African Innovation Outlook 2010

Executive Summary

NEPAD Planning and Coordinating Agency
Agence de Planification et de Coordination du NEPAD

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Acronyms

AIDS	Acquired immune deficiency syndrome
AMCOST	African Union Ministerial Conference in charge of Science and Technology
ASTII	African Science, Technology and Innovation Indicators Initiative
AU	African Union
AUC	African Union Commission
CIS	Community Innovation Survey
CPA	Consolidated Plan of Action
FTE	Full-time equivalent
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
HIV	Human immunodeficiency virus
HRST	AUC Directorate of Human Resources, Science and Technology
ICT	Information and communication technology
NEPAD	New Partnership for Africa's Development
NPCA	NEPAD Planning and Coordinating Agency
OECD	Organisation for Economic Cooperation and Development
PICD	Programme Implementation and Coordination Directorate (NPCA)
PhD	Doctor of Philosophy
PNP	Private non-profit organisation
R&D	Research and experimental development
Sida	Swedish International Development Cooperation Agency
STI	Science, technology and innovation

Introduction

Africa suffers from a lack of an adequate, African-led, science, technology and innovation (STI) system of indicators in support of evidence-based policy. This has been attributed to the continent's use of traditional development approaches that have ignored the role of measuring science and innovation activities in the socio-economic transformation of the continent. African political leadership has recommended several schemes to advance the role of STI for development, yet there are no appropriate instruments to gauge the implementation of these schemes by member states of the African Union (AU).

Notwithstanding this development, the African Union Ministerial Conference in charge of Science and Technology (AMCOST) has repeatedly called for better understanding of, and improvement in, the state of STI on the continent. These recurrent calls have been embodied in the outcomes of AMCOST decisions over the last decade. The African Science, Technology and Innovation Indicators (ASTII) initiative is a response to AMCOST calls to address the lack of evidence-based policy processes. The *African Innovation Outlook* is an outcome of the implementation of the ASTII initiative.

Over the last three years, ASTII has been implemented through designated Focal Points at national levels coupled with coordination at continental level by the Directorate of Human Resources, Science and Technology of the African Union Commission (AUC–HRST) and the NEPAD Office of Science and Technology.[1] The first phase of the initiative was implemented in 19 countries and benefited from seed-funding provided by the Swedish International Development Cooperation Agency (Sida) and contributions from participating countries, namely: Algeria, Angola, Burkina Faso, Cameroon, Egypt, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia.

The ASTII programme forms part of Africa's Science and Technology Consolidated Plan of Action (CPA), which among other things aims to build the human and institutional capacities needed to produce common internationally comparable indicators as tools for the ongoing survey of research and innovation at national levels. One of the outcomes has been the establishment of national capacity to conduct such surveys regularly.

This phase of the programme was designed to serve as a learning mechanism based on implementing R&D and innovation surveys, analysing the data and using the results in policy-making. The knowledge and experience gained will be consolidated to improve the process in future, inform the roll-out to further countries and increase the scope of the programme.

The *African Innovation Outlook 2010* is published as the first in a series, intended to inform the people of Africa and other interested parties about STI activities in African countries. The availability and usage of the *African Innovation Outlook* is expected to generate debate, which will enrich the process of collecting better quality data and improve understanding of policy processes in Africa. The debate is expected to contribute to African solutions to African problems and influence the work on STI indicators.

The R&D and innovation surveys are underpinned by international best practice. The R&D surveys are informed by the definitions in the OECD *Frascati Manual* and the innovation surveys by the OECD/Eurostat *Oslo Manual*, as adopted by the first Intergovernmental Meeting on Science, Technology and Innovation Indicators in Maputo, Mozambique in 2007.

The *African Innovation Outlook* comprises six chapters. Readers are advised to refer to the various chapters and references therein for more information.

Chapter outlines

Chapter 1: Background

Chapter 1 sets the scene and describes the genesis of the programme by stating its objectives and scope. The chapter also highlights the roles and structures of the national Focal Points, which implemented the surveys, as well as outlining the essence of the *African Innovation Outlook*.

Chapter 2: Economic growth and human development challenges for science, technology and innovation in Africa

Chapter 2 utilises the systems of innovation approach to development in trying to broaden the discussion of identified structural impediments that tend to constrain and inhibit African economic growth and human development. The chapter argues that improving institutions, so that they become broadly participative, transparent and universal, is imperative in redressing the failures of the past and ending the inevitable continuities with path dependencies and trajectories. The chapter is structured around themes, including: demographics; economic sectors; diversity; growth and development; entrepreneurship; global competitiveness; industrialisation; the macro-economic environment; regional integration; science, technology and innovation institutions and policies; and the Millennium Development Goals.

