SCIENCE AND TECHNOLOGY ADVICE TO AFRICAN PRESIDENTS
Evidence-Based Leadership in the Age of Exponential Innovation

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Introduction

Africa has understandably had an uneasy relationship with science and technology in history. Its early encounters with western technology were through colonization, which involved technologies for extraction of resources and subjugation of populations. Basic roads were contested in parts of Africa because of their use to extend colonial influence rather than support local livelihoods.[1] Biomedical research on the continent has an equally checkered ethical history.[2] The uneasiness extends to ecological sciences where knowledge served as a tool for control.[3]

Similarly, the disregard of local crop knowledge on local crops needs to be viewed in the context of contestations associated with the remaking of agricultural systems using exotic crops such as maize.[4] Racial and power imbalances influenced access to the results of medical research in the allocation of colonial budgetary resources, which further widened social inequities.[5] The failure of post-independence import substitution strategies and the associated collapse or underutilization of industrial plants added to mounting international debt. But more vividly, the white elephants served as monumental evidence of technological folly.

Under such circumstances it is clear cultural norms have emerged that view western science and technology with skepticism, if not passive objection. Up to that time, discourses on science and technology often started by discussing risks and hardly shifted to examining the benefits. The clamor for local solutions to local problems relying on indigenous knowledge became a clarion call through the 1990s.

The beginning of the new millennium coincided with two pivotal events that reshaped the debate on the role of technology in African development. The first was the replacement of the Organization for African Unity (OAU), which focused on decolonization, with the African Union (AU) whose mandate became largely to foster economic integration and transformation. This opened the avenue to start exploring the economic benefits to Africans and to apply science and technology irrespective of its origins. It became possible to start discussions with exploring the benefits of science and technology first and then moving on to identify minimalizing risks second.

Mobile phone adoption facilitated a discernible impact across African countries by serving four important purposes. The first was to provide tangible benefits over landlines and to demonstrate the power of leapfrogging in services using imported technologies.[6] It also showed that it was possible to design inclusive business models that created new economic opportunities for a wider

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1. Freed, L. 2010, "Networks of (Colonial) Power: Roads in French Central Africa after World War I," *History and Technology*, Vol. 26, No. 3, pp. 203-223.
2. Tilley, H. 2011. *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950*, University of Chicago Press, Chicago, USA.
3. Kjekshus, H. 1996. *Ecology Control and Economic Development in East African History: The Case of Tanganyika, 1850–1950*, Ohio University Press, Athens, Ohio, USA.
4. McCann, J. 2007. *Maize and Grace: Africa's Encounter with a New World Crop, 1500-2000*, Harvard University Press, Cambridge,MA, USA; Juma, C. 1989. *The Gene Hunters: Biotechnology and the Scramble for Seeds*, Princeton University Press, Princeton, NJ, USA.
5.Gottschalk, K. 1988. "The Political Economy of Health Care: Colonial Namibia 1915-1961," Social Science & Medicine, Vol.26, NO. 6, PP. 577-582.
6. Juma, C. 2017. "Leapfrogging Progress: The Misplaced Promise of Africa's Mobile Revolution," *Breakthrough*, No. 7, Summer, pp. 39-47.

section of the population. The mobile revolution also showed it was possible to turn devices into a technological platform that could help in spawning new industries in diverse fields such as mobile banking, mobile health, and mobile education. But probably the most important contribution of the mobile revolution was its role as a metaphor for technological possibilities. This mental shift made it possible for people to start envisioning the equivalent of mobile phones in other sectors such as energy, health, agriculture, and transportation.

The extent to which this mental shift is reflected in the organization of government, so they can serve as facilitators of technological innovation, is one of Africa's emerging policy challenges. This paper seeks to examine the critical role that science and technology advice to African presidents and prime ministers can be strengthened. This is part of Africa's political commitment to moving the economy from being resource-driven to being innovation-led.[7]

The paper is divided into five sections. The first section presents the key features of Africa's technological vision as expressed in the various presidential summits convened by the AU. Section II examines the key global trends in presidential science and technology advice. Section III provides an overview of the institutional arrangements and models used to provide presidential science and technology advice. Section IV uses the case of Namibia to illustrate how structures of government, often arising from national constitutions, can hinder or facilitate the effective provision of presidential advice. The final section outlines various options that could be pursued to strengthen the institution of presidential science and technology advice in Africa.

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7. Juma, C. 2014. "Complexity, Innovation, and Development: Schumpeter Revisited," *Journal of Policy and Complex Systems*, Vol. 1, No. 1, pp. 4-21.

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1. Science, technology, and innovation in Africa

Strong demand for raw materials, especially by China, and a growth in consumption by an expanding middle class have driven Africa's growth in the past two decades. The recent commodity price downturn has slashed the growth prospects of some of the fastest growing African countries. Historically, commodity price fluctuations appeared to be cyclical, creating the illusion of reversibility. Contemporary trends appear to tell a different story. Some of the sources of the downturn are associated with irreversible trends such as the steady erosion of fossil fuel markets by the entry of alternative energy sources. Such disruptive shifts not only signal irreversibility, but they also point to the need for technology and innovation driven economies.

