much more about funding institutions and not so much about funding individual scientists (which is not always very sustainable). So, I think there is a shift to say let's take the best research centres and best research universities and put money in them*". Many key Western donors and foundations now also support initiatives that aim to improve the environment of research, with recent flagship schemes such as the EDCTP and AESA explicitly aiming to achieve this as one of their objectives. There is also a much wider range of donors interested in promoting the development of national-level science and technology policies. AOSTI (2013) report that in the 1990s it was just IDRC and Sida who were interested in assisting with development and implementation of STI policies, but today a much wider range of actors is engaging, such as the World Bank, African Development Bank, USAID and a number of private foundations, amongst others. The SGCI, noted in Section 3.1.3, is another example of this shifting pattern of STI support. Working with 15 SGCs across SSA, and through four African Collaborating Technical Agencies, SGCI aims[21] to build capacity in research management, increase the use of indicators, and improve knowledge-exchange with the private sector, as well as to strengthen partnerships between SGCs and other actors in SSA science systems.

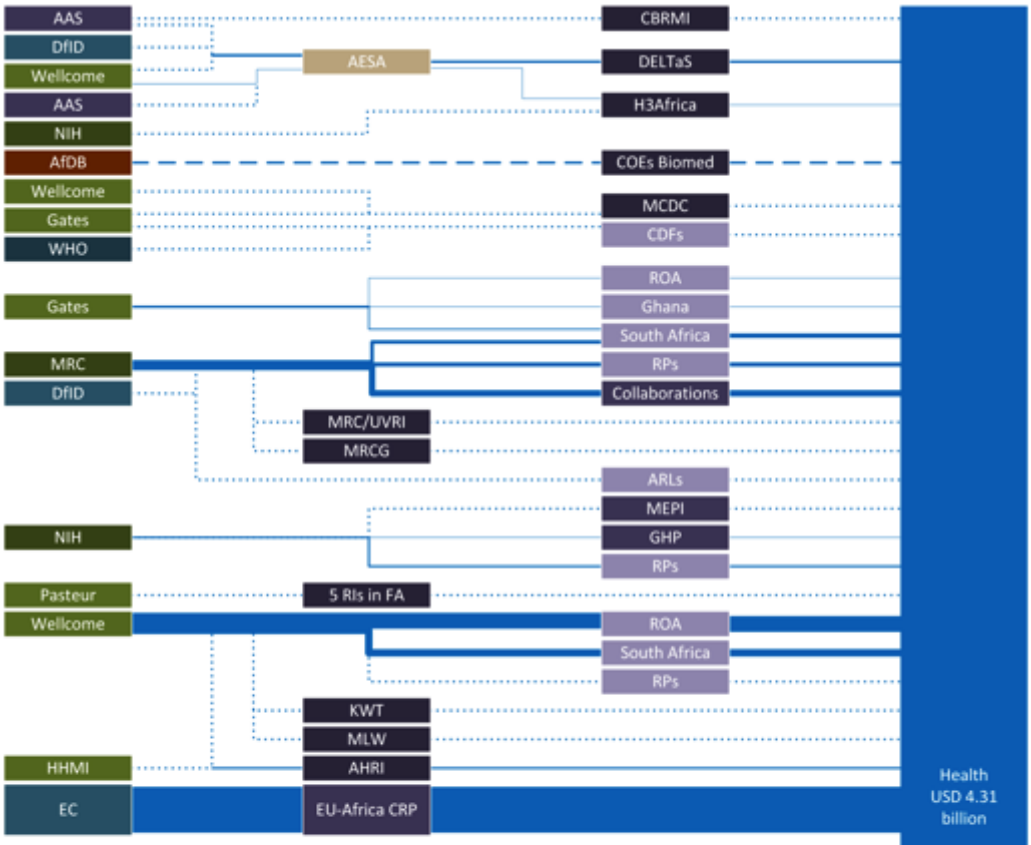
Despite the growing interest in creating an enabling environment for research in SSA, the numbers of actors remain relatively modest. Jones et al. (2007), for example, found few funders focussed on system-level capacity strengthening. Sida, however, was identified as having a long history of such work, and Japan International Cooperation Agency (JICA) was recognised as a new entrant. A more recent study, based on a rapid mapping exercise and conducted by UKCDS, identifies only 10 actors for whom the environmental level was a primary or secondary priority compared to 40 and 35 actors who prioritised organisational and individual levels respectively (Enoch 2015). Compared to institutional and organisational level schemes, the amounts of money flowing into the environmental level also appear relatively small and are often parts of larger programmes rather than standalone initiatives.

There are now many initiatives relevant to the development of the STI systems across SSA and many actors. We have attempted to capture as much of this activity as possible in a diagram to show graphically who is active, with whom they are collaborating, how much money is flowing, and what the targets of those money-flows are. The diagram, given in Figure 4, is necessarily incomplete, as the data and information available are themselves incomplete or inaccessible. The diagram, therefore, should be taken only as a first attempt to capture the landscape of STI activities as they stand at present. But we should make it clear that the funding data represented in the diagram includes historical, current and, to some extent, future flows of grant funding (or, in some cases, loans) rather than a snapshot of funding at one point in time. It would potentially complicate the diagram too much to indicate the periods covered for each of the funding flows, so we refer the reader to Annex 6 where we have given this information.

[21] See http://sgciafrica.org/en-za/the-initiative (accessed 14 August 2017).

Figure 4: STI actors, initiatives and funding flows to and in sub-Saharan Africa

Part A (includes the Legend for both parts A and B)



LEGEND: COLOUR-CODING, LINES AND ABBREVIATIONS

Actors, Programmes, Projects

Association | Donor | Foundation | Bank | Multilateral
Research Council | Institute | Initiative | Programme | Research Project

Funding Flows

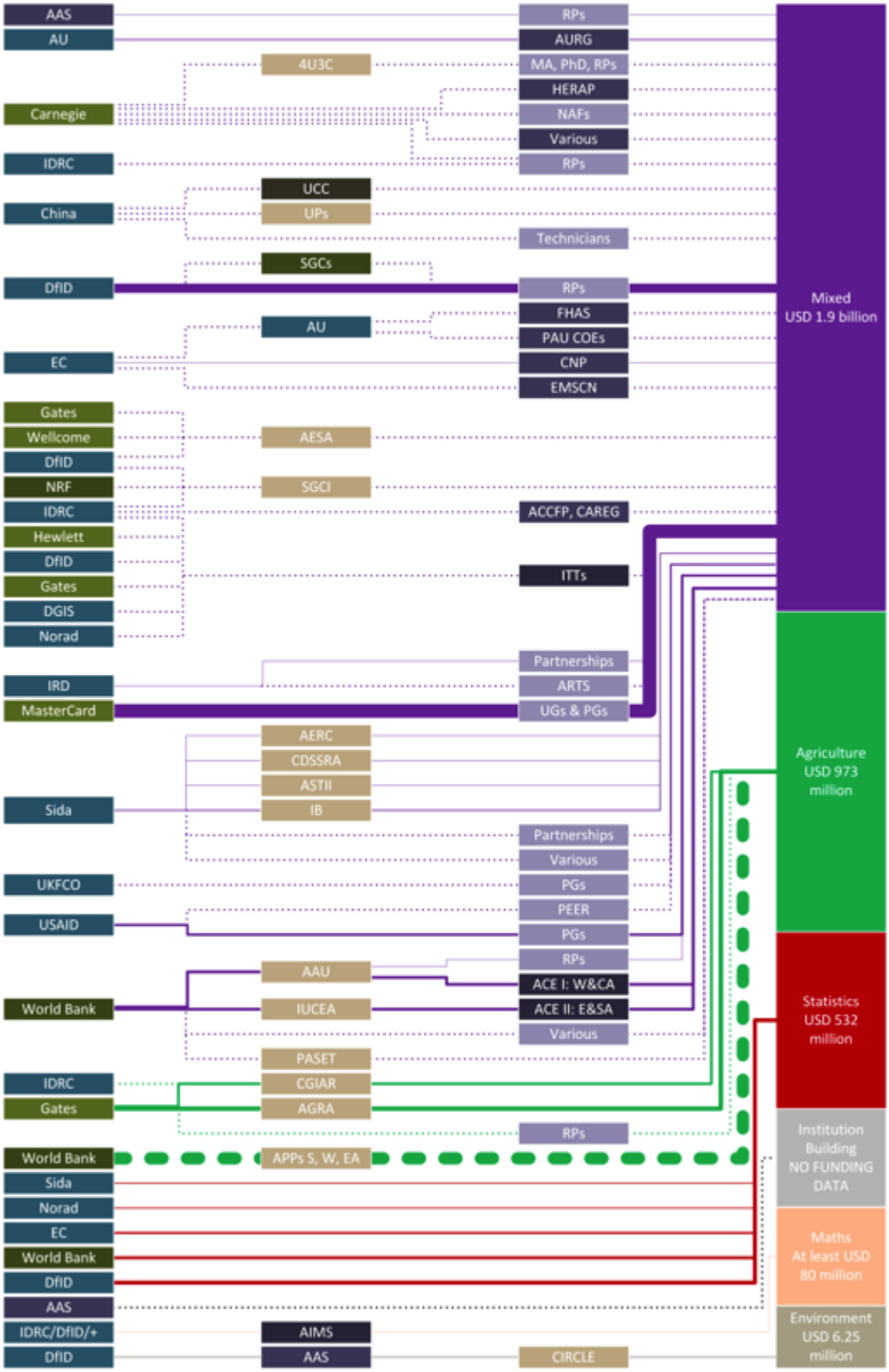
Quantified funding | Quantified lending | Unquantified funding

Note: Line thickness reflects quantity but is not to scale; historical and future funding flows are mixed

Abbreviations and Acronyms

4U3C: 4 universities in 3 countries
AAS: African Academy of Science
ACCFP: African Climate Change Fellowship Program
ACE: African Higher Education Centre of Excellence
AERC: African Economic Research Consortium
AESA: Alliance for Accelerating Excellence in Science in Africa
AfDB: African Development Bank
AGRA: Alliance for a Green Revolution in Africa
AHRI: Africa Health Research Institute (South Africa)
AIMS: African Institute for Mathematical Sciences
APP: Agricultural Productivity Program
ARL: African Research Leaders
ARTS: Allocations de Rercherche pour une Thèse au Sud
ASTII: Africa Science, Technology and Innovation Indicators
AU: African Union
AURG: African Union Research Grants Programme
CAREG: Canada-Africa Research Exchange Grants
Carnegie: Carnegie Corporation of New York
CBRMI: Cell Biology and Regenerative Medicine Initiative
CDF: Career Development Fellowship
CDSSRA: Council for the Development of Social Science Research in Africa
CGIAR: Consultative Group on International Agricultural Research
CIRCLE: Climate Impacts Research Capacity and Leadership Enhancement
CNP: CAAST-Net Plus
COE: Centre of Excellence
CRP: Collaborative Research Programmes
DELTaS: Developing Excellence in Leadership, Training and Science
DfID: UK Department for International Development
DGIS: Dutch Directorate-General for International Cooperation
EC: European Commission
EMSCN: Erasmus +, Marie Sklodowska-Curie and Nyerere
FA: Francophone Africa
FHAS: Funding Harmonisation and Quality-Assurance Schemes
Gates: Bill and Melinda Gates Foundation
GHP: Global Health Program for Fellows and Scholars
H3Africa: Human Heredity and Health in Africa
HERAP: Higher Education and Research in Africa Program
Hewlett: William and Flora Hewlett Foundation
HHMI: Howard Hughes Medical Institute
IB: Institution Building
IDRC: Canadian International Development Research Centre
IRD: French Institute of Research for Development
ITT: Independent Think Tank
IUCEA: Inter-University Council for East Africa
KWT: KEMRI-Wellcome Trust Research Programme
MCDC: Malaria Capacity Development Consortium
MEPI: Medical Education Partnership Initiative
MLW: Malawi-Liverpool-Wellcome Trust Clinical Research Programme
MRC/UVRI: UK Medical Research Council/Uganda Virus Research Institute
MRC: UK Medical Research Council
MRCG: MRC Unit The Gambia
NAF: Network Initiatives and Fellowships for African Academics
NIH: US National Institutes of Health
NRF: South African National Research Foundation
PASET: Partnership for Skills in Applied Sciences, Engineering, and Technology
Pasteur: Institut Pasteur
PAU COE: Pan-African University Centre of Excellence
PEER: Partnership for Enhanced Engagment in Research
RI: Research Institute
ROA: Rest of Africa
RP: Research Project
SGC: Science Granting Council
SGCI: Science Granting Councils Initiative
UCC: Universities and Colleges Construction
UKFCO: UK Foreign and Commonwealth Office
UP: University Partnership
Wellcome: Wellcome Trust
WHO: World Health Organization
W, S, C, EA: West, Southern, Central, Eastern Africa
UG/PG/MA/PhD: Scholarships

Part B



Source: Authors

The "Mixed" category includes some health and agricultural funding because it is not possible to disaggregate the data for the initiatives depicted. For the category "Institution Building" we have no data, we only have a figure of USD 80 million for the AIMS initiative (the "Maths" category) but this is likely an underestimate, and there is only one source of funds so far identified for the category "Environment". It should also be noted that the diagram does not include the significant French and German funding of scholarships, mentioned in section 3.1.1. However, if the information shown in Figure 4 is otherwise a fair reflection of activities, it is clear that the health and agricultural domains are receiving the bulk of funds. It is also interesting that national-level SGCs appear to receive little in the way of international funds or support for STI activities, apart from the notable exception of SGCI.

