African Science, Technology and Innovation Indicators

(ASTII)

Towards African Indicator Manuals

A Discussion Document

Summary

This document provides the rationale for the development of manuals to guide the producers and users of ASTI indicators in their production, interpretation and use. It sets out the steps required to bring the NEPAD ASTII Manuals into being and to develop the African Innovation Outlook as a means of informing the public and policy makers about the state of African countries in respect of their science, technology and innovation system, and how they can advance their position, collaboratively.

A separate document, 'Towards an African Observatory of Science, Technology and Innovation' deals with the rationale for, and development of, an institution to provide co-ordination of the development of Manuals, the gathering of statistics, the development of the indicators and their publication, as well as the capacity building in African countries needed to build indicators and to use them in support of evidence-based policy.

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1. Introduction

The NEPAD Ministerial Conference on Science and Technology, November 6-7, 2003. endorsed the compilation of indicators for scientific research, technological development and innovation activities. It also stressed that it is a priority for all African countries to have comprehensive national science, technology and innovation policies with emphasis on the development of effective National Systems of Innovation.

The Ministerial Conference instructed the NEPAD Secretariat to design a programme that would generate an African Innovation Outlook (AIO). The second meeting of the NEPAD Science and Technology Steering Committee resolved that the Secretariat should establish an experts' working group to propose a comprehensive programme on indicators

This document draws on the advice of the experts' working group to provide a conceptual framework and guidelines for developing indicators of science, technology and innovation activities, and of the existence of related national policies, in an innovation system context. It provides a set of core indicators, which can be elaborated in response to comments on successive publications of the African Innovation Outlook.

A companion document, 'Towards and African Observatory of Science, Technology and Innovation', addresses the institutional arrangements needed to support the collection and analytical activities required to produce the indicators, to publish the African Innovation Outlook (AIO), and to develop the capacity of African countries to produce African science, technology and innovation indicators (ASTII), and to use them in support of evidence-based policy.

2. Science, Technology and Innovation Indicators and their Application

An indicator is a statistic, such as Gross Domestic Product (GDP), or population, or a combination of statistics, such as GDP per capita, which tells the public and the policy maker about the state of the economy and the society. Members of the public can use such information to participate in public policy debate and policy makers can use it to support the design and monitoring of evidence-based policy.

African countries recognize the importance of science, technology and innovation in economic and social change and sustainable development. These activities are also key to attaining the goals of the New Partnership for Africa's Development (NEPAD), and the United Nations Millennium Development Goals (MDGs). However, there is also a need to develop ASTII indicators to support monitoring and benchmarking of the state of the innovation system.

2.1 Using Indicators

Indicators can be used for monitoring and benchmarking of systems, for foresight analysis, or for evaluation of projects. Each use can have a different time perspective.

Monitoring (present and past)

Governments, and civil society, need indicators to understand the state of the system, to support the development of evidence-based policy, and the public policy debate which provides constructive feedback to government departments, and to other institutions of the society, such as policy research institutes, universities and industries.

Examples are the ratio of gross domestic expenditure on R&D to the Gross Domestic Product (GDP) of the country, the number of university graduates in science and engineering, or the value of imports of capital equipment. Indicators describe the present state of the system, or as close as the indicators can come to doing that, and they permit comparison with the past. The principal requirement for an indicator used for monitoring is that it be comparable over time.

Benchmarking (present and future)

The same indicators as used for monitoring can be used for benchmarking. The difference is that they are compared with target values of the indicators for some other system, or for some future time. The indicators support debate on how to move from the present state of the indicator to the desired target. That debate may point to the need for additional indicators that illuminate the path(s) to be followed.

An example is the Lagos target of a ratio of R&D spending to GDP of 1% for African countries by 2008. It becomes immediately evident that indicators of the number of people engaged in research at the present time are needed, to suggest how many will be required if the target is to be achieved. That raises questions about the production of researchers by universities, and their mobility within the system and across its boundaries through immigration and emigration. Again more indicators are needed if the picture is to be understood. As part of gathering the data to construct the indicators, best practices may be found in the organizations being surveyed which can be shared across the system. At the end of the day, the target may not be achieved, but the functioning of the system may have been improved. This is an important outcome of a benchmarking exercise.

Foresight (present and future)

Foresight is a process focused on a technology or a set of practices. It involves participants expert in the subject who meet to discern, based on their expert knowledge, the future trajectories of the subject and the interventions which might improve its development.

The future of ‘voice over internet protocol’ (VOIP) is an example as it could provide inexpensive telecommunications worldwide. The relevant indicator would be the penetration of the use of the internet by businesses and by individuals. These are core

indicators in the programme of the World Summit on the Information Society (WSIS 2005).