This mental shift is evident from the decisions of African leaders under the auspices of the AU. For example, the adoption of the African Union's 10-year Science, Technology and Innovation Strategy for Africa (STISA-2024) in 2014 clearly expresses the shift in policy orientation.[8] STISA's mission is to "accelerate Africa's transition to an innovation-led, knowledge-based economy." The strategy is part of the 50-year Agenda 2063, the AU's long-term development vision that stresses the importance of inclusive growth and sustainable development.

1.1 Strategic actions

The strategy accounts for Africa's contemporary levels of development and their persistence. It focuses on the need to harness science, technology, and innovation to help solve six key grand challenges. They are building infrastructure, eliminating hunger, improving human development, protecting the environment, enhancing social cohesion, and spreading prosperity. These grand challenges are used in the strategy as illustrations of areas that require urgent attention. They also help to show the character of problems that African countries are grappling with.

These priorities have been extensively discussed and are not new. It is a common practice in international development to define a major theme on an annual basis, without consideration of the long-term nature of its implementation. Another common practice is to abandon working on a particular theme simply because it is no longer new. This is often used to scoff off proposals to focus on improving rural infrastructure, especially through expansion of low-cost roads. There is often an instrumental assumption that if an action was relevant it would have been fixed. The fact that solutions have not been found is used to justify low priority ranking. What is different is the commitment of African leaders to harness existing and new technologies to address persistent challenges based on their strategic importance not their rhetorical relevance. The focus is to apply the solutions in an inclusive and sustainable manner relying on policy consistency.

STISA-2024 builds on a series of previous efforts to leverage science and technology for development. Most of the previous attempts assumed a linear flow involving research, development, demonstration, and deployment. As a result, much of the policy focus was on the need for governments to allocate at least 1% of national GDP to research and development

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8. Juma, C. and Serageldin, I. 2016. R*ebooting African Development: Science, Technology and Innovation Strategy for Africa*, Belfer Center for Science and International Affairs, Harvard Kennedy School, Cambridge, MA, USA.

(R&D). The thinking behind this approach that was borrowed from discussions in industrial countries was informed by the historical correlation between R&D expenditures and national GDP growth rates. This model, however, does not explain why in many cases much of the economic catch up has occurred in countries with low R&D expenditures, negligible scientific publishing records, and modest patenting efforts. Lessons from these countries suggest the existence of other social capabilities beyond investments in R&D as the starting point for economic development.[9]

STISA-2024 acknowledges the importance of R&D but does not adopt the linear view. It rejects the separation between basic and applied research as a vestige of our understanding of how to allocate funds to the development of new military technologies in the 1940s.[10] Instead, it takes the view that research, invention, and innovation interact, though in complex ways. Many practical applications grow out of science discovery just as myriad scientific breakthroughs have come from engineering teams working to solve practical problems in fields such micro-processing or radio communication. The Second Law of Thermodynamics, for example, resulted from knowledge gained while working to improve the efficiency of steam engines.

Africa's view of the relationships between discovery, invention, and innovation is being shaped by practical experiences from the mobile revolution. Based on the experiences, the continent is looking into combining R&D with leveraging existing technologies and using them to create new enterprises and expand development growth options. This approach provides Africa with a more hopeful future that involves tapping into an exponentially-growing global knowledge reservoir using mechanisms such as joint ventures to build local technological capabilities.[11]

The approach also includes fostering innovation through interactions between government, academia, business, and civil society associations. For example, South Africa has become a major actor in the global wine market through interactions between private producers, research institutes, universities, and government.[12] STISA-2024 has identified four strategic actions that reflect Africa's state of development while accommodating differences among states. These are investing in infrastructure, building technical capabilities, incubating and scaling up enterprises, and providing an enabling environment for innovation.

1.2 Infrastructure development

Africa has identified two important areas of infrastructure development that have a direct impact on science, technology, and innovation. The first is physical infrastructure (covering energy,

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9. Abramovitz, M. 1986. "Catching Up, Forging Ahead, and Falling Behind," *Journal of Economic History*, Vol. 46, No. 2, pp. 385-406.
10. For a detailed critique of the model and the development of alternative approaches, see: Narayanamurti, V. and Odumosu, T. 2016. *Cycles of Invention and Discovery: Rethinking the Endless Frontier*, Harvard University Press, Cambridge, MA, USA.

11. Nam, K.-M. 2011. "Learning through the International Joint Venture: Lessons from the Experience of China's Automotive Sector," *Industrial and Corporate Change*, Vol. 20, No. 3, pp. 855-907.
12. Giuliani, E., Morrison, A., Pietrobelli, C. and Rabellotti, R. 2010. "Who are the Researchers that are Collaborating with Industry? An Analysis of the Wine Sectors in Chile, South Africa and Italy," *Research Policy*, Vol. #, Vol. 9, No. 6, pp.748-761.

transportation, water and sanitation, telecommunication, and research facilities that could be shared or networked). This includes associated institutional and legal arrangements, and the African Development Bank has estimated that Africa needs to invest nearly US$93 billion a year over the next decade to bridge its infrastructure gaps. The second area involves the creation of research infrastructure, especially research laboratories.