3.2 Evolving STI agendas in sub-Saharan Africa

Having sketched the key actors and initiatives relevant to science funding and STI activities in SSA, we now explore some of the themes that emerge from the 16 interviews conducted as part of the regional-level study. We also draw from the (mainly grey) literature as a way to bolster or triangulate, where possible, the information provided by our interviewees.

In general, as mentioned above and apparent in the wide range of initiatives being implemented, there is increasing recognition that STI is important for achieving economic growth and development in SSA. Many countries are trying to turn more general STI agendas into action which is relevant to their specific needs – evidenced by a growing number of national and pan-African STI policies, as well as the growing number of donors providing support for STI initiatives. Indeed, one interviewee reported that, "*you increasingly see science, technology and innovation mentioned in economic blueprints*" and another explained that, "*STI is now central to negotiations about investment and is much prominent in discussions about bilateral investment and cooperation*".

In line with attempts to turn agendas into action, some countries and regions are strengthening their capabilities to implement STI policies by establishing institutions and targeting funds for STI activities. However, there appear to be different understandings of what STI is and what it means to promote STI for economic growth and development. The specifics of the agendas being adopted seem to vary in ways that are conditioned by these different understandings and which actors appear to be influencing them. In some cases, as sketched in the preceding section, policy rhetoric and ambitions are translating into support for individual scientists and research projects while in other cases there are attempts to strengthen systems: the science system, more narrowly; or the innovation system, more broadly. But, in many cases, there appears to be a lack of clarity about whether promoting STI for economic growth and development means an emphasis on strengthening the capabilities of individual scientists and improving the quality of their research, strengthening wider systems, or intervening across a spectrum of activities. Often, there are overlapping or confused understandings of what should be done and how to achieve it.

There are differences across SSA, whether by sub-region or country, the reasons for which are many: linguistic, historical, colonial, political, economic and geographical, amongst others. And there are differential capabilities and capacities to set and implement agendas, including those associated with measurement, data-collection and indicators.

We discuss these various developments in terms of the influences on the diffusion of STI agendas, the evolving content of those agendas, Africa's STI needs and differences across the SSA sub-regions. Following these discussions, we end the regional review section with an examination of the issue of ownership and implementation of STI agendas.

3.2.1 The influences on the diffusion of STI agendas

It is clear, as we have noted, that STI is increasingly understood to be important for achieving economic growth and development goals in SSA. This is reflected in policy and institutional developments at various levels. At the continental level, the African Union (AU) has adopted the STI strategy *STISA 2024* (AUC 2014) intended to guide the first ten years of action towards achieving *Agenda 2063* (AUC 2015), further detailed in its first ten-year implementation plan (AUC 2015). Institutionally, the New Partnership for Africa's Development (NEPAD) is now well-established and continues to evolve in order to more effectively implement the AU's policies (NEPAD 2013) alongside other arms of the AU such as its longstanding Scientific Technical Research Commission[22] (AU-STRC).

There is also widespread adoption of STI policies and institutional developments in support of these at the sub-regional level (UNESCO 2016) – some of which we discuss in Section 3.2.4. – and by many SSA nations (AOSTI 2013). All these developments are happening in the context of the adoption by the international community of the Sustainable Development Goals (SDGs) that include specific reference to STI within SDG 17 (UNGA 2015), in contrast to the absence of explicit reference to STI in the Millennium Development Goals, which some argue may have hampered efforts to pursue STI capacity building (HOC-STC 2012). Accompanying these policy developments, as demonstrated above, there has been an increase in the number of donors interested, or active, in supporting STI in Africa compared with the support of just a few during the 1990s (AOSTI 2013). The proliferation of STI policies across SSA is a relatively recent phenomenon but the drivers of interest in STI are longstanding and varied. As evidence of this interest at the national level, ECA et al. (2016) point to the creation of the Ghana Research Council in 1959, the Nigerian National Council for Scientific and Industrial Research in 1966, and the Kenyan National Council for Science and Technology in the late 1970s (1977, according to Finnemore 1993). At the regional level, ECA et al. (2016) cite the Monrovia Declaration in 1979 and the Lagos Programme of Action in 1980, both of which identified science and technology as being essential to achieving development and both of which called for commitments for action from the member states of the Organization of African Unity. However, ECA et al. also note that it is unclear whether the creation of the Ghana Research Council was driven by Ghana or UNESCO, and Finnemore (1993) cites UNESCO records to demonstrate that it largely forced some kind of science policy body on Ethiopia, Kenya, Sudan, Tanzania and Zambia as part of "*one of [its] large…science policy campaigns in East Africa during 1967 and 1968*".

More recently, according to AOSTI (2013), pressure has come from within Africa for governments to take science – and, indeed, STI – more seriously; pressure that now comes from a wider constituency than the *"small circles of eminent African scientists and engineers"* of the 1970s to 1990s to include African civil society organisations and think tanks, and the public more widely. According to our interviewees, the political pressure from the African science community does seem to be an important factor in pushing STI higher up national and regional agendas. For example, one interviewee explained:

> *You see [the science community's political influence] more in the bigger countries on the continent. If you think about how it's configured in Ethiopia … South Africa, Namibia, there is a lot of pressure from the science community on the government to say "you need to support us more; you need to put money into science".*
>
> *In the bigger economies, you are starting to see government reaching out to science more to support their decision-making processes, to figure out what choices to make or not. [Top scientists] are engaged constantly with governments in terms of "how do we influence policy*

[22] See http://austrc.org/history.html (accessed 14 August 2017).

making, are we giving the right evidence to government, how do we package it?". Academies of Science [such as] in South Africa, Uganda and Nigeria have been very vocal about the importance of increasing investment in science … It is not just the think tanks or individual scientists. There is an entire community constantly putting this message across in different platforms and in different ways to governments, and I think that governments are starting to listen.

Reflecting on this interviewee's comments, as we described in various parts of section 3.1, interventions such as the Think Tank Initiative may have played a role in helping the science community to develop and convey their message. Other interventions may also be playing a role. For example, SGCI includes partnership and networking components that could assist the science community more broadly to develop something of a single voice on these issues, and we could include AIMS with its efforts to reach wider publics.

But our interviewees also noted other forces and strategies at play. These included: an increasing number of political leaders with backgrounds in science and engineering; the influence of female leadership in promoting education (citing the President of Mauritius as an example); the strategy of having the president or their deputy chair a "Science and Competition Council" – or something similar, following the example of Malaysia – which then ties STI to industrial development; and the effect of the work of philanthropic foundations in creating pressure on African governments to match such investments.

Furthermore, as discussed earlier, there is now a large number of donor-supported initiatives to promote STI in various ways, much more so than in the 1990s when IDRC and SAREC (now part of Sida) were amongst the few donors promoting STI in Africa (AOSTI 2013). However, this last point brings us back to the nature of the relationships between donors, international organisations and SSA governments that the example of UNESCO in the 1960s, mentioned above, suggests may be problematic. That is, it raises questions about who is setting the agendas for science in SSA. Indeed, as was highlighted by many of our interviewees, the focus of agenda-setting has become something of a higher-profile issue recently and so we will return to it in the sub-section below on ownership.

3.2.2 The evolving content of STI agendas

Leaving aside, for now, the issue of who is, or should be setting, the science agendas in SSA, it is useful to review something of the content of those agendas as they stand at present and the ways in which they may be changing. We can organise this in terms of social domains or topics, motivations for what science is expected to achieve, and inferred quality (using bibliometrics). In terms of social domains, as demonstrated above (especially in Figure 4), the bulk of scientific research, initiatives and support is focussed on health (overwhelmingly) and agriculture. These are unsurprising (Blom, Lan et al. 2016), and they are reflected in two of the six focal areas of *STISA 2024*. According to the latest UNESCO Science Report (UNESCO 2016), biological and medical sciences dominate publishing across SSA (specifically, for West Africa, see Essegbey, Diaby et al. 2016, for Southern Africa, see Kraemer-Mbula and Scerri 2016, and, for East and Central Africa, see Urama, Muchie et al. 2016). However, AOSTI (2014), using a specialisation index[23] to analyse Scopus data, finds that research intensity in Africa as a whole is only in line with these efforts to some extent. It shows that Africa is highly specialised in biology and in agriculture, fisheries and forestry. It also shows that Africa is almost equally as

[23] The specialisation index measures the proportion of papers published by an entity (country, university, etc.) in a field compared with the proportion of that field in world publications. If the entity's published proportion is higher than the global proportion then the index is higher than 1, representing above-average research intensity or effort (AOSTI 2014).

specialised in general arts, humanities and social science. There is lesser specialisation in philosophy and theology, and in general science and technology, followed by a number of fields for which specialisation is only slightly above the world average, including biomedical research.

Looking at the citations of publications in the two focal areas of health and agriculture, AOSTI (2014) finds they are only at the world average in health, and only in public health and health services. All the fields of high specialisation mentioned above are below the world average of visibility according to citations. Civil engineering, which enjoys lower than world average specialisation in Africa, achieves the world average in citations. The only field to score well above the world average in citations is historical studies (specifically anthropology and archaeology), a field that enjoys only world average specialisation on the continent. AOSTI suggests that the citation impact of historical studies derives from the African continent being the birthplace of humanity, inspiring many national and international studies in anthropology and archaeology, and publications in high impact factor journals.

Interestingly, according to AOSTI (2014), those papers that achieve higher citations than the world average all include authors from at least two countries and so it seems that international collaborations are important. A general tendency is for co-authored papers to be more highly cited,[24] and, according to Confraria et al. (2017), the effect is heightened if there are both more international collaborations and the research is in a specialisation. In regard to health and possible reasons for increased international collaborations, one of our interviewees observed that:

> *… the kind of health issues in Africa make it very interesting for external researchers to come in and collect public health data because it is very interesting stuff that they have and unknown, while material science is the same whether you do it in Kumasi or in San Pasadena*

This would imply that international collaborations in health sciences are more likely to include researchers external to Africa. AOSTI (2014) does find that collaboration with researchers external to Africa tends to generate higher citations but, interestingly, finds that the biggest effect is when authorship includes researchers from at least two African countries along with at least one non-African. And Blom et al. (2016) argue that the majority of international collaborations, whether in health or other fields, include researchers external to Africa. Nevertheless, AOSTI (2014) argues that it is difficult to determine with certainty why international collaborations occur and what the citation analysis means. This provides a number of reasons to be cautious about its results as indicated also by Confraria et al. (2017) who provide a similarly cautious discussion.