Chapter 3: Research and experimental development

Chapter 3 presents the estimates of two main R&D indicators developed on the basis of the R&D surveys conducted in 13 of the 19 participating countries between April 2009 and February 2010, namely: Cameroon, Gabon, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Senegal,

South Africa, Tanzania, Uganda and Zambia. The reference year for the surveys was 2007. The main indicators of interest were: (1) gross domestic expenditure on R&D by source of funds and sector of performance; and (2) R&D personnel by level of formal qualification and occupation, gender, headcount and full-time equivalent, as well as researchers by gender and field of study/research. A full R&D survey requires that the business enterprise sector, government sector, higher education sector and private non-profit organisations (PNP) be covered.

Where a sector has not been covered or reference parameters differed (for example, with respect to the reference year or survey period), a note to that effect has been added. Readers are advised to exercise caution in interpreting certain related statistics. The text points to areas that need further work. The estimates of the indicators, as mentioned, are described and broken down as follows:

Gross domestic expenditure on research and experimental development (GERD). This is one of the most common and most often quoted R&D indicators, indicating how much a country spends on research and experimental development as a percentage of GDP. The target for African countries of spending 1% of GDP on R&D – as endorsed by the Executive Council of the African Union in the Khartoum Decision (EX.CL/Dec.254 (VIII) on Science and Technology in 2006 – is an example of the use of this indicator for policy purposes.

- *The R&D intensity or the GERD/GDP ratio.* The survey results indicate that three countries (Malawi, Uganda and South Africa) scored an R&D intensity above 1%. For the other countries, the percentages range between 0.20% and 0.48%.
- *GERD by sector of performance.* With the exception of South Africa and Malawi, the public sector (comprising the government and higher education sectors combined) accounted for the lion's share of R&D expenditure in all of the countries surveyed. The two sectors combined accounted for over 50% of total GERD. The private non-profit sector accounted for a relatively small share of total R&D activity.
- *GERD by source of funding.* The survey data indicate that government is the most important funding source of R&D activities in participating countries. In addition to financing its own research institutes, government also finances R&D at public universities, and universities sometimes finance R&D from their own funds. In future research, the programme intends to look at the combined sum of expenditure in the government and higher education sectors in order to make a more detailed comparison of the role of governments. The data also indicate that R&D activities in Africa are to a large extent financed by international donors and other foreign sources. Among the countries surveyed, Mozambique is currently the most dependent

on foreign donors, in that more than 50% of its R&D is financed from abroad, followed by Mali (49.0%), Tanzania (38.4%), Senegal (38.3%) and Malawi (33.1%). By contrast, Nigeria and Zambia show very low dependence on foreign funding. In countries such as Ghana, South Africa and Malawi, the business enterprise sector accounts on average for 40% of R&D funding, while in most other countries its share of funding is less than 10%.

- *GERD by type of R&D.* The survey data show that Nigeria devotes relatively more resources to basic research (36.1%) than other countries, although the share of R&D funding for basic research is also relatively high in South Africa (20.6%) and Tanzania (19.2%). South Africa devotes most of its resources to experimental development research (45.2%), while Tanzania focuses on applied research (58.6%). The picture is rather different for Malawi, Mozambique and Uganda, where basic research accounts for only about 10% of GERD; by contrast, applied research accounts for 60% of R&D expenditure in Malawi, 83.2% in Mozambique and 59.3% in Uganda.

R&D human resources. These statistics indicate the human resources devoted to R&D in the survey year. The allocation of these human resources among the sectors describes the available R&D personnel and their actual utilisation in conducting research, as well as the qualifications of researchers and their distribution by gender. More specifically, the survey results show the following:

- *Researcher density or the deployment of R&D human resources.* The data reveal that South Africa, of all the countries surveyed, has the highest number of human resources available for R&D activities, with a researcher density of 825 per million inhabitants, followed by Senegal with 635 researchers per million inhabitants. At the lower end of the scale, Mozambique, Uganda and Ghana have a researcher density of fewer than 25 per million inhabitants. The findings related to this indicator call for further investigation in order to understand these differences, some of which may be attributed to the complexity of the definition of 'researcher'.
- *The role of women in R&D.* The data show that Tanzania and South Africa lead in terms of the participation of women performing R&D, since women account for 40% of all researchers in those two countries. The next highest percentages of women researchers are found in Mozambique and Uganda. The female participation ratios are similar for women employed as researchers and as support staff. This indicator is worth monitoring over time, as it will show whether there is growth in the participation of women in scientific careers in Africa.