Physical projects are inherently high-tech and offer a foundation for building up scientific and technological capabilities. Doing so requires procurement procedures that stress the need to domesticate the associated technologies and knowledge.[13] Designing and implementing such projects involves expertise in mechanical, civil, electrical, and chemical engineering, among other fields. Africa's design of infrastructure will, therefore, need to be directly linked to the creation of engineering capabilities drawing from strong connections with local universities and research institutes. In many cases, large infrastructure projects may need to create their own internal research institutes or align their operations with a university. An example of this is the establishment of the Korea Railway Research Institute concurrent with their high-speed railway construction.[14]

Research facilities can be directly linked to infrastructure projects, but others need to be set up at universities and institutes with opportunities for common use and collaborative study. The Internet, for example, was first created as infrastructure for research. The rise of data analytics involves the generation and storage of large datasets that can be better managed through decentralized, cloud-based facilities, which serve as common research infrastructure.

This approach could prove cost-effective with the design and implementation of regional research programs. Taking this approach involves rethinking how research facilities are funded and exploring how to incorporate the design of infrastructure projects and support from education and research budgets. It is notable, however, that some of the most debilitating barriers to research lie in the provision of basic infrastructure such as energy. It is not possible to undertake research without reliable electric supply.

The same procurement rules that stress the lowest bidders also tend to undermine research by making it difficult to include long-term maintenance, repair, and upgrading in the initial budgeting for research facilities. Rapid technological improvement in the field of scientific equipment often leads to African researchers falling behind, which undercuts international research collaboration.

1.3 Technical capabilities

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13. For contrasting experiences of South Korea and the Netherlands in how procurement procedures affect technological innovation, see: Rouach, D. and Saperstein, D. 2004, "Alstom Technology Transfer Experience: The Case of the Korean Train Express (KTX)," *International Journal of Technology Transfer and Communication*, Vol 3, No. 3, pp. 308-323; Priemus, H. 2009. "Do Design & Construct Contracts for Infrastructure Projects Stimulate Innovation? The Case of the Dutch High Speed Railway," *Transportation Planning and Infrastructure*, Vol. 32, No. 4, PP. 335-255.
14. Rouach, D. and Saperstein, D. 2004, "Alstom Technology Transfer Experience: The Case of the Korean Train Express (KTX)," *International Journal of Technology Transfer and Communication*, Vol 3, No. 3, pp. 308-323.

African countries will need to expand the availability of quality postgraduate education, especially in specific programs that lead to doctoral qualifications. Achieving this requires a systematic and coordinated approach to human capital development. This view also includes increasing the supply of technicians, and particularly those with vocational training. It is through having such a broad skill base that it is possible to foster integrated approaches that combine research, training, and commercialization of new products and services. This could be achieved through the creation of innovation universities.

In much of Africa, research is carried out in national research institutes that do not teach, and most universities teach but have little research capacity or funding. This setting has intellectual entropy build into it. The work that is undertaken in research institutes does not get diffused into the economy. This process is usually facilitated by graduating students, whom research institutes do not have. Universities, on the other hand, continue to teach without the benefit of using new research findings, and as a result they pass on knowledge that is generally out of date. Each successive class may in fact be acquiring knowledge that is more out of date than the previous class purely on the basis of time knowledge depreciation.

A common response to such inefficiencies is to call for increases in university research funding. An additional approach is to add teaching functions to research institutes to create a new generation of innovation universities that combine research, teaching, commercialization, and community engagement.[15] Another path is to encourage the creation of new research universities under technology-oriented businesses, as is being done in Ethiopia and in other isolated cases.

1.4 Entrepreneurship

Enterprises, whether public or private, are the primary vehicle for turning knowledge into goods and services. They are, therefore, the main drivers of economic change. Enterprises are also where technological capabilities accumulate. These capabilities are the fuel for competitiveness. At the center of this process lies the entrepreneur who plays the critical role of creating new economic value.[16]

Africa is investing in enterprise development. But the growing awareness of technical knowledge and entrepreneurship will require forging close connections between business and academia.

15.Juma, C. 2016. *Education, Research, and Innovation in Africa: Forging Strategic Linkages for Economic Transformation*, Discussion Paper, 2016-01, Science, Technology, and Globalization Project, Belfer Center, Belfer Center for Science and International Affairs, Harvard Kennedy School, Cambridge, MA, USA; Trencher, G. et al. 2014. "Beyond the Third Mission: Exploring the Emerging University Function of Co-creation for Sustainability," *Science and Public Policy*, Vol. 41, No. 2, pp. 151–179; Mok, K.H. 2012. "The Quest for Innovation and Entrepreneurship: The Changing Role of University in East Asia," *Globalisation, Societies & Education*, Vol. 10, Vo. 3, pp. 317-335.

16. Hunter, M. 2012. "On Some Misconceptions about Entrepreneurship," *Economics, Management, and Financial Markets*, Vol. 7, No. 2, pp. 55-104.

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Other ways to spur entrepreneurship include using universities as incubators for new firms. Creating this role for educational establishments will require reforms to redefine the missions of some universities.