Notwithstanding the potential citation benefits of international collaborations, AOSTI (2014) comments on what some of the implications could be for African development goals:

> *It may also be worth distinguishing between international collaboration driven by programmes funded by international donors, and international collaboration on programmes funded solely by Africa. Where funding opportunities from local African donors are absent or scarce, African researchers may accept scientific projects driven by international donors. Such projects driven from outside Africa have been of great help in some instances in addressing critical issues facing the continent, but they present the danger of attracting African researchers who are interested in the funds only for the sake of achieving personal agendas (e.g., career advancement), rather than pursuing scientific interests for Africa. Scientific publications derived from such international collaboration grants could be published in high-impact factor journals without necessarily solving Africa's most urgent S&T needs.*

[24] We are grateful to a reviewer for this point.

There are reasons to be careful in accepting this view uncritically, such as the benefits for researchers and their local science system of being involved with the international frontier in a particular field. We do not have specific evidence that international donors are unduly influencing research projects in the ways suggested in the quote above. However, there is a logic in the argument that suggests the need to consider seriously the issues of agenda-setting and ownership. We discuss these more fully in the final part of the regional review, and too, the issue of donor-influence arises in relation to the country case studies. But, for now, we will consider in a little more detail what "Africa's most urgent S&T needs" are – as reflected in policies and in our interviews – and how STI is understood to play a role in meeting those needs.

3.2.3 Africa's STI needs

Given the extent and depth of poverty across the continent, it is unsurprising that the overriding concern of SSA governments is to achieve economic growth. However, in addition to a need to raise GDP, there is a desire to achieve economic *development*. In essence, this means achieving structural change by moving away from a reliance on natural resources and commodities to more value-adding economic activities associated with enhanced capabilities and increased capacity in science, technology and innovation (Essegbey, Diaby et al. 2016, Kraemer-Mbula and Scerri 2016, Urama, Muchie et al. 2016), a longstanding ambition across the developing world (Bell and Pavitt 1993, Fagerberg and Godinho 2005, Cimoli, Dosi et al. 2009, Lundvall, Vang et al. 2009), and a goal of Agenda 2063 (AUC 2015).

What emerges from our research are clues that there are different understandings amongst the African STI community of how STI and economic development are linked. In some cases, there seems to be an assumption that scientific excellence will lead – almost automatically – to economic development, and the achievement of other development goals, in what could be described as a linear science-push model (Chataway et al 2007). An example of this comes from the way individuals connected to one major initiative spoke about science and its connections to economic change and development. One interviewee spoke about the need for strategic frameworks for STI at the national level, regional differences in science capacity and how they were "*very aware of economic development of countries and planning for a very different future that there will be in 20 years' time*". In contrast, another interviewee described how the same initiative only has one model of scientific excellence. In this view, it was clear that any considerations beyond scientific credibility judged through competitive peer review should not be countenanced, with the interviewee saying, "*there are no two models of research excellence. There is one model. We aim to fund the generation of data that is re-doable and can be published anywhere. We are very careful to insist on benchmarking with the best science. Science is Science. Period*".

Whilst the latter quote does not express a science-push model explicitly, it does suggest a focus on the science system rather than the broader STI system. In itself, this is not problematic. Rather, it is the absence in this view of how the science and broader STI systems are connected – and the links with economic development – that implies a science-push model. For example, the same interviewee also said, "*Africa's contribution to global economic output is still low. It has to increase in fundamental and applied areas*". This, perhaps, is a clearer expression of a science-push model in that it implies a direct connection between fundamental and applied research, on the supply side, and economic output on the other. Another interviewee talked of the relationship between research and economic output, commenting that, "*the private sector is important because we need to be able to translate what we do in the lab to be able to work outside in the private [sector]*". Here, too, we could argue

there is a science-push model conditioning the understanding of how science and economic development are linked, without a clear articulation of the nature of that link.

Looking back to the funding flows described in Section 3.1, the rhetoric promoting this "linear model" appears to have been successful in mobilising resources to support scientific research in health and agriculture in particular. Although, the extent to which this research effort includes attention to economic or other development links is not clear. Indeed, in health research, there is some evidence to suggest that local disease burdens are under-researched (Evans, Shim et al. 2014). If we are accurate in detecting the operation of some kind of linear model, then science system actors are potentially failing to apply the insights gained from decades of work in innovation studies. In terms of the impact of scientific research on economic activity, the innovation studies literature long-ago critiqued the linear model (Kline and Rosenberg 1986, Rothwell 1994), and a study of the OECD countries argues that the vast bulk of their economic activity derives not from scientifically-intensive R&D but from incremental innovations that do not make use of new science (Arnold and Bell 2001). Nevertheless, as discussed in the latest UNESCO Science Report, including critical comment, there is a strong focus on R&D funding, scientific publishing and patenting as indicators of the state of STI in Africa (Essegbey, Diaby et al. 2016, Kraemer-Mbula and Scerri 2016, Urama, Muchie et al. 2016).

This is not an argument against promoting scientific research, or seeking scientific excellence, however it is defined (Tijssen and Kraemer-Mbula 2017). Scientific R&D can contribute to innovations that generate significant economic gains and societal change, as Mazzucato (2013) demonstrates in an analysis of the technologies behind the iPhone. Radically-new general purpose technologies can play a key role in sociotechnical transformations that lead to decades-long economy-wide returns of huge significance (Perez 2016). The innovation studies literature shows that such innovations do not simply emerge because of scientific R&D. Rather, they become economically significant through the complex interactions of many different players, some of whom may be charismatic entrepreneurs such as Steve Jobs, within an innovation system that includes government intervention to support, or even guide, the investment decisions of firms or the research foci of scientists.

Many of the challenges of bringing scientific invention to economically-productive innovation may be of little interest to scientists who wish to publish in highly-ranked international journals. This was the case in parts of Latin America where centres of scientific R&D excellence failed to interact with local firms (e.g. see Bell 1997). More successful in economic terms, was the strategy followed by some Asian countries of applying existing technological knowledge through increasingly-enhanced management and engineering competences in firms, supported by the training of thousands of engineers, along with government policies to encourage those firms to focus on a narrow range of strategic industries (Freeman 2002). One lesson that emerges from the Asian experience is that policies across areas of activity need to be complementary[25] if STI is going to contribute to achieving development goals.

The language of innovation systems theory appears in African STI policy documents, in the latest UNESCO Science Report, and several of our interviewees talked in such terms. For example, one interviewee, when speaking of some of the oil-dependent economies in SSA, said, "*the recession could stimulate them to invest in science, engineering, education, innovation*" - echoing to some extent the point made on complementary policies at the end of the last paragraph. So, it appears that there is some discourse around STI in Africa that can be characterised as expressing a systemic view, in contrast to the linear view discussed above. This discourse of a "systemic model" seems to have gained some traction, evidenced by resources flowing to initiatives that strengthen science, technology,

[25] We are grateful to one reviewer for this point.

engineering and mathematics (STEM) on the continent, as well as support for networking initiatives across the region.

However, links between science-intensive centres and the private sector do not seem to have received much more than rhetorical support so far, except in a few countries (e.g. see Kraemer-Mbula and Scerri 2016). And the resources flowing to strengthen STEM are few in comparison with those for more traditional scientific research. Nevertheless, an interesting development in regard to STEM is that, according to one of our interviewees, five SSA governments have each committed – although not yet allocated – USD 2 million of their own funds towards the scholarship and innovation fund in the Partnership for Skills in Applied Sciences, Engineering and Technology[26] (PASET). Moreover, senior figures attending the monthly meetings of PASET do not get sitting fees, we have been told, and yet they seem keen to participate. If so, this suggests a strong interest in promoting STEM. It is possible that politicians and senior figures may be able to see a more direct link between fields such as engineering and economic development compared with the less articulated links between science and the economy. One interviewee's testimony would support this when they described the difficulties many political leaders have in seeing the link between "basic" science[27] and development.

3.2.4 Differences across the SSA sub-regions

Looking across the sub-regions of SSA, there are many similarities but also important differences in the SGC landscape. The most obvious differences relate to structural or institutional arrangements, and to the capacity and capabilities of SGCs. In the main, our interviewees discussed these differences in terms of national-level characteristics but the sub-regional level did feature too. This may become just as important as the national level given the ambitions to strengthen integration within the Regional Economic Communities and across the continent. Historically, as one interviewee expressed it, the STI community in West Africa made faster progress than elsewhere, not least because of the large number of highly-educated researchers in a range of disciplines in Nigeria who were enthusiastic about STI research. According to the same interviewee, East Africa was able to catch up quickly, partly because of the presence of so many international organisations in Nairobi, whilst Southern Africa has been slower (with the exception of South Africa).

In the opinion of several interviewees, East Africa is now set to race ahead: it has created the East African Science and Technology Commission (EASTECO) and is making rapid progress with its regional integration plans. EASTECO[28] has been established to, "*promote & coordinate the development, management and application of Science & Technology to support regional integration & socio-economic development*" in the East African Community (EAC). Although there is evident optimism, there is also concern that EASTECO does not yet possess the capacity to successfully implement STI policy, as it has a staff of just four or five (including administrative support), suggesting it is not well-resourced. Whether this reflects a lack of political support in the EAC is also unclear although, as we have said, several of our interviewees were enthusiastic about the organisation and optimistic for its future.

The challenge for EASTECO is implied in a comment from one interviewee, who said, "*the East African Community jumped in at the deep end by establishing a commission*". In contrast, SADC started with

[26] PASET is described as an African-led partnership facilitated by the World Bank. Many African countries are involved along with some of the emerging economies. See http://www.worldbank.org/en/programs/paset (accessed 14 August 2017).
[27] In line with this perception of political leaders, EDCTP et al. (2014) found that 38% (116 out of 303 respondents) of health researchers they surveyed identified "*lack of policymaker understanding of the importance of research as the most important barrier*" to clinical research in Africa.
[28] See https://easteco.org/welcome-note/ (accessed 14 August 2017).

a department that has worked for many years to put national STI policies in place. EASTECO has to harmonise national STI policies that already exist. Moreover, given its small staff, it is clear that EASTECO will likely encounter enormous challenges in managing a large number of complex stakeholder relations across East Africa whilst also needing to collect and analyse STI data, as well as coordinate STI activities. It is unclear the extent to which its staff will be expanded commensurate with its challenges. Nor is it clear whether it will be institutionally and practically (or politically) "autonomous", or whether it will suffer similar conditions to many national-level SGCs that must exist with low levels of unstable funding and with no institutional mandate to act independently (as evidenced in the national case studies summarised in Section 4).

However, having just noted what may be a strength in SADC's approach, Kraemer-Mbula et al. (2016) comment that there has been "*limited progress … towards STI targets, owing to the lack of human and financial resources at the SADC Secretariat to co-ordinate STI programmes*". And one reviewer noted that it is difficult to coordinate across such a diverse set of member countries, each with such different science systems. Regarding low levels of unstable funding, which appears to be an issue for many national SGCs across the continent, Ghana was mentioned as an interesting example. According to one interviewee, although Ghana does not have an SGC, it does have a relatively "*secure pot of money*" that is to be used for science granting. The interviewee claimed the money is derived from oil revenue and is legislated to be put into science, but then further claimed that Ghana is now grappling with how to actually achieve this: how to spend the money but also what structures need to be in place to make it work. We were unable to substantiate these claims, although the Government of Ghana have announced[29] their intention to set up an STI fund and to raise STI funding to 1 per cent of GDP, in line with the AU's recommendations on research spending.

The other important difference across the continent appears to be the consequence of language, linked with colonial histories. In general, our interviewees spoke of this in Francophone versus Anglophone terms, although they also noted the other languages in use in Africa. The headline assessment we were given is that the Anglophone countries are doing better in STI than the Francophone ones, although Senegal was mentioned as an exception. Part of the difference in performance may be to do with so much science being conducted and communicated in English. Certainly, this would be an exclusionary mechanism, and is recognised in the literature as a challenge (e.g. Evans, Shim et al. 2014).