- *Where do the researchers conduct research?* Most researchers in the surveyed countries are employed in government research institutes or public university laboratories. The role of the business enterprise sector in R&D ranks higher in Mali, South Africa and Ghana than in other participating countries. Private non-profit institutions play a very modest role in R&D activities in the surveyed countries, with the notable exception of Malawi.
- *Qualifications of researchers and support staff.* The data indicate that South Africa and Senegal have the highest percentages of PhDs among their R&D staff, scoring 32% and 26% respectively. However, several countries (Ghana, Malawi, Mali and Mozambique) have low percentages of PhDs among their R&D personnel as well as high percentages with non-tertiary education. Although this situation needs attention, it does not necessarily mean that research projects in these countries are staffed by less competent R&D staff. This is an area that warrants future research.
- *Estimating full-time equivalents (FTE).* The FTE data indicate the proportion of their working time that researchers and support staff devote to R&D activities. By comparison, headcount data record only the numbers of R&D personnel. Six countries provided data on FTEs. The average ratio between FTE and headcount is approximately 50%, with South Africa as a case in point. Malawi and Senegal are in the same range, and Ghana follows with a slightly higher ratio. Nigeria and Uganda are at the lower end of the range, although the FTE status of women employed in research in Uganda seems to be higher than for men. This area calls for further research.
- *Researchers by field of science.* This indicator shows the shares of researchers in six countries (Ghana, Malawi, Mozambique, Senegal, Tanzania and Uganda) in the fields of the natural sciences, engineering and technology, medicine and health, agricultural sciences, social sciences and humanities.

Chapter 4: Innovation

Chapter 4 summarises the outcomes of the innovation surveys conducted as part of the ASTII project. Ten of the 19 participating countries conducted such surveys using the reference period of 2005–2007, namely: Burkina Faso, Egypt, Ethiopia, Ghana, Lesotho, Mozambique, Tanzania, South Africa, Uganda and Zambia. As stated with reference to R&D surveys, where reference parameters differed, caution is recommended in interpreting the data.

The surveys used the definition of 'innovation' given in the *Oslo Manual*, namely that an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. A common feature of an innovation is that it must be connected to the market. For there to be a 'product innovation', the product has to be new or significantly improved, and for there to be a 'process innovation', the means of producing the product or delivering the product to the market has to be new or significantly improved.

The participating countries piloted a Community Innovation Survey (CIS)-type questionnaire. This served as a learning mechanism in defining and measuring innovation for statistical purposes. The main aim was better understanding of the innovation system in Africa. At this stage of the programme, the survey data at hand do not support precise comparable findings between countries, and care ought to be exercised in reaching policy conclusions based on a single survey. However, the findings could serve to attract policy interest and provide a basis for the selection of a set of core questions that have been shown to work in most countries and can be used for the next series of surveys. In addition to the core questions, countries might be invited to add questions of particular national interest.

This chapter discusses the significance of the survey findings and highlights areas for future research. It also offers ways of interpreting the survey findings and using the outcomes for policy purposes.

Findings

Innovation is pervasive. The data show evidence of innovation in all participating countries, in both small and large firms. The innovations included product and process innovations, as well as organisational and marketing innovations. In all cases, some of the resulting goods and services from innovative firms were sold outside the producing country. Trade is a means of connecting the firm not just to purchasers, but to the knowledge of markets, technologies and practices in other countries.

Innovation is a connected activity. The client or customer is the lead source of ideas for innovation outside the firm itself. Public institutions such as universities, governments and public research organisations are low on the list of external sources of innovation. Innovative firms collaborate, and their first choice of collaborator, within their own country, is the client or customer. Partners of choice vary in the case of collaboration outside the country. In most countries, the lead innovation activity has been the acquisition of machinery, equipment and software, followed by R&D conducted by the firm. This order was reversed in the case of Ghana and Tanzania.

Innovation has impact. Most countries consider the main impact of innovation to be the improved quality of the goods and services offered, followed by flexibility in production, an increased range of products and increased capacity to produce.

There are barriers. The barrier most frequently cited is the lack of funds in the enterprise and the cost of innovation. Other barriers include the domination of the market by established enterprises and the lack of information on both technologies and markets. In Burkina Faso, the most significant barrier is the lack of qualified personnel.

Size matters. Innovation activities, including both R&D and innovation itself, are related to the size of firm. Ghana examined the propensity to innovate in small, medium and large firms and demonstrated a clear correlation between size and propensity to innovate. This situation is also observed in industrialised countries, but the statistics require further investigation in other African countries to prove their robustness on the continent. Another observation on firm size and innovation is that surveys of firms with large employment or turnover tend to yield a high estimation of the propensity to innovate.

In most countries, many firms that innovate do not perform R&D. Innovation can and does take place without the need for inhouse R&D within the firm, but this raises questions about the source of the knowledge supporting the creation of value in the firm.

Interpreting the findings

The results of this first round of innovation surveys describe the innovative firm in Africa, but the results cannot support country comparisons, because different size cut-offs, sample sizes and reference periods were used. The interested reader or researcher is encouraged to review the reports of participating countries as they become available and raise questions that could enrich and contribute to future rounds of innovation surveys or surveys in new participating countries. Access to micro data will be a valuable asset. Notwithstanding the comparability challenges, the results are sufficiently robust to support certain observations, such as (1) the importance of the client and customer as both a source of ideas for innovation and as a collaborator and (2) the fact that not all innovative firms perform R&D. The latter observation raises policy questions about promoting entrepreneurship and R&D, especially among small firms.