As businesses grow, they demand more technical knowledge. Some of this can be generated internally. Focusing on the scaling up of business, therefore, increases a country's knowledge base. As firms grow, they also produce new technical knowledge that makes them suitable locations for training future generations.

Universities serve as incubators of businesses. Enterprises also act as midwives of new knowledge-based universities. Africa can learn from South Korea, which has considerable experience in supporting enterprises to create universities. Some African enterprises have internal training programs that could be upgraded to the level of university-level courses.

1.5 The innovation state

The approaches outlined above demand greater creativity and flexibility from African policy makers so that they can act as agents of the innovation state. Enlightened leadership is required with heads of state or governments acting as innovation champions. In addition to providing coordinated policies that fit specific purposes, African countries will need to create governance structures and policy environments that nurture innovation.

Fostering a culture of innovation requires continuous policy adjustment. This process is best achieved with the support of effective Offices of Science, Technology, and Innovation Advice for heads of state and government. So far, no African country has a statutory Office of Science and Innovation Advice. The few advisory mechanisms involve *ad hoc* appointments that are associated with the creation of formal advisory offices using specific procedures to generate, provide, and disseminate advice. One of the functions of such offices, especially in the early years of the implementation of STISA-2024, would be to advise on how to incrementally adjust governance structures to support innovation.

STISA-2024 will be implemented over four phases at continental, regional, and national levels through flagship programs that reflect local priorities, needs, and capabilities. The strategies outlined above make it possible for countries to leverage their regular investments in infrastructure, education, and entrepreneurship to support innovation.

The first task is therefore exploring how to integrate innovation into ongoing activities. Making innovation a routine aspect of existing activities involves considerably less additional financial investment than other routes.

The main task facing Africa is identifying opportunities for integrating innovation into existing programs. New and additional resources are important. But they are not as critical as using local resources to leverage international cooperation. In the final analysis, making Africa an innovation-driven economy will require creativity and imagination. There is no shortage of these two intrinsic assets.

STISA-2024 is only one instrument adopted by African presidents that focus on science, technology, and innovation. Other relevant decisions include results of summits on issues such as infrastructure, agriculture, industrialization, youth, and education. In addition, the African Union has also initiated programs on technical areas such as space technology. The creation of the Pan African University (PAU) represents yet another clear signal of the emphasis the AU places on building human competence. These measures are guided by a 50-year vision enshrined in Agenda 2063.

One of the key challenges is designing institutions that enable African presidents to implement their commitments using evidence-based science and technology advice. Strengthening science and technology advice to African presidents will play a critical role in shaping informed decision-making and execution. There are no viable alternatives in the self-correcting and constantly-changing world of science and technology. Economies that rely on the export of raw materials need information on limited parameters such as quantities of deposits and reserves, price fluctuations, market intelligence, and shifts in the composition of actors. Much of this can be outsourced. The field of innovation is more complex and dynamic and needs continuous assessment and advice from dedicated institutional structures. Creating such institutions is an emerging priority as African countries broaden their view to expand the application of science, technology, and innovation in economic transformation. The next section provides a synthesis of lessons learned worldwide on presidential science and technology advice and its relevance for Africa.

2. Trends in presidential science and technology advice

2.1 Principles of science and technology advice

There is a growing body of knowledge on the types of principles that could guide the conduct of presidential science and technology advice. These principles have emerged from codification of practices in various countries, mostly from the industrialized world. The work started in the late 1990s with the publication of advisory principles and guidelines by countries such as the UK, Canada, the US, and New Zealand. The principles stress the importance of the quality of advice and selection of the appropriate principles that fit national realities. In addition, they also cover the use of democratic principles such as inclusiveness and openness, effectiveness of policy advice, and continuous institutional self-review of advisory mechanisms.

The principles provide a starting point for exploring their suitability to African conditions. Despite the growing interest among African leaders to strengthen their science and technology institutions, there is a need to take unique national conditions into account. Over the last decade African presidents have experimented with a diversity of science and technology advice. The approaches have included making political appointments of presidential advisors, designating existing ministers to serve as advisors, and creating advisory councils. The approaches reflect the nature of national constitutions structure, limited financial and human resources, and lack of legal capacity to sustain science and technology advice. Part of the problem also lies in the nascent nature of national scientific academies.

2.2 Quality of science and technology advice

Maintaining quality expert advice can depend on a variety of conditions that include early and appropriate identification of issues, recognition and appropriate treatment of scientific uncertainty and risk, and diversity of opinion and cross-disciplinary approaches.[17]African prospective science and technology advisors in universities and scientific academies often seek to maintain the same level of independence from government like their industrial country counterparts. The main difference is that African countries lack institutional arrangements that foster advice while maintaining independence.

The extent to which a science and technology advice system can adhere to each of these guidelines depends on domestic conditions of the country, particularly financial circumstances and robustness of the scientific, engineering, and technological community. Early and appropriate identification of issues is a key aspect of the quality of presidential science and technology. Anticipation of hazards of emerging issues such as climate change is a prime candidate for science and technology advice. Early responsiveness of science and technology advice to emerging issues has also proven to be important in building and maintaining trust between science advisors, the public, politicians, and the wider scientific community.