Evaluation (present and past)

Evaluation tends to be project based and answers questions about whether the objects were achieved, or are being achieved, and if so, whether this is being done in the most efficient and effective manner. The indicators required for this relate directly to the project, but they might be compared against national or regional indicators to situate the project within an existing community of practice.

An example is the establishment of a government laboratory to develop nanotechnologies for use in developing countries. The evaluation would look at whether research in nanotechnology was being done, and then at how it was being done. This could include comparisons of the spending for each researcher, or the distribution of researchers, technicians, and other staff, with national statistics. Finally, there would be analysis of the technology transfer to developing countries which could be measured in various ways.

In NEPAD, there is the need to propose and to facilitate the adoption of common indicators for evaluating the performance of networks of centres of excellence in the flagship programme areas (NEPAD 2003)

2.2 Indicators and Policy

For indicators to be used effectively, they must be embedded in the policy process, and that requires interaction between policy makers and statisticians.

Policy makers must be able to formulate objectives, such as the need to feed more people with domestically grown food, and programmes to move the economy and the society towards the objectives. These could include genetic research leading to more robust breeds of plants and animals, or new breeds, the development of vaccines and of better diagnostic tests for food safety.

Statisticians can then formulate survey questions which provide information on the state of these programmes (funding, number of researchers involved, …), of their outcomes (number of new plant breeds), and their impacts (increase in quantity of food delivered to market). For the process to work, there has to be discussion of the policy questions to be illuminated, leading to the formulation of survey questions, which, if answered well, will provide the information needed. The process of interaction and co-operation allows each group to do what it does best, policy analysis and development on one hand, and survey question and questionnaire development on the other. These are quite different skills, but they must be brought together if the resources available for indicator production are to be used effectively and efficiently.

In both cases, there may be need for capacity building which can be addressed by the African Observatory for Science, Technology and Innovation (AOSTI) through the provision of training, sample survey instruments, and case study templates, as well as practical advice on the development of country profiles, indicator reports, and the use of indicators in evidence-based policy.

There are examples of policies and of the need for indicators in the work following from the UN Millennium Project, and more specifically in the area of science, technology and innovation from that of Juma, Yee-Cheong and colleagues (UN Millennium Project 2005). The importance of this is that the development of the AOSTI will not happen in isolation, but as part of a world movement to bring together development and science, technology and innovation.

2.3 Indicators in Africa: Special Topics

Indicators can be used in any country for all of the purposes just discussed. However, they do require a capacity to formulate questions and to design surveys which yield useful information which can be analysed to produce indicators.

Informal Economy

In an African context there are areas of indicator development that differ from the interest of industrialized countries. The informal economy in Africa is a source of knowledge generation and of the diffusion of technologies and practices. It is not amenable to conventional mail-out and mail-back surveys, but requires interviews leading to case studies.

Indigenous Knowledge

A related topic is indigenous knowledge, as there is a wealth of such knowledge in African countries which could be used to provide medicines, improve agriculture, and to promote local culture. Again, interviews and case studies are required, which may lead to indicators. There are also issues of intellectual property protection, and the need for related indicators.

Biodiversity and Biotechnology

Biodiversity is an African asset with implications for biotechnology, pharmaceuticals, fuels, and other chemicals.

Biotechnology has the potential to provide answers to African agricultural and environmental challenges, but only if it takes account of local conditions.

Health

The presence of HIV/Aids, malaria, and tuberculosis in Africa provides both threats and opportunities for economic development. There are threats to the supply of highly qualified people which should be monitored and there are opportunities to build knowledge of dealing with such infectious diseases. Again, there is an opportunity to track this work using indicators.

Security and Connectedness

The history of Africa has fostered specialized knowledge in the areas of security and of the application of information and communication technologies (ICTs). ICTs are being promoted in Africa to bridge the digital divide (Sciadas 2003) and this is revealing the challenge of the knowledge divide (Chataway et al. 2003).

Measurement of Rare Events

Some science, technology and innovation activities in African countries will be rare events and methods will have to be developed to find them and to produce, where feasible, population estimates. As this work evolves, so will African expertise in dealing with such statistical problems.

2.4 Indicators for Country Comparisons and Resource Management

A set of indicators can be developed to describe the science and innovation system in a country, and to support the policy process and public debate. However, those indicators become even more valuable if they support comparisons with other countries in Africa.

For this to happen, there have to be agreements between country experts on definitions, on statistics, indicators, and