But other explanations were also offered by our interviewees. One explanation was to do with relative political stability, where, in general, the Francophone countries were seen as less stable, and that this results in poor working conditions for scientists. On this point, Kraemer-Mbula et al. (2016) cite a UNESCO study that suggests good national governance correlates with stronger scientific productivity (see UNESCO 2013). Another reason suggested for the linguistic divide, concerns the ease with which donors can work with a country. Many donors are from English-speaking countries and so it is easier for them to operate in Anglophone Africa. Donors often work with countries that were their former colonies. One interviewee suggested that there is a need for Francophone donors, in particular, to pay much more attention to Francophone Africa, so as to narrow the divide rather than allow it to widen. The interviewee suggested that one way to make progress would be to work with the better-performing Francophone countries and this would help lift the other Francophone countries' scientific development.

[29] See, for example, the website of the Ghanaian Ministry of Environment, Science, Technology and Innovation: http://mesti.gov.gh/government-invest-one-per-cent-gdp-science-innovation/ [accessed 11 August 2017]

3.2.5 Measurement, data and indicators

Finally, before turning to a discussion on ownership, we note the cross-cutting issue of measurement, data and indicators. Several initiatives are in progress around this issue and it seems there has been considerable development in some areas. For example, NEPAD has the African Science Technology and Innovation Indicators (ASTII) initiative and has produced two African Innovation Outlook reports, the first in 2011 and the second in 2014 (see NEPAD 2011, NEPAD 2014). The focus is on supply-side factors such as the policy environment and input indicators, for example, expenditure, number of researchers, and there is little on output or outcome indicators.

Connected with ASTII, the African Observatory for Science, Technology and Innovation (AOSTI) started operation from 2012. Given the extent to which the lack of African data, and the poor quality of those data that are available, is raised in reports and was discussed by several interviewees, ASTII and AOSTI are initiatives with important potential to address measurement, data and indicator needs. And there is a new initiative to develop an African citation index[30] being implemented by the Council for the Development of Social Science Research in Africa.

Partially in support of these particular initiatives, but also for other activities, several donors are providing funding to develop statistical capacity. We were able to identify over half a billion USD spent on statistics support, as shown in Figure 4. Despite these developments, one interviewee noted that many national SGCs, and perhaps this is reflected at the regional level as well, do not have useful data on what research spending is going on in their countries. As that interviewee further argued, as well as others, such data are essential to supporting the functional capabilities of SGCs to better coordinate research and lobby their governments, and to help countries understand their research landscapes so that they can be clearer about priority-setting.

3.3 Ownership

At several points in the discussion so far, and in many of our interviews, issues related to degrees of control over research agendas and funding were raised. As a way of capturing the range of these issues, we refer to them as “ownership” and use this final section of the regional review to explore them. In various ways, many of our interviewees identified ownership as a crucial challenge that lies at the heart of whether SGCs, and the STI system, will mature to the point where they can play a sustainable role in Africa’s development. Foremost amongst the reasons for this belief is the recognition that the power to set and implement agendas depends on control of sufficient and stable flows of funding, and this is something that clearly resonates with the ongoing efforts to improve aid effectiveness most recently articulated in the Accra Agenda for Action (OECD 2008). All OECD donors support the Accra Agenda and so, in principle, we can assume they are in agreement with the views of our interviewees on SGC ownership. Whilst there has been some positive movement in placing ownership in the hands of Africans – most notably with the AESA initiative, in which agenda-setting and funding decisions have been passed from the Wellcome Trust and DfID to the complete control of AESA – it is clear that there is still much to do.

Our study reveals some of the remaining challenges and current efforts to address these challenges, and suggests that the process of realising African ownership of STI agendas and their implementation is going to be a long one that will need substantial and sustained assistance. Part of the reason for this is that ownership is not just about the control of financial resources. As our interviewees observed, there are also many capability and capacity weaknesses across the full spectrum of STI-related

[30] See https://www.codesria.org/spip.php?article2669&lang=en (accessed 14 August 2017).

activities, not just in relation to scientific research and publication. A study on capacity needs for STI policy making in Africa for AOSTI (2013) identifies that, in addition to inadequate funding from African governments (despite commitments), official STI bodies are: generally isolated from their own governmental institutions and from non-governmental actors with STI policy capabilities; lack adequate in-house research and analysis capabilities; lack adequate information to assist them in evidence-based policy making; and are in need of much more support from political leaders. In addition, the scrutiny of STI that is supposed to come from parliamentary committees is weak because of similar capability and capacity constraints to those mentioned, as is the scrutiny expected to come from civil society organisations.

These AOSTI findings are in line with our study but, as we were looking at a wider landscape of activities around SGCs, we would add several other findings. As one interviewee said, "*capacity building is a sort of euphemism for a large number of things*". The same interviewee went on to give a list of the kinds of capacity building necessary, starting with the physical infrastructure of equipment – such as enabling access to global knowledge held in article databases – and the civil works that are needed. Much of the remaining capacity building needs are then around capabilities of various kinds: e.g. funding PhDs; making professors; research management; competitive research bidding; monitoring of research quality and relevance; research priority-setting; intra-government collaboration and coordination; institutional accountability; fiduciary management; and interactions with the global research system.

In support of some of this capability-building, the interviewee suggested that funds were needed for involvement in global research networks, which includes money for travel and for internet connectivity, for visiting faculty, and for joint research. In regard to research management and priority-setting, another interviewee mentioned that SGCs would like to collaborate more in order to learn from each other, and that there is a need for training in areas such as IP issues and bibliometrics. Indeed, another interviewee noted that the Global Research Council (GRC) is an increasingly important actor in this respect. It draws together SGCs from across the world and discusses various issues such as open access, equality and status of women in research, capacity, interconnectivity, interdisciplinary research and how to fund it.

It is clear, then, that there are substantial capacity-building needs but it is also clear that there are some initiatives being implemented to address those needs. In addition to the GRC, other actors mentioned in regard to capacity building included the German Research Foundation, the EU Commission, RCUK, Sida and UNESCO (who get their funding for capacity building from Sida, amongst others). PASET also seems to be taking a more comprehensive approach to capacity building than just supporting research projects, and is focussed on STEM capabilities rather than the usual fields of health and agriculture. There is also of course the SGCI, funded by IDRC, DfID and the South African NRF. This is targeted at several of the research management needs mentioned above, as well as encouraging broader network building (including with the private sector). Finally, as discussed in the section above on actors and initiatives (Section 3.1), there are many other capacity building interventions in operation as part of larger initiatives. To what extent all these initiatives will succeed in helping to build the necessary capabilities and capacity in the SGC systems across SSA, remains to be seen and, as previously highlighted there is uneven treatment of various issues across the continent. But there is also the risk, or perhaps the reality, of duplication of efforts and there is certainly heavy bias towards particular fields of enquiry.

This study also sheds light on the political level at which initiatives to transfer ownership are aimed. Efforts have taken place at the sub-national level of research institutions, at the national-level SGCs or at the regional organisation level although the amount of funding and degree of effort are not

evenly spread across these levels. As described above in the actors and initiatives section, the model of supporting research organisations directly is a longstanding and increasingly popular one while the option of empowering regional-level actors to make funding decisions seems to be on the rise with initiatives such as AESA and the AU Grants Programme. However, apart from some notable examples, such as SGCI, the option of working with national-level actors and giving decision making power to them is rarely pursued and has involved relatively small amounts of money. Discussions of the need to shift ownership to Africa often fail to make the distinction between the different levels, masking the question of why donors focus on empowering certain levels and not others. This is a highly complex question concerning the politics of funding and cannot be addressed comprehensively in this study. However, some initial perspectives from the interviews and grey literature can be provided that suggest there is a wide range of diverging views on this subject.

First, some expressed the view that donors want to maintain control so that they can shape agendas to their own interests and therefore do not want to hand control to African governmental bodies to distribute funding. One interviewee said, "*it seems that most of these international funders bypass the national bodies, the national academies … It is the old politics of funding. They want to make sure the funding serves their interests. So, they want to make sure they have enough information about TB, HIV, etc. so that if these come to Europe then they get the benefit*". Another said, "*so, there is the self-interest but perhaps the continental policy documents help to shape it a little bit*". A more generous view perhaps is that donors are hampered by their own domestic public demands for aid projects that can show clear benefits over a relatively short timescale. In line with this, Vogel (2012) summarises a workshop of research funders explaining the view that "*research capacity strengthening at the environmental level is non-linear, iterative, political, and context-driven*" and "*trial and error is a legitimate part of the process, but taking a learning and adaptive approach is not easily supported by funders' home politics nor if local organisations prioritise their own goals in the process*".

This last comment points to the related perspective that there is a lack of trust amongst international donors that national-level bodies will use the money as intended. This is illustrated by the experience of Nordic countries' engagement with research strengthening in Africa. Hydén (2017) reports that, "*in the 1970s, donors gave priority to building national research councils but these were abandoned some ten years later after an evaluation concluded that the funds had been used primarily to build new bureaucracies that had done little to serve the academic community*". This lack of trust that the money will be used for intended purposes is not necessarily related to a cynicism about government motives. There is a view that money may get diverted purely because of the multiple priorities competing for funds from a limited budget. Hydén (2017) states that, "*such practices are almost inevitable in countries where the revenue base is narrow and tax income falls short of official targets*".

There is clearly then a range of reasons why donors may have been reticent to invest in national SGCs. Changing these perspectives is an enormous challenge and will likely take many years of patient and sustained effort. SGCs themselves may also have good reasons for wanting to avoid receiving funding from donors if it means they can avoid the risk of having their priorities dictated to them. However, as the next section will show, national-level SGCs have struggled to receive adequate funding from national sources and may need to seek partnerships with international funders to help pursue their aims. Ultimately, if African countries are to achieve meaningful ownership of their STI agendas they will have to meet their commitments to providing financial resources for funding the STI systems on a long-term sustainable basis. As one interviewee noted, "*the dependency on donors is a problem for sustainability – once a donor drops out, then if the recipients haven't developed mechanisms for sustainability, they have to scramble for another donor in order to survive*".

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 with implementation plans. Part of the problem may also lie in the different narratives at play – the linear and systemic models of STI. A further part of the problem may lie in insufficient understanding of how the few areas of success, discussed above in relation to international citations at least, have been achieved. The next section delves more deeply into these crucial issues of capacity and funding from a national level perspective.

4 Key themes from national case studies

During this study four "deep dive" case studies were conducted to understand the STI landscape and science funding situation in Ethiopia, Kenya, Rwanda and Tanzania. In addition, a "light-touch" case study was conducted of Senegal in West Africa. This last study was conducted to understand – at a high level – the potential similarities and differences between the East and West African sub-regions. The full case study reports are provided in Annexes 1-5[31]. What follows is a review of the similarities and differences in the findings of the case studies. It starts with an overview of the context in which STI is promoted and science funding takes place in each country. This includes a comparison of science funding in the five case study countries. The final section outlines key issues and themes that were raised across all five case studies including similarities and differences between the countries. It should be noted that the methodology used does not allow fine grained comparisons to be made. Instead, we consider differences and similarities that arise from these cases more generally. We are unable to give causality to these, or the degree to which the similarities and differences, hold across other countries on the continent. Instead, we are providing a snapshot of issues and themes that appear to be useful areas to investigate during the SGCI.

Although this is not a formal baseline study, some of the quantitative and qualitative data collected could potentially be used as a baseline for assessment of progress across the SGCI. Therefore, in the last sub-section, we provide recommendations on potential baseline indicators for use to measure progress of the SGCs.

4.1 The context of the case study countries

Figure 5 provides an illustration of the overarching economic context within which the case study countries of Ethiopia, Kenya, Rwanda, Senegal and Tanzania have been operating. For the most part, all five countries have seen high levels of economic growth and improvements to the indicators measured in the Human Development Index. That said the East African countries have witnessed a decline in growth rates in the last few years following the global recession. Despite this, it is not unusual for these countries, especially Kenya and Rwanda, to be described as "innovation achievers", having "economies that perform at least 10 percent higher than their peers for their level of GDP" for each of the past five years (Cornell University, INSEAD et al. 2016). All the case study countries (with the exception of Ethiopia) rising investment in R&D and growing the numbers of scientists and researchers are observed.