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17. Juma, C. and Lee, Y.C. 2015. *Innovation: Applying Knowledge in Development*, Earthscan, London, pp. 140-158.

Recognition and appropriate treatment of scientific uncertainty and risk are important elements of science and technology advice. There are many strands of risk analysis that address the issue of scientific uncertainty. One approach has been to seek to apply the precautionary principle. The focus of this approach is to take preventive measures and not wait for scientific certainty. Other approaches aim to base decisions of the best available evidence rather than take arbitrary measures.

Diversity of views and cross-disciplinary approaches to scientific questions is essential for effective science and technology advice. This is especially true in cases of scientific contention in fields such as transgenic crops. A variety of perspectives improves the accuracy of scientific evidence, analysis, and conclusions and can boost public trust in the science advice system. Small African science and technology communities may find it challenging to gather a diversity of appropriately qualified advisors and even more difficulty in assembling groups of experts from across disciplines. The African Union, for example, has relied on setting up scientific panels that include experts from the diaspora and wider international community.

Independence and disinterestedness in outcomes, on the part of science advisors, are also key issues that affect advice processes. Public trust in science and technology advice and resulting policies depend to a great extent on whether or not a given advice mechanism relies on information sources that are independent from government and industry. Major factors in public advisor disinterestedness include: individual advisors' organizational separation from advice recipients in government, freedom from political influence, and financial independence from government. The interpretation of independence and its value depends on each country's individual circumstances, and those circumstances demand close consideration by potential funders of science and technology advice mechanisms. In many African cases experts advising executives and departments are necessarily chosen on the basis of governmental connections and ties to industry; in other cases, full financial independence from government may simply be infeasible.

Engagement of science and technology advisors with government is slowly emerging as an important contribution to national development efforts. This is despite the absence of institutions that facilitate advisory activities while guaranteeing the independence of the advisors.

2.3 Inclusiveness and openness

Increasing the inclusivity and openness of science and technology advice processes can strengthen public trust while also improving the value of the final advice and product. Gathering a diversity of science and technology perspectives from across disciplines, sectors, institutional boundaries, and stakeholder interests has been said not only to spark public dialogue and accountability, but also to check accuracy of facts and opinions. Such proactive legwork in the beginning stages of science advice can help to avert or at least minimize controversy in the long term.

2.4 Review and feedback mechanisms

Governments use a range of different methods to review S&T decisions and to obtain feedback from within the system in order to ensure that S&T advice is serving the interests of government and the public good. Most of these review mechanisms focus primarily on the robustness of the discussion process rather than any estimated value of a given policy's outcome. Four models derived from an analysis of existing review and feedback systems will be explored in the following section.

3. Institutions of science and technology advice

3.1 Models of science and technology advice

Agency outreach model: In developed countries, many research agencies often seek input from the scientific establishment to assist in the priority setting process. This priority-setting model involves establishing workshops that bring together leading scientists and technologists from government, industry, and academia. Discussions and debate identify common themes for research within each field of science, which then compete at the program and directorate levels as budget priorities are set.

Application of this framework would work especially well in countries that have an already established science and technology advisory system where advice recipients are accustomed to inclusivity and openness in their decision-making processes. Moreover, because the primary goal of this agency outreach would be for the decision-makers to draw on a diversity of perspectives, it might also work more effectively in large countries with established science, technology, and engineering communities. In other words, the agency outreach may require more human and financial wealth than developing countries with scarce finances can afford.

Independent advisory model for priority setting: An independent advisory model offers more maneuvering room for developing countries. This model of priority setting is one in which the science agency turns to an objective group for input. This independent advisory model, in which a scientific and engineering academy would be an ideal leader, is a more promising option than the agency outreach model for small countries with developing science and technology communities. This model is also more realistic for developing countries because it allows for success with a range of institutional variation and financial circumstance. As long as the public and concerned actors feel confident that the advisor can in fact provide objective advice, it may not even matter whether such an institution is supported by government funds.

Convened science advisory board model for priority setting: A third model for input from experts is the convened science advisory board model. These advisory committees can have members with several year terms and can be convened to advise on scientific and technical issues, as well as to provide scientific and engineering advice.

Such a science board would offer external advice and would have a greater stake in outcomes than workshop panels. Similar to the advisory board model, the convened board model provides more flexibility for small and developing countries to tailor their own review and feedback systems.

Networked model of science: Countries that have robust science and technology advisory structures in various government departments are seeking to create a networked model drawing from the sectoral advisory mechanisms to inform national decisions. The UK, for example, has established offices of the chief scientist in all its functional departments. This enables the Chief Scientist in the Office of the Prime Minister to coordinate input on specific issues from across the different departments. This model requires extensive financial and institutional resources that are not available in African countries.

Three of the four sample processes for review and feedback bring the views of scientists and stakeholders to government decision-makers, but the agency outreach model may be too taxing for African countries given limited resources. The independent advisory and convened board models assume less about the pre-existing science and technology base and therefore give African countries great room for adaptation and individual tailoring. Realistically, the successful selection and implementation of any institutional arrangement and principles will ultimately depend on whether the national economic circumstances, science and technology community size, and other conditions permit financial and organizational support for advice.