Using the findings

- The importance of the relationship of the innovative producer with the client, both as a source of ideas and as a collaborator, might suggest support for collaboration.

- The fact that the leading innovation activity is the acquisition of machinery and equipment could lead to discussion of tax incentives to encourage investment in certain classes of machinery and equipment, such as those related to information and communication technologies (ICTs).
- The tendency of innovative firms to trade abroad might suggest a role for an export development bank or other institutions providing support for firms that are trying to enter the export market.
- Human resources are a factor in all innovation activity. There is thus a link between innovation and policies on education, health, training and migration that governments use to create framework conditions through service provision, regulation and practice.
- Understanding what firms are doing, and how or whether government programmes support what they are doing, is an area for further research. In particular, better understanding is required of firms that innovate without performing R&D.

Chapter 5: Bibliometric analysis of scientific output

It is well understood that a more realistic and complete picture of the science, technology and innovation landscape in participating countries will require additional indicators to those produced from the R&D and innovation surveys. To this end, Chapter 5 provides a bibliometric analysis of science and technology production and knowledge flow as a critical aspect of the state of science, technology and innovation in the participating countries. The analysis used the Scopus database as the primary data source.

The bibliometric analysis reveals that the production of science is dependent on a wide range of systemic, institutional and individual forces and that the scientific effort in most of the countries reflects physical and material realities and challenges related to the three main areas of food security, disease control and industrialisation. The analysis further assesses the impact of historical influences, particularly colonial legacies, on science in many African countries.

The study shows that knowledge production in all 19 countries, irrespective of their size, is dominated by the work of academics and scholars at the major universities. The smallest science systems on the continent often rely heavily for the production of knowledge on the role and contribution of just a few public universities (or possibly just a single university).

Whereas agricultural research dominated the research agendas of African countries in the 1990s (especially in anglophone countries), research in medicine and related fields now dominates. In addition to the challenges of dealing with traditional tropical and other infectious diseases such as sleeping sickness and malaria, the HIV/AIDS pandemic and the continuing effects of tuberculosis have led to renewed R&D effort in these areas. Issues related to food security, the effects of drought, poor crops, and the impact of internationalisation and open trade on certain markets have yet to generate appropriate R&D.

South Africa, Egypt, Algeria, Nigeria, Kenya and Tanzania have developed some local capacity in the engineering sciences, especially metallurgical and mining engineering, chemistry and chemical engineering, and physics (including nuclear physics and astrophysics). Coupled with growing pockets of expertise in electronics, mathematics and computing sciences, the shape of knowledge production in these countries differs markedly from the rest of the continent.

It should be noted that Africa's share of world science continues to decrease. The few African countries where scientific output is substantial and even growing are not as productive as developing countries elsewhere in the world; these countries therefore do not have a significant effect on the overall findings in this regard. For Africa to become more competitive with respect to scientific output will require greater investment in human capital development, the strengthening of scientific institutions and equipment, as well as significantly higher funding for science.

Chapter 6: Recommendations

Chapter 6 provides an overview of the next steps for ASTII in its contribution to addressing the challenges to STI in Africa.

Conclusion

Evidence from the implementation of the first phase of ASTII demonstrates that participating countries need to place the measurement of STI on their national development agendas, but that measuring STI is easier said than done.

This initiative is the first major African-led, politically authorised effort to generate a comprehensive and comparative survey of STI on the continent. Implemented by a network of national Focal Points, the initiative has benefited from the synergy of information exchange, the richness of diversity and shared resources. It establishes a foundation for Africa to continue experimenting and measure the effects of STI on its economic and social transformation. At the same time, the initiative leads to the creation of a community of practice in African countries.

In order to sustain the ASTII programme and increase its significance for the development and implementation of STI policy for development, additional work is required, including the use of STI indicators for policy formulation and implementation, strengthening statistical capabilities to improve the quality of data and a greater investment in human capital development.

Over time, the *African Innovation Outlook* series is expected to contribute to better understanding of the interventions required of African governments, international partners and the STI community in the further development and application of science, technology and innovation in Africa.

[1] The text makes reference to the then Office of Science and Technology in the New Partnership for Africa's Development (NEPAD) Secretariat under which the first phase of the ASTII initiative was implemented. Since the integration of NEPAD into the structures and processes of the African Union in February 2010, the NEPAD Secretariat has been transformed into the NEPAD Planning and Coordinating Agency (NPCA), and ASTII operates under its Programme Implementation and Coordination Directorate (PICD).

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