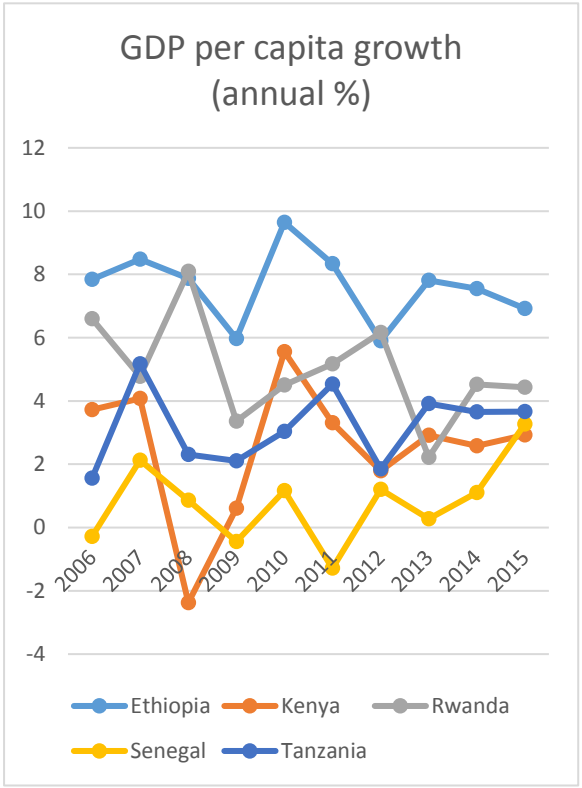
4.2 Research systems compared

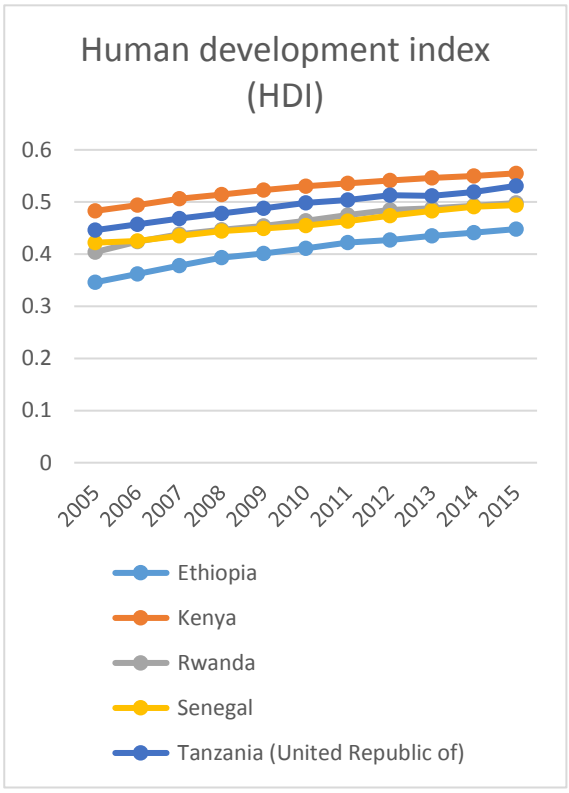
The five case study countries have all reoriented efforts in STI and science funding at a policy level in the last ten years. Ethiopia, Kenya, Rwanda and Tanzania have all introduced new legislation that creates dedicated SGCs (see Figure 7). As noted in Mouton et al. (2014), there are many different styles of relationship that are used to structure research and, specifically, research funding systems across Africa. Mouton et al. (2014) use the Principal-Agent model to discuss these differences and describe the structuring relations of each country using this model while recognising that many of these structures are in the process of being revised. In the three years since their analysis, Ethiopia, Senegal and Tanzania remain examples of embodied principal-agent relations: i.e. where the SGC is embodied within the principal organ of government responsible such as a Ministry of Science and Technology or Education. On the other hand, the SGCs in Kenya and Rwanda (although it technically

[31] Due to the contextual differences of each country, the case study reports do not all follow precisely the same format.

sits under the Office of the President) are now principals in their own right, having become essentially autonomous from the ministries under which they once sat.

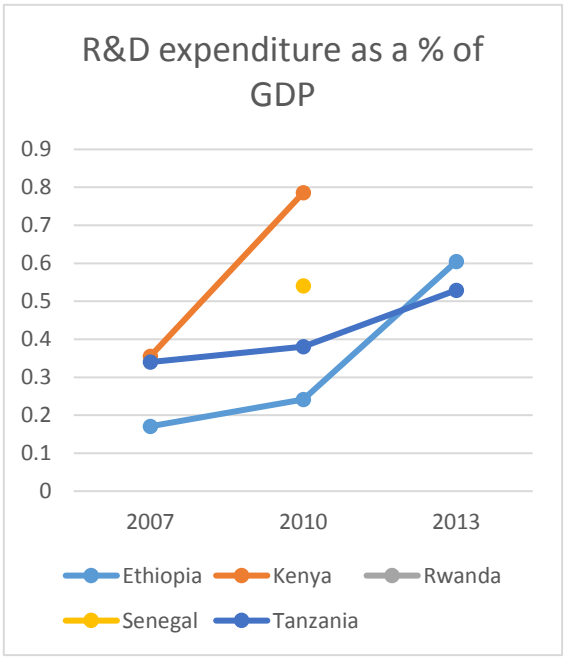
Figure 5 Comparison by case study country of GDP and HDI data (2005-2015)

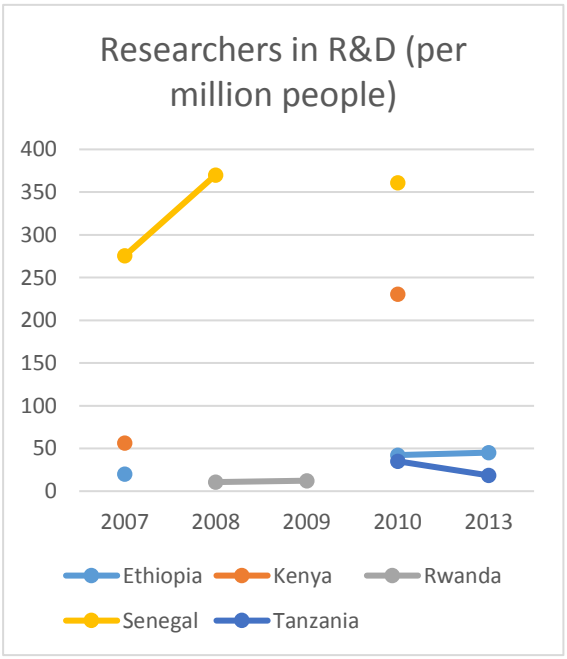




Source: http://data.worldbank.org and http://hdr.undp.org/en/data# (accessed 18 May 2017)

Figure 6 R&D expenditure and researcher numbers for case study countries





Source: http://data.worldbank.org (accessed 18 May 2017)

As noted also by Mouton et al. (2014), the functions of the SGCs are multiple and at times expand beyond research and science funding. However, the focus of this report is on Science *Granting* Councils and therefore on the funding function of the SGCs as opposed to other – also very important – functions that an SGC might have, such as policy advice.

Figure 7 Overview of science funding legislative frameworks in case study countries

	Ethiopia	**Kenya**	**Rwanda**	**Senegal**	**Tanzania**
SGC	National Research Granting Council (2015+)	National Research Fund (2015+)	National Council for Science and Technology (2015+)	Finance Directorate of Scientific Research and Technological Development	National Fund for Advancement of Science and Technology (2012)
Principal - Agent relationship	Agent of the Ministry of Science and Technology	Principal	Principal	Agent of Directorate of Research, Ministry of Higher Education and Research	Agent of Commission for Science & Technology, Ministry of Education, Science, Technology & Training
Has started dispensing funds?	Yes	Yes	No	Yes	Yes
STI bill or equivalent?	Yes	Yes	No	Yes	Yes
STI policy	Yes	Yes but not ratified by parliament yet	Yes but not ratified by parliament yet	n/a	Yes

Source: Authors

4.3 Funding overview

Details of the science funding available in each of the countries are outlined in Figure 6. The case study countries reviewed (excluding Rwanda) have set targets for funding of science or R&D that either match or exceed the AU recommended 1 per cent of GDP. No official figures are available for Rwanda and so those reported in

Figure **8** have been taken from key informant interviews. The Rwanda case study report (Annex 3) notes that key informants stated that Gross Expenditure on Experimental Research and Development (GERD), excluding private sector R&D investment, is currently about 0.17 per cent. This is lower than the 0.5 per cent of GDP target set by the Rwandan National Science, Technology and Innovation Policy. In fact, all of the case study countries have yet to meet their mandated targets. A comparison of their current spend against their mandated targets is outlined in

Figure **8** below. Please note that these figures include all funding (other than private funds in the case of Rwanda) and not just government funding allocations for R&D.

Figure 8 Comparison of case study countries' spend on R&D and mandated targets

	Current spend on R&D (% of GDP)	Target spend on R&D (% of GDP)
Ethiopia	0.60	1.5
Kenya	0.79	2.0
Rwanda	0.17	0.5
Senegal	0.54	1.0
Tanzania	0.53	1.0

Source: http://data.worldbank.org, http://www.costech.or.tz/?page_id=1616 (accessed 18 May 2017) and key informant interviews

Figures in the UNESCO Science Report (see Figure 9) show four case study countries (Ethiopia, Kenya, Senegal and Tanzania)[32] have funding from government allocated to research and development. Government funding is the major source of funding for Ethiopia (approximately 80%) and for Tanzania (58%) while others such as Kenya only receive around 25 per cent from government. International donors and foreign universities provide over 40 per cent of R&D funding in the case of Kenya, Senegal and Tanzania. No country had large amounts of funding from the private sector to conduct research but there are some interesting examples of other funding sources being pursued[33]. For example, Tanzania has a telecoms fund, which means a percentage of money made by the mobile phone operators in Tanzania is given directly to the National Fund for the Advancement of Science and Technology. In addition, farmers pay for research in the areas of coffee, tea and tobacco through a ring-fenced or dedicated funding scheme. In Rwanda, the government set up the Agaciro Development Fund which is a voluntary donation scheme for citizens and the diaspora who wish to contribute to support those in need during times of crisis. While this is not aimed at research specifically, it is an example of an alternative and innovative funding mechanism that could be tried in increasing ring-fenced or dedicated funding for STI.

Government funding for research and STI is not ring-fenced in any of the countries studied. In fact, in all four East African countries, respondents highlighted the problems of not having dedicated and ring-fenced stable funding, and the difficulty of planning research activities as a result.

Figure 9 also provides details, garnered from the UNESCO Science Report, of which research areas received funding in four of the case study countries[34]. The majority of the funding went to research in the higher education sector in Ethiopia and Tanzania (based on latest data available); in Kenya and Senegal, the majority of funding went to government organisations.