3.2 Institutions of presidential advice

Science and technology advice mechanisms can be described along numerous dimensions. Perhaps the most useful descriptors of an S&T advice institution are organizational, financial, and political characteristics including: nature or type of institution (organizational), kinds of capabilities needed to run the institution (organizational), procedures needed to run the institution (organizational), resources to run the institution (financial), and sources of outside legitimacy and credibility (political).

Advising takes place at all government levels, and advice can be sought in a variety of ways. The primary differences between advice mechanisms exist in the level at which scientific input is received; how formal or flexible the advisory process is; the relative use of science advice in different branches of government (executive or legislative); and the degree of decision-making involvement of advisors. The taxonomy of advising bodies and the circumstances under which they are established are also complex. Some committees are *ad hoc* and flexible while their counterparts in other countries may be more permanent. In many countries, a single person serves as chief scientific advisor to the president and chair of a panel of prominent scientists advising the executive branch.

3.3 Scientific and engineering academies and science and technology advisors

The establishment and maintenance of scientific and engineering academies in African countries comprise a particularly interesting area for exploring these issues of funding, capacity, and politics. National academies provide excellent institutional illustrations of the trade-offs that science advisors face in regards to these three parameters. In some circumstances, these factors greatly limit the freedom of countries to create new and innovative science advice institutions.

Most academies now function in an advisory capacity, though they vary in origin, structure, and mission- all of which are to some extent determined by their sources of funding. While some academies have grown from the scientific and engineering community, independently of the government, others have been formed through concerted efforts on the part of national government cabinet members. Some academy leaders pride themselves on taking no money from government, while others find that they must accept government grants to pursue necessary expansions or simply maintain the capacity to stay afloat. Governments and science and technology advisors of developing countries may well view the practice of basic science research as a luxury, given the urgency with which more obviously pressing, practical problems demand attention from the science and technology community. In any case, it is clear that funding and its sources shape both the conscious innovation and natural evolution of academies.

All academies tend to defend their independence from political influence, but national academies vary a great deal in their degree of financial reliance on government. Academy leaders have observed that financial jumpstarts and even ongoing support from government can be vital for young academies in developing countries with small S&T communities. Even under normal conditions, let alone in tight economic circumstances, neither private sector (through investment) nor prospective members (through fees) can agree to provide any funds to initiate and run a successful academy, unless government takes the initiative to provide funding.

3.4 Institutional obstacles

Much of the discussion on presidential science and technology advice focuses on issues such as lack of political will to commit to leveraging the power of innovation for economic transformation. The presumed lack of political will is often attributed to the president, which is often used by the scientific community to absolve themselves from proposing or initiating the necessary institutional innovations. In many cases the scientific community is more preoccupied with securing financial support than with doing research, and it ignores deep constitutional, legal, and institutional factors that influence the creation of presidential advisory bodies, including those devoted to science and technology. The next section uses the case of Namibia to outline the challenges and opportunities associated with presidential advice.

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4. Presidential advice in Africa: The case of Namibia

As one of the youngest democracies on the African continent, Namibia has made significant progress since obtaining political Independence from South Africa on 21 March 1990, following a process of United Nations supervised elections. Namibia's internationally lauded Constitution has laid the strong foundation for a well-functioning electoral democracy where citizens have the opportunity every five years to hold political office bearers to account through the ballot box. Namibia has succeeded over the 27-year period in developing firm macro-economic and robust governance architecture, underpinned by the rule of law and individual freedoms such as freedom of speech.

To improve on the concept of representative democracy, Namibia, a unitary state, adopted the three tiered approach to governance, which brings government closer to the people. Accountability in Namibia is further entrenched through separation of powers between the three organs of state: Cabinet (Executive), Legislature (National Assembly and National Council), and the Judiciary (Supreme Court, High Court, and Magistrate Courts). The applied principle of checks and balances ensures organs maintain oversight and remain accountable to one another. Bills initiated by the Cabinet, need be passed by Parliament before enforcement and where necessary, administration of justice by the Judiciary.

As established in Chapter 6 (Articles 35-42) of the Constitution, the executive political authority is vested in the Cabinet, which is an institution under the leadership of the President, who is Chairman of Cabinet and Head of State and Government. The Cabinet is therefore the nucleus of Namibia's political leadership, assuming the apex role to run the machinery of State through collective decision-making. By virtue of its accountability to the legislature, the Cabinet is collectively responsible for policy initiation, formulation, adoption, and execution, which means steering through Parliament where necessary.

Namibia introduced a tandem Cabinet system following the inauguration of the incumbent administration. The Deliberative Cabinet is tasked with discussing detailed policy matters, and the Decision Making Cabinet then considers recommendations from the Deliberative Cabinet with final authority. This arrangement enables the latter Cabinet to adopt informed public policy decisions.

The decision-making process in Namibia is based on the principles of effective governance, such as consultation, transparency, and collective ownership, which are multi-layered facets executed at the Executive and institutional level.

Despite progress made since independence, social deficits persist. The Head of State and Government is elected by one single constituency. The President is therefore ultimately accountable to the electorate to execute the mandate entrusted and uphold the Constitution of the Republic. President Geingob, the third democratically elected President of the Republic of Namibia, assumed Office on 21 March 2015 and declared war against poverty and concomitant inequalities so as to deliver on his promise of "Prosperity for all Namibians."

The broad Presidential mandate, leadership, coordination, and oversight role of the Office of the President- coupled with the time-bound nature of the Presidential term limits- necessitate more focused, impartial, and timely advice to support and strengthen the decision-making process and the capacity of the Office of the President to govern effectively. To support the execution of his Constitutional duty as Head of State and Government, His Excellency the President appointed seven Presidential Advisors on 29 June 2015 to serve in the Office of the President.

4.1 Focus on effective governance and informed decision-making

The political leadership provided by the Founding Fathers of Namibia's democracy recognized that effective public management would not only hinge on the delivery of public services but also on the formulation of appropriate policy to back the national strategic vision. The pioneers of Namibia's democracy therefore established a reconciliatory Constitution and a robust governance framework, which placed due emphasis on efficient and effective civil service, anti-corruption, and the protection of human rights.

Commitment towards the principles of effective governance can be measured by the rate of Namibia's socio-economic transformation. The electoral democracy, three-tiered Government structure, and emphasis on effective participation during electoral campaigns all demonstrate the leadership commitment towards accountable and inclusive politics.

The separation of power between the organs of state strengthens accountability by providing the necessary checks and balances. Namibia's efforts are tailored to strengthen electoral, legislative, and anti-corruption systems while enhancing public service management and service delivery.

In 2015, President Geingob and First Lady Madame Geingob became some of the first of few African Presidents to publicly declare their health and assets. This unprecedented public declaration further demonstrated the leadership commitment to democracy and upholding good governance.

Effective governance requires prudent management of public finances and overseeing the collection, allocation, and investment of public funds and resources to the benefit of all. Namibia has adopted the Medium Term Expenditure Framework based on a three-year rolling budget system. Public procurement legislation has also been recently amended to enhance public fund management.

The Namibian Government adopted the Harambee Prosperity Plan in 2016 to accelerate implementation of the Five Year Mid-Term National Development Plans towards the attainment of Vision 2030. Active, transparent, and fair governance has been essential to the attainment of the national development agenda.

4.2 Origins and evolution of presidential advice

It should be noted from the onset that Namibia's political leadership have recognized the need for policy advice in the administration and management of the affairs of the government. Section 7 (a) to (c) of Article 32 of the Namibian Constitution states:

"*Subject to the provisions of this Constitution or any other law of application in this matter; the President may, in consultation with the Cabinet and on the recommendation of the Public Service Commission*:

a) Constitute any office in the public service of Namibia not otherwise provided for by any other;
b) Appoint any person to such office;
c) *Determine the tenure of any person appointed as well as the terms and conditions of his or her service.*"

In addition, Section 2 of the Special Advisors and Regional Appointment Amendment Act, 2010 (Act No 15 of 2010) further empowers the President to appoint a Governor by proclamation and to appoint Special Advisors to assist the Regional Governors.

It is argued against this background that the referenced Constitutional provision and Act of Parliament legitimize appointment of advisors to the Presidency, Executive, and Regional Governors and has given rise to the emergence and evolution of advisors in Namibia.

Essentially, advisors are appointed on a basis of trust, technical expertise, and competency at the discretion of the appointing authority, and as such, their appointments are linked to the term of office of the appointing authority. The function of Advisors is to contrast policy advice against the political ideological direction of the President (or principal politician) within broader context of the socio-economic, legal, environmental, and political arena.

4.3 Functions of presidential advisors

The Office of the President is established in accordance with Chapter 5, Article 27(A) of the Namibian Constitution, which states that:

"*The Presidency shall consist of the President and the Vice-President, who shall be served by Ministers, Special Advisors and such other persons as the President may appoint as well as such staff members from the public service as may be appointed for that purpose in accordance with the laws regulating appointments in the public service".*

Furthermore, Section 7 (a) to (c) of Article 32 of the Constitution provides that the President:

"Subject to the provisions of this Constitution or any other law of application in this matter; the President may, in consultation with the Cabinet and on the recommendation of the Public Service Commission:

a) *Constitute any office in the public service of Namibia not otherwise provided for by any other;*
b) *Appoint any person to such office; and*

c) *Determine the tenure of any person appointed as well as the terms and conditions of his or her service."*

In accordance with Section 2 of the Special Advisors and Regional Governors Appointment Act, 1990 (Act No.6 of 1990), both the Founding President and the Former President appointed Special Advisors to the President, focusing on the dimensions of defense, economic, and political affairs. Constitutional provisions cited above empower the President to constitute any office at his discretion and appoint persons to hold such office. To support the execution of his Constitutional mandate, President Geingob appointed seven Presidential Advisors on 29 June 2015 to serve at his behest in the Office of the President. The Advisors have the following titles related to governance and socio-economic development:

1. Presidential Spokesperson
2. Economic Advisor
3. Constitutional Advisor and Business Sector Interface
4. Policy Advisor: Monitoring and Implementation
5. Advisor for Youth Matters and Enterprise Development
6. Advisor for the Elderly
7. Advisor for Community Engagement

Six of the total seven advisory positions have existed on the institutional structure prior to appointment. The Youth Advisor is the only new advisory role added to the structure. The six existing roles have only undergone title changes to bring alignment to the President's strategic focus. The addition of a Youth Advisor is plausible. President Geingob has identified the nation's youth as an important segment with a key role to play in the attainment of Namibia's vision for prosperity.