Accurate figures on the field of science that benefited from the funding are scarce. Only Kenya and Ethiopia provided these data to UNESCO[35]. Therefore, we are unable to triangulate the information given during key informant interviews in the case studies. In both Ethiopia and Kenya the majority of

[32] No data are available for Rwanda

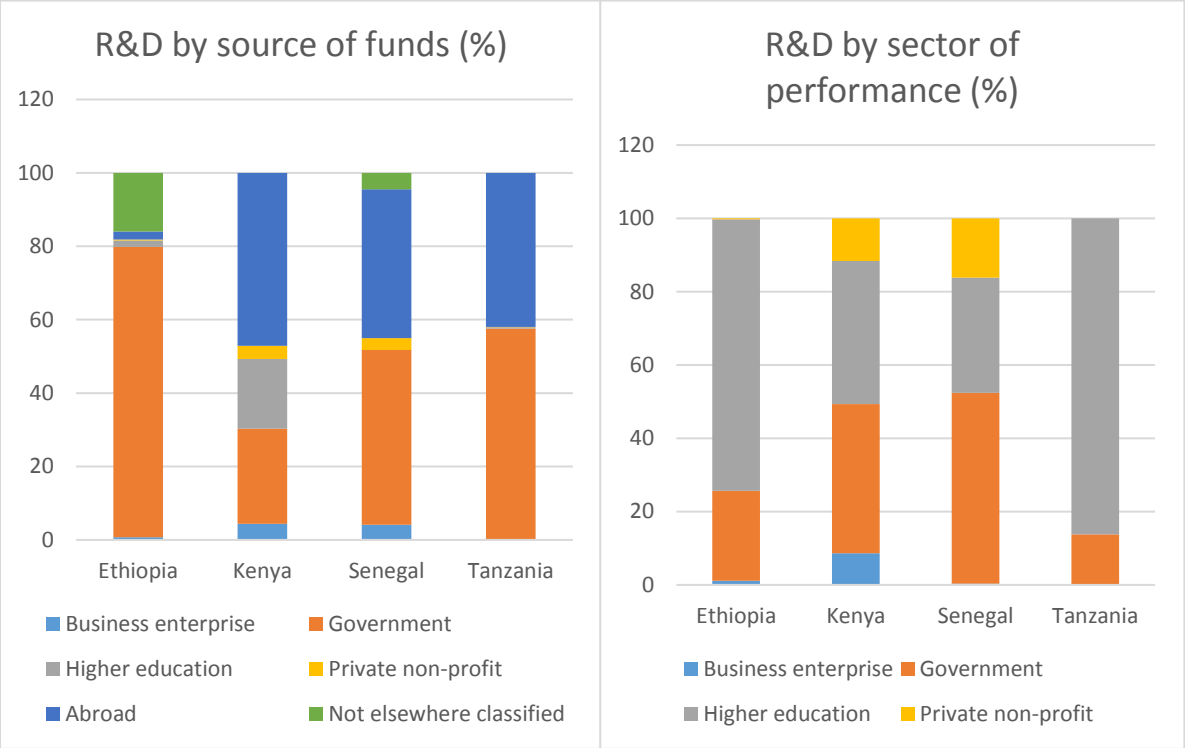
[33] These are data from the 2015 UNESCO Science Report. The research team did however receive anecdotal evidence that the private sector is a large investor in some sectoral areas: for example, research in the biotechnology field in Kenya. Such evidence highlights the need for more robust data capture and the difficulty of high level indicators to capture the nuances of the reality on the ground in many African countries.

[34] No data were available for Rwanda at the time of the UNESCO report.

[35] UNESCO collects these data. See http://data.uis.unesco.org (accessed 18 May 2017)

funds (around 45%) went to agricultural sciences, followed by medical and health sciences (15% in Ethiopia and 27% in Kenya).

Figure 9 R&D by source of funds and sector of performance in four countries



The figures on publications, however, dispute the potential for agricultural research to dominate over medical and biological sciences.

Figure **10** provides a review of publications between 2008 and 2014 by researchers in each of the five case study country's agricultural sciences, medical sciences and biological sciences, for the three largest areas of publication (i.e. sectors with smaller numbers of publications are not shown).

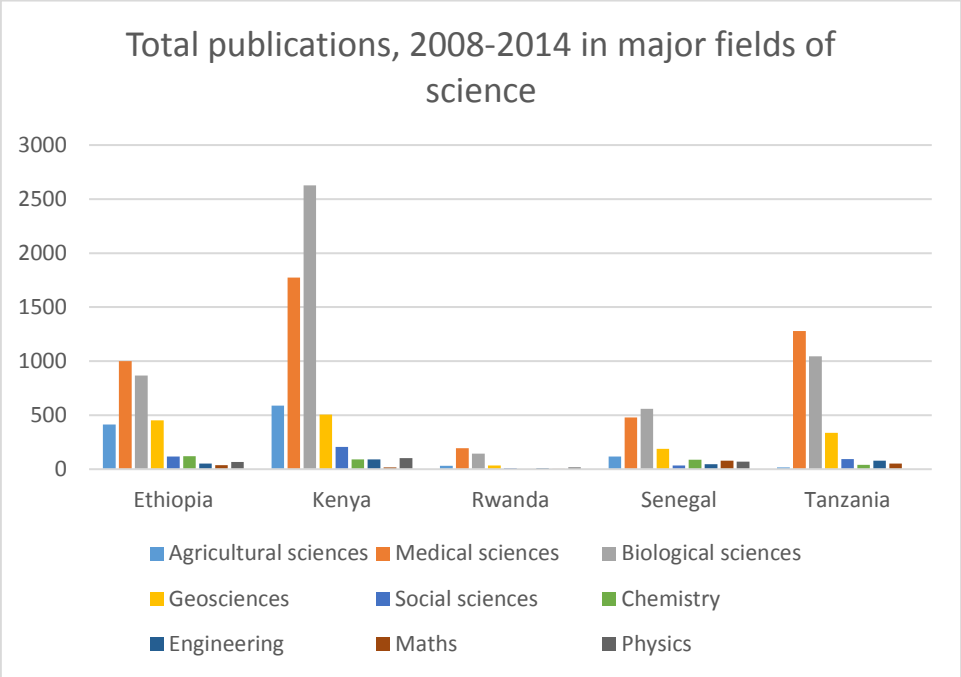
4.4 Issues and themes raised by the country case studies

A number of themes and issues recur across the case study reports in Annexes 1-5. These are each discussed in turn.

4.4.1 Governments, political cycles and development strategies

The term "political will" or similar phrases was used in many of the key informant interviews across all the case study countries. Key informants in Rwanda stressed the "*strong place of STI in politics*" because it sat within the Office of the President, signifying the political commitment placed on STI in the country. Key informants in Tanzania stated that COSTECH, on the other hand, was hampered because it was not in the Prime Minister's Office - it is housed within the Ministry of Science and Technology. Issues regarding the position of the organisation responsible for science granting and promotion of STI were also raised in the Kenyan and Senegalese cases.

Figure 10 Publication totals for three key science areas in each case study country



Source: UNESCO (2016)[36]

Related to this, several key informant interviews across the case study countries highlighted the importance of – and challenges from – political cycles. For example, in Tanzania there was a strong sense that STI policy was influenced by the government's development strategy. This resulted in an initial focus on STI and science funding related to agriculture due to the government promoting a development strategy putting agriculture first (known as "Kilimo Kwanza"). More recently, attention has shifted towards technology and manufacturing being supported because the latest development strategy aims to create an "Industrialised Tanzania". Similarly, there is evidence in the case studies conducted, of national development strategies, as well as international development strategies (the MDGs and now SDGs) being used as "focussing devices" with positive impacts in Kenya and Rwanda. For example, Kenya's development strategy, Vision 2030, makes STI a pillar for economic and social development success and sets out various STI related flagship projects, providing a highly visible focus on STI matters at government level.

The final cross-cutting governance issue raised by the case studies relates to coordination across ministries. There is clear consensus through all five case studies that there is often a lack of coordination across ministries. Key informants across the case studies talked about duplication of work, somewhat ill-defined parallel funding streams and important issues falling through gaps. This raised issues of mandate limits or the difficulties of managing, promoting and funding STI activities in the country when other actors also have the mandate to manage, promote and fund research: e.g. when research centres are housed in other ministries. In the four East African countries, this was

[36] Data are taken from multiple tables in the report. Original data are available in UNESCO Science Report from Thomson Reuters' Web of Science database by Science Metrix. See (accessed 12 August 2017): http://science-metrix.com/en/publications/reports/unesco-science-report-towards-2030

perceived as a problem impacting the ability to ensure the most efficient use of resources which often led to parallel research tracks.

4.4.2 Other actors' influences: donors and foreign universities

Interviewees in all the case studies noted the quantity of funding that donors and foreign universities provide relative to governments although – as shown above in Figure 9 – they are not the major funders of R&D in all case study countries. Reviewing the evidence collected, there was overwhelming consensus across the four East African case studies that donors and foreign universities influence research agendas and, at times, this means that research activities are not always aligned with where research is needed in terms of a government's development priorities. For example, as noted by one interviewee in Tanzania, certain international funders often produced parallel funding streams while in other cases "*government involvement is sought for [by donors] projects where it is not involved in initially and where the research is not aligned to their work*". Similar sentiment was noted by a fellow at an Academy of Science (not in Tanzania) who reported that foreign partners often come with their own research agendas.

4.4.3 Other actors' influences: The private sector

Both in terms of funding (see Figure 9 above) and in terms of who we were able to interview, and what was discussed by those we did interview, there is an absence of the private sector engaging in science funding in the case study countries. In the case studies of Ethiopia and Rwanda, the private sector does not feature at all. In Senegal, Tanzania and Kenya they do feature but not as dominant actors in the science funding environment. In these three countries, they are acknowledged as being on various committees and boards related to STI and science funding but there is no evidence of significant private sector funding. That said, we could argue that the fact Tanzania collects revenue from the telecoms sector highlights private sector support of science funding more proactively than Kenya. Kenya has a burgeoning linkage organisation[37] working to connect industry and academia.

Three countries (Kenya, Rwanda and Senegal) have started promoting innovation activities separately to science funding more generally. Kenya set up the National Innovation Fund (KENIA) in 2015, Rwanda set up the Rwanda National Endowment Fund in 2012 and Senegal is including innovation into its newly created National Fund for Research and Innovation. The three funds award innovation grants or prizes. Specifically, they are focussed on the commercialisation aspects of innovation processes and, therefore, these efforts will require more private sector engagement than is currently taking place in these countries.

4.4.4 Impact and priority setting

There was a lot of discussion in the key informant interviews across the case study countries – and in the grey literature reviewed for these case studies – on the importance of focussing science funding on societal impact. This relates to the discussion about how science funding should map onto country development priorities and strategies. A comment (paraphrased) by a respondent in Tanzania sums up this sentiment, "*it's not how much is invested in R&D but what is done with it that is the key*".

Linked to this was a debate that came up across all case study countries as to the relative merits of funding basic or applied research. In Rwanda it was made clear that a conscious decision had been made to move from funding basic research to applied research while in Ethiopia the government had

[37] See Linking Industry with Academia: https://www.liwaprogrammetrust.org/

always focussed on funding applied research. In Tanzania and Kenya, there was a lot more debate on the relative merits of funding applied research at the expense of basic research, while in Senegal, there is a strong rhetoric of a push towards the downstream side of the R&D continuum and a dedicated National Agency for Applied Scientific Research. Currently, there appears to be an overwhelming focus on applied research, which is often sector focussed with agriculture and health getting significant levels of funding. There also appears to be an increasing focus on research that is multi-disciplinary (although sometimes still within the overarching confines of a sector approach). It should be noted, however, that as in many other contexts there was no consensus on what is meant by "applied" or "multi-disciplinary" research.

Finally, one interviewee in Ethiopia highlighted the need for user engagement in defining priority areas. While no other interviewee appears to have focussed on this, there is an underlying theme that comes out of the interviews, and the secondary data review in particular, of a "turn" towards demand led research, or the rise in rhetoric of this nature, especially in terms of funding efforts that meet development goals, and also where there are problems facing a country's population. As an example, an interviewee in Tanzania noted, "*ST&I researchers are not good at researching on problems (e.g. malaria, food insecurity) thus scientists have also failed. So there is need for problem-solving research/demand-driven research*". However, the dominance of a limited number of institutions and individual researchers gaining funding suggests otherwise - that there is still a serious supply push to research funding as a result of a self-reinforcing cycle of funding and re-funding successful and/or prominent researchers as individuals or groups.

4.4.5 Human resources

The last point above hints at a capacity issue with regard to the quantity and quality of researchers in the case study countries. Interviewees in Kenya and Ethiopia highlighted the difficulty of receiving high quality research proposals. Ethiopia has introduced a yearly training course for grantees to try and enhance research capacity. In both countries, interviewees highlighted a link between this and the lack of incentives in universities and the education system for research (rather than teaching), for example, and the need for more appropriate incentive mechanisms.