4.4 Reactions to the appointment of presidential advisors

Ranked number #1 in Africa and #17 in the world for press freedom by Reporters Without Borders (2016), Namibia's Constitution guarantees freedom of speech, press, and other media.

The appointment of Presidential Advisors was met with mixed reactions. Few media houses hosted expert panel discussions where political analysts voiced their views on the appointment of Presidential Advisors.

Public debate argued that the appointment of Presidential Advisors:

a) Has negatively added to an already bloated civil service;
b) Has added to the fiscal burden because Advisors are paid more than Ministers; and
c) Creates overlap in responsibilities between Advisors and Cabinet Ministers.

4.5 Responses from the presidency to public reaction

Despite predominating negative reports on the appointment of Advisors, other media houses have also positively reported on the appointments, claiming the legitimate need for advice in order to deliver on the challenging mandate of prosperity.

The Office of the President wishes to note:

a) The majority of the appointed Presidential Advisors occupied public office immediately prior to their appointment;

b) The annual cost for all seven Presidential Advisors is 6 million NAD. This amount represents 0.02% of the total civil service cost, per annum;

c) The President's broad mandate; extensive leadership, coordination, and oversight role; and inherent term limit all come together to necessitate a system for more focused, impartial, and timely advice to support and strengthen the decision-making process and capacity of the Office of the President to govern effectively.

The President has repeatedly and publicly expressed his satisfaction with the performance of his appointed team of Presidential Advisors and his intent to retain them in spite of popular discourse.

5. Strengthening presidential science and technology

5.1 Adopt a high-level strategic vision for innovation and development

A robust, synergistic system of science advice institutions and policies in a given country must be founded on an internal, cross-sector, and countrywide agreement that showcases how science and technology advancements are relevant to national inclusive and sustainable development strategies. Governments must support the establishment of a vision for science achievements, and science and technology advice improvements can facilitate the building of internal capacity to in turn drive further growth.

5.2 Reform the various branches of government

First and foremost, innovations in government science advice groups must be shaped by legislation and/or formal orders, not only by personal appointment. This type of reform in governance will be vital not only to recognize the need for executive-level attention to science advice, but also to establish the institutional independence of science advisors from background political interests.

5.3 Diversify advisory procedures

An efficient system for science advice unites various institutions and policies, and it adapts the nature of its advice to the different tasks at hand. For example, the function of science advice in intergovernmental negotiations should be very different from that of science advice in the government's determination of how to commercialize scientific breakthroughs in a publicly-funded laboratory. Nonetheless, all of these different roles of science and technology advice should exist and ideally function together as coordinated elements under one broader science advice system.

5.4 Build capacity to manage advisory processes

The role of government in all its policies should be to "outsource" learning to existing institutions, such as schools, universities, government research organizations, firms, and community-level technology diffusion initiatives. To maximize the benefits of this outsourcing, governments must improve access to funding for these initiatives and also gear future research toward addressing issues of why mixed records of science advice and learning can exist within a single country. The process of examining why science advice and learning mechanisms have succeeded or failed in different regions of the same country will help national governments and national science advice leaders to tailor their institutional arrangements more effectively for the future.

5.5 Improve funding and legal capacity for advisory activities

This could range from funding innovative councils, universities, and agencies to linking foundations with academies in African countries. In early stages, African presidents might want to designate the heads of national academies to also serve on an ad hoc basis as presidential advisors. The approach was adopted in Malaysia and served the country until it was feasible to establish a dedicated office of the Chief Scientist to the Prime Minister. Under such circumstances, it is important to balance between the autonomy of the academies and the need to provide independent advice to government.

These arrangements should be expressed in law to provide the necessary legal capacity to act while maintaining public accountability. The procedures used by the academies to provide advice should be made public and open to regular review. Finally, it is important to clarify in law that advisory offices do not have implementation functions in the same way as presidential economic advisor do.

Conclusion

Economic policy reforms across African countries are increasingly recognizing the importance of science, technology, and innovation as major sources of economic transformation. This recognition is expressed in the daily functions of African presidents. The challenge, however, is reforming the system of governance to strengthen the role of presidential science and technology advice. This paper has outlined the key concepts, procedures, and institutional arrangements needed to strengthen scientific advice. An indicative roadmap includes adopting a high-level strategic vision for innovation and development; reforming the various branches of government to reflect a coordinate approach to science and technology advice; diversifying advisory mechanisms and procedures to reduce uncertainty; building capacity to manage advisory processes; and improving the funding and legal capacity for science and technology advice. There is no viable alternative to adopting an evidence-based approach to decision-making and codifying the activities in law and institutions.