4.5 Baseline indicators

At the time of report completion, the UNESCO Science Report provides the most up to date indicators on science funding and capacity of STI systems in African countries that could be used to measure progress of the SGCs involved in the SGCI. That said, the national level case studies highlight a number of issues that need to be considered before such data are used and also a series of other indicators that could be considered for collection. These are discussed in turn.

4.5.1 Indicators against which data is already collected

The UNESCO and earlier AOSTI Innovation Outlook reports provide a series of quantitative indicators from which to understand the progress of countries in terms of research funding and the capacity of their STI systems[38]. As can be seen from the above and in the case study reports (Annexes 1-5), countries do not always measure these in the same years (most countries collected data in 2010 but

[38] We note that there is academic debate as to the usefulness of these indicators given their creation predominately for high income contexts. Unfortunately, this has not stopped these indicators from becoming the dominant means for measuring STI related activity and expenditure across the world. It is for this reason that we have also suggested a set of additional indicators to supplement these more rigid indicators.

not necessarily in 2007 or 2013) and for some countries (i.e. Rwanda) they collect and/or make public very few data for these international reports. This has implications on the ability to make detailed comparisons of the data collected. However, if quantitative baseline data are required for each of the case study countries for the SGCI, the following indicators and data points would be recommended as outlined in Figure 11 for the latest year available:

1. **Science funding indicators**
   R&D expenditure as per cent of GDP is a widely regarded and internationally recognised indicator to highlight the degree of attention given to science funding of all kinds. Perhaps even more useful – in the context of understanding the changing environment in which the SGCs work – is the source of this funding (especially the percentages from government and the private sector).

2. **Science priority area indicators**
   The case studies highlighted the importance of science funding being directed at issues of national importance from an economic and social development perspective. Therefore, another key existing quantitative indicator to measure would be R&D expenditure broken down by field of science: e.g. agricultural or health sciences as opposed to humanities or social sciences.

3. **STI system capacity building indicators**
   From the UNESCO database, the key indicators on STI system capacity (to understand better the ability to absorb funds from the SGCs) appear to be those related to researcher numbers (both total and percentage of which are female), together with details of publications in order to understand better the quality of scientific researchers in each country.

4.5.2 Issues raised from the national case studies on indicator choice

As outlined above, many of the countries have their own national priorities which at times differ from regional ones (e.g.

Figure **8** above, which highlights national targets that differ from the AU 1% target for R&D expenditure as a percentage of GDP). This highlights the difficulties of what might be termed 'top-down' or 'prescriptive' target setting as opposed to country led target setting. In this context, and the fact that interviewees in the country case studies frequently discussed how scientific endeavours related to impact, considering only existing indicators that relate to R&D expenditure as a percentage of GDP as an absolute figure, and the degree to which it has increased or decreased over time, might not be the most useful. Instead, adding an indicator that considers degree of movement towards nationally set targets for this measure appears more relevant. In addition, so too does a quantitative indicator that measures progress not necessarily by field of science but by nationally agreed development priorities. These priorities could be related to dominant productive sectors (e.g. agriculture in many of the case study countries), productive sectors that are being pushed by government (e.g. manufacturing in the case of the "Industrialised Tanzania" strategy) or social and sustainable development goals at a sub-sectoral level (e.g. where in health to target funding based on disease burden figures, or targeted challenge funds for key agricultural or fisheries pests such as water hyacinth or army worm in Kenya).

Finally, the case studies highlighted the issue not just of scientific human resource capacity, in terms of numbers of qualified researchers available to conduct R&D and, therefore, the ability to absorb any increase in research funds, but also the degree of capacity within the science funding system – the SGCs and allied organisations – to manage the science funding environment. Therefore, a potentially

useful additional quantitative indicator would be the number of staff within the country's SGC compared with agreed plans. This takes cognisance of the different setup of each SGC and their contextual differences, i.e. relative size of funding portfolios.

Taking these issues into account, in Figure 11, a series of additional quantitative indicators is suggested to augment those currently collected and discussed in the last sub-section. These also address a number of the issues and themes raised in the previous section.

4.5.3 A series of additional indicators

Finally, the analysis of the case studies above highlights a series of thematic areas of interest that run across all the cases. Many of these can be measured by the more quantitative indicators just discussed. However, several require alternative indicators to measure trends in perceptions and changes in understandings over time. Such measures provide important contextual analysis which otherwise is missing from a purely quantitative approach. It also allows for more politically sensitive issues to be addressed in a less confrontational manner, rather than ignoring them, which often happens because of the difficulty of asking certain questions. The areas where such alternative indicators might be useful include:

1. Relative place of STI on the policy agenda: e.g. have STI issues gained a more prominent place on the government agenda?
2. Changes in dominance of different actors: e.g. have domestic actors (as opposed to regional and international actors) become more prominent in the science funding landscape since 2017?
3. Changes in emphasis on applied vs. basic research, on multidisciplinary and user-integrated research.
4. Degree of improvement in human resource capacity of the system to manage increased levels of funding as a funder and as a funding recipient.

These indicators can be collected through survey type approaches to gain a sliding scale of perceptions (as per the baselines outlined in Figure 11). In addition, a series of in-depth semi-structured interviews with key informants would enable the answering of two further qualitative questions: what evidence is there of these changes and why have these changes taken place?

Figure 11 Baseline indicators with baseline data (latest available date)

	Ethiopia	Kenya	Rwanda	Senegal	Tanzania	Comments
Science funding						
R&D expenditure as % of GDP	0.60%	0.79%	0.17%	0.54%	0.53%	UNESCO, 2015: Ethiopia and Tanzania 2013 data; Kenya and Senegal 2010 data Rwanda data self-reported for this study
- Distance to national target	0.9% (target: 1.5%)	1.21% (target: 2%)	0.33% (target: 0.5%)	0.46% (target: 1%)	0.47% (target: 1%)	
- Distance to regional target of 1%	0.4%	0.21%	0.83%	0.46%	0.47%	
- % from government	79.07%	25.96%	No data	47.62%	57.53%	UNESCO, 2015: Ethiopia and Tanzania 2013 data; Kenya and Senegal 2010 data
- % from business enterprise	0.75%	4.35%	No data	4.10%	0.08%	UNESCO, 2015: Ethiopia and Tanzania 2013 data; Kenya and Senegal 2010 data
Role of foreign funders over the past five years	↑	↑	↑	↑	↑	Increasing role observed across the board. Based on general perceived trend during case study analysis. In future suggest asking a specific question of key informants.
Science impact						
Field of science receiving most R&D funds	Agricultural science	Agricultural science	No data	No data	No data	UNESCO Science report 2015
Place of STI on policy agenda over the past five years	---	↑↑↑	↑↑↑	↑↑↑	↑	↑↑↑ - high and increasingly on agenda; ↑ - on agenda and slow increase in attention; --- no change. Based on general perceived trend during case study analysis. In future suggest asking a specific question of key informants.
Importance of applied research over the past five years	↑	↑	↑	↑	↑	Increasing role observed across the board. Based on general perceived trend during case study analysis. In future suggest asking a specific question of key informants.
Importance of multidisciplinary research over the past five years	↑	↑	↑	No data	↑	Increasing role observed across the board. Based on general perceived trend during case study analysis. In future suggest asking a specific question of key informants.
Importance of user-integrated research over the past five years	No data	No data	No data	No data	No data	Not a significant part of this study's protocol so little collected data to use here despite the fact it was raised in conversation by several key informants in multiple countries.

Science system capacity						
Researchers in R&D (per million people)	45.12	230.73	12.29	361.12	18.49	UNESCO, 2015: Ethiopia and Tanzania 2013 data; Kenya and Senegal 2010 data; Rwanda 2009 data.
Number of staff in SGC	5	3	13	No data	No data	Case study interview data where available. In future suggest asking a specific question of key informants.
- Distance to target	No data	70	No data	No data	No data	Case study interview data where available. In future suggest asking a specific question of key informants.
Improvement in science system to absorb funds in terms of researcher quality	No data	No data	No data	No data	No data	Not a significant part of this study's protocol so little collected data to use here despite the fact it was raised in conversation by several key informants in multiple countries.
Improvement in science system to absorb funds in terms of fund manager quality	No data	No data	No data	No data	No data	Not a significant part of this study's protocol so little collected data to use here despite the fact it was raised in conversation by several key informants in multiple countries.

5 Main findings, issues, challenges and implications for the SGCI

The SGCI aims to strengthen the capacities of science granting councils in SSA to support research and evidence-based policies that will contribute to the continent's economic and social development. This study was commissioned to explore the political economy dynamics which emerge in relation to this endeavour. The overall aim of the research is to provide some baseline data and analysis that can be used in future assessments and evaluations. In this final section of the report we summarise key findings from the research. We then discuss tensions and challenges associated with the SGCI aim. Finally, we make some brief recommendations for the follow-up research that will update this study towards the end of this phase of the SGCI.

5.1 Key findings

This section spans key regional and national findings, and implications for the SGCI are suggested briefly in relation to each finding.

1. All case study countries are committed to increasing funding for science but overall levels of funding are still low. Increased funding commitments are both for activity and for institutional support associated with funding. At the national level we observe the following in relation to increased funding commitments:

- All case study countries have begun to establish SGCs but there is a variety of ways in which SGCs are taking root and with different implications for the way SGC activity is likely to be funded, and for the way that SGCs themselves are funded.
- There is a common problem with stability of funding and lack of resource affecting all national SGCs. None of the case study countries has reached target spend. Whilst the appropriateness and use of targets is controversial, they do create the basis for stable funding. This is important in planning for medium and long term development.
- Novel funding mechanisms have begun to emerge such as hypothecated tax on companies in Tanzania, and in Ghana the possible legal stipulation of a percentage of oil revenues to be spent on R&D.

Implications for the SGCI: 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.

- Kenya appears to have the most engagement but the influence is still quite limited, and mostly relates to modest representation on funding panels.
- The absence of the private sector in funding and engagement is particularly important because many interviewees stressed the benefits of applied approaches to funding research. Without more active presence from the private sector it maybe difficult to create more applied perspectives and strategies.

Implications for the SGCI: 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. Greater consideration could be given to the variety of ways in which the private sector could be encouraged to fund and engage with public sector and joint funding initiatives. The majority of firms will not make use of formal R&D activities and may not identify as innovating companies. The type of engagement and activity will also vary across sectors. However, there will be aspects of research that may have relevance and use and although actual private sector spend may remain limited, greater involvement will lay the basis for sustained and growing collaboration. A study already commissioned by SGCI will contribute to greater understanding about the ways in which public and private sectors can work together and the different modalities of engagement that are emerging in SSA. SGCI may also consider whether greater resource needs to be allocated to private sector engagement activities. The role of other civil society actors, such as charities and non-governmental organisations, could also be explored.

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

- International donors are trying to find ways to move ownership of decision making to Africa.
- Currently, most of these efforts are either concentrating on the regional level (e.g. AESA) or building institutions at the sub-national level (e.g. KEMRI, Makerere University, centres of excellence).
- National funding is important if regional funding bodies are to be fully locally owned and for sustainability. Local funding however is not yet assured.
- There appears to be little communication between regional funders.
- International funders vary in their approaches to interacting with regional and national actors and this will influence the way in which regional and national funding and policy relate to each other.

Implications for the SGCI: If national level SGCs are interested in leveraging funding from international funders alongside national funding then there seems to be potential because of the good fit with the pervasive narrative of local ownership amongst donors. However, careful thought should be given to which international funders to prioritise in seeking to leverage these funds, and to possible effects on the level of local ownership.

Second, the ratio of funding from national, international or regional funders is unlikely to change quickly. Therefore, it is important for major regional funders in particular, to be encouraged to discuss between themselves and with national SGCs how best to reduce overlap in funding initiatives and/or conflicting goals of funding activity between regional and national efforts.

4. There are divergent agendas at national and regional levels

- 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.
- Diversity can be very productive but lack of communication makes it more likely that there will be duplication or that programmes will be designed at cross-purposes.

Implications for SGCI: 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 have an important role to play here.

5. There is no clear narrative about relative strengths of East, South and West Africa sub-regions

- There is a general perception that southern Africa is better resourced but interviewees differed in their perception about whether there was a clear difference in capacities and capabilities above and beyond other sub-regions.
- Assessment by interviewees of East and West African strengths and capabilities varied. Differences in historical legacies and difficulties in working across cultural and linguistic divides were noted.

Implications for SGCI: There is a potential issue for SGCI in monitoring whether regional initiatives have an equalising impact. Sub-regional bodies could play an important intermediary role amongst national research funders themselves, and between regional and national funders. This will be important to understand and monitor. There may also be ways in which particular strengths emerge in different regions and 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

- National agendas evolve with greater diversity and reflect local priorities.
- ICT and energy are growing in significance.
- Interviews and documents suggest that future trends will include more investment in climate change and a greater presence of Japanese and Chinese supported activity.

Implications for SGCI: The traditional sector focus is likely to become more diverse over the coming years (moving away from agriculture and health) and it will be important to build capacity to fund science over a wider variety of areas. New international funders may become more significant and early discussions about their interests and plans may be important. Looking for ways in which to build capacity across sectors in a manner that makes research initiatives broadly relevant could be an important avenue to explore.

5.2 Discussion of issues and challenges

In this section, we discuss the issues and challenges that emerge from the study. These are grouped into six categories: autonomy and ownership; excellence narratives; national and regional funding relations; private sector engagement; challenges for international donors; and university and academic priorities.

5.2.1 Autonomy of national funding agencies and ownership of science funding agendas

An overarching theme is the relative autonomy of national SGCs to make decisions about science funding in diverse ways in relation to the other issues and challenges. This reflects a tension identified by this study between demands on national decision-makers to fund science designed to meet national goals and a series of constraining factors which potentially constrict their ability to do so. Lack of resources at the national level in particular, is the backdrop against which a range of tensions,

conflicting messages and varying incentives complicate decision-making about how to fund science and research, and on what criteria. Science based on academic priorities and norms may not be the same as priorities defined by national policymakers. Policy or private sector priorities may not align with domestic scientific capabilities and pressures for quick answers may mean that the case for capacity building gets lost.

This is a multifaceted issue and one that cuts across all case study countries. It is complicated by the differing roles that SGCs play in national contexts. In some countries, such as Kenya for instance, they are more clearly implementing agencies, whereas in other countries they also have policy functions. Additionally, there are further complexities when – as is clear in Senegal but also evident to varying degrees in the other case study countries – there are multiple funding "pots" across ministries and/or sectors. Below, we discuss different components of the problem and at the end of this section we discuss things that the SGCI might do to progress effective measures in addressing these key issues and challenges.

5.2.2 Different and confused narratives around excellence

Scientific merit constitutes the most accepted way of making decisions about which research proposals to fund and where. This approach is reflected in norms and operational procedures of emerging regional actors such as AESA. AESA is committed to funding on the basis of scientific merit alone and, whilst active in funding workshops and activities to enhance capacity of researchers to bid for grants, does not see that funding decisions should be made on equity criteria or in relation to particular national agendas. Scientific excellence is evidenced by publication in top journals and other indicators of academic recognition. The idea that investment in excellent science will deliver social and economic benefits in a linear way, fundamental to much post-second world war science policy in the West, underpins this narrative about how excellence should be defined. In this view, scientists and researchers play the key role in determining the direction of funding and investment. "Responsive mode" mechanisms are core to structuring funding calls but certain amounts of funding may be designated to priority subject areas.

Our study finds that whilst national SGC decision makers may agree with and use aspects of this narrative and discourse, they also express the view that science should reflect capacity building agendas and national priorities. It is unclear then, how actual funding mechanisms and decision making will reflect these inconsistencies. Strategic considerations, including ease of collaboration with regional and international partners, and the implications of decisions for reputation amongst international science funding and policy actors, are also likely to influence decisions.

PASET has a different model. By focussing more explicitly on national priorities in programme design there is potential for a reduction in conflicting aims, ambitions and tensions, although the initiative is at an early stage. There are promising signs (e.g. country commitments) however it may be that early enthusiasm will wane if benefits are not quickly apparent.

5.2.3 Securing regional commitments from national funders

All regional initiatives will depend in the longer term at least partly on resources from national funders. Success in securing funding might be considered as an indicator of the relative strength of different narratives. The influence of powerful regional funders of sub-regional and national profiles and, in particular, the issue of whether regional funds have an equalising or otherwise, impact will be important to monitor.

Another way of thinking about this is as a question of ownership. One interviewee expressed the view that those "*who have skin in the game*" and who have committed resources will "own" agendas and narratives. The same interviewee said, "*those who pay the piper call the tune*". This may be difficult for resource-poor national SGCs although much depends on what sort of funding requirements are needed by regional funders.

5.2.4 Determinants of private sector engagement

Levels of private sector engagement are currently very low. Getting private sector investment means making convincing arguments that investment in national resource will have payback. A review study on why the private sector invests in R&D (Martin and Tang 2007) tells us that the main benefits to the private sector from research are as follows: increase in the stock of useful knowledge; supply of skilled graduates and researchers; creation of new scientific instrumentation and methodologies; development of networks and stimulation of social interaction; enhancement of problem-solving capacity; creation of new firms; and provision of social knowledge. Private sector investment in research will rest on the extent to which these benefits are evident. This requires extensive consultation and involvement with the private sector in setting agendas. This may have consequences for the way in which SGCs make decisions and may mean that alignment with other national and regional actors will need careful thought and negotiation.

It may be important to gain a clearer understanding of factors that have influenced the private sector in other similar contexts to engage more significantly with funding of science and with SGCs. Decisions about how to engage the private sector could also usefully be informed by an analysis of different organisational and institutional pathways governing private sector engagement. Data relating to public and private partnerships would be very useful addition around the different ways in which partnerships are evolving in the region. There are many ways in which interaction can happen and in many cases industry associations and civil society organisations play important roles in enabling greater engagement.

5.2.5 Challenges for international donors

The diversity of models for regional and national funding of science means that international donors have an increasingly complex environment to navigate. Funding science and innovation in Africa may become more attractive as partnership and impact possibilities multiply. But decision-making about how to fund science in SSA may become more complex as different options emerge. Some international donors naturally align with one model over others. For example, the Wellcome Trust and AESA have close ties and a shared and clear understanding of the primacy of a definition of scientific excellence based on international recognition of merit. The focus is predominantly guided by a desire to offer opportunities and support to individual researchers. Other funders, such as the World Bank, DfID, IDRC and Sida, have a variety of support mechanisms focussed on individuals, organisations and systems. Different types of perspective and intervention can complement each other but this will not always be the automatic outcome. The way in which international donors align themselves to different regional and national funders, and the consequences of multiple interventions, will be important to track over the coming years.

Building capacity and capabilities is naturally core to national level SGC concerns, and of some international funders and regional initiatives. Whilst regional funders acknowledge the importance of capacity strengthening, there is a commitment from AESA to funding on the basis of merit, although there is clearly also commitment to capacity building activity. How regional and national funders construct their interactions, understandings and networks on the basis of this tension can be traced as regional and national SGCs evolve.

5.2.6 University and academic priorities

The study found that in some contexts SGCs can find it difficult to get uptake for calls for funding. For SGCs, this is clearly a critical issue. How SGCs influence and build constructive engagement with researchers and universities will be an important area for monitoring and research in future years. This issue is complex and involves at least two important arenas of interaction for SGCS. The first is with universities individually and as institutions, through collective agreements and understandings, and the second is with researchers directly. Important issues will include the priority that universities give to research and to enabling their staff to develop as researchers. Researcher preference for bidding for certain types of research and research funding over others will also be important to understand. In this way, university and researcher decision making may also emerge as factors which impinge on SGC autonomy.

5.3 How can SGCI progress further discussion of these issues and challenges?

As we noted above, the SGCI aims to strengthen the capacities of science granting councils in SSA to support research and evidence-based policies that will contribute to the continent's economic and social development. The previous section raised some of the tensions and challenges associated with that effort. While all are beyond the direct control of SGCI, the initiative can play an important role in progressing constructive discussion. It can do this in two main ways.

First, SGCI can facilitate evidence collection and dialogue around the issues highlighted here. All of the issues relate to SGCI's broad themes, and the initiative has begun to generate internal evidence-based discussion in relation to some of the issues, including definitions of this evidence. We understand that this work has already been initiated. Existing efforts could be complemented with workshops or seminars hosted in collaboration with national and sub-regional bodies or other regional initiatives.

Second, the SGCI has particular strengths in terms of deep links with national policy and funding bodies. Finding ways to articulate and promote national level successes in funding science, and building partnerships which meet critical social and economic need, might be a particular focus for SGCI over the coming years.

5.4 Recommendations for follow up study

This study has highlighted 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. These are split below into those that we see as essential and immediately required, and those that are recommended.

5.4.1 Essential areas for further study

This study will be used as the baseline against which future trends and developments can be assessed and analysed. There are three broad areas that are recommended as next steps for additional and further research in this area. The first relates to getting a better sense of the data behind the funding environment. The second relates to a larger number of case studies in order to get a more comprehensive compendium of the current situation or baseline of SGCs and their enabling environments across the continent. And the third, concerns the variety of roles of SGCs beyond funding.

1. **Funding numbers**: This study has made recommendations with regard to a set of baseline indicators for measuring progress of the SGCs moving forward. Further work on these baseline indicators would be useful to fully interrogate their relevance. In addition, the study has highlighted a dearth of compiled data that interrogates regional funding activity and its impact at national level. Further work could consider where money is spent (by country, sector and area) i.e. data on the flows of research funding across the continent. The 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. Whilst OECD data are largely constructed around STI and economic growth, new and additional indicators could be developed to reflect a regional concern with human and social development. This is urgently needed.

2. **Further case studies**: This report was only able to consider five countries of which only four were in-depth. Further in-depth case studies of a larger number of countries across the continent are needed. This will require additional resources to monitor.

3. **Further analysis of SGCs as policy advice agents and mediators of different science policy tensions**: We were only able to concentrate on the main political economy dynamics of the SGC landscape. But it is clear that SGCs play, or could play, many different roles, as Mouton et al. (2014) show. Understanding these different roles, and the possible diversity of models already in use, is urgently needed as this has a significant bearing on the work of SGCs across the continent.

5.4.2 Recommended areas for future study

There are several gaps in knowledge highlighted by this study which further research activity would usefully address. These are listed here in order of urgency (most urgent first) when it comes to informing the SGCI in how best to support the SGCs in Africa.

1. **A comparative analysis of other SGCs and science funding mechanisms from other parts of the world**: e.g. India, Hong Kong, Mexico and Singapore who have successfully (or otherwise) built capacities of research systems. They have done so in different ways and funded science and innovation on varying criteria. The study would determine the ability of different approaches to create meaningful impact in terms of strategic development objectives. This could include graphical representations of different models and pathways of science funding, and examination of the diverse impacts and "paybacks". The study could then make explicit attempts to relate the learning to challenges for SGCs in SSA including at least one experience sharing workshop to enable African SGCs to hear first-hand the successes and challenges of other systems, and the publication of several policy briefs. This study can build on previous initiatives such as the IDRC Research on Knowledge Systems (RoKS).

2. **A dedicated research project focussed on university-SGC interaction**: to understand in more depth how decisions on what to fund are made and how those around - for example, applied vs. basic, multidisciplinary - research are understood and articulated. SGCs and universities juggle priorities when constructing their research agendas. It is often assumed that researchers follow research funding but it is likely that the relationship between SGCs, universities and researchers, and especially those who have significant reputations, is more complex. Particularly in systems where there are scarce resources, it may be important to understand these dynamics further.

3. **A dedicated research project focussing on the interaction between SGCs and the private sector**: to analyse different organisational and institutional pathways governing private sector engagement. These could include some form of network analysis of emerging partnerships and collaborations with SGCs.

4. **A study to understand the relevance of regional policy initiatives**: for example, STISA on national level STI narratives and practice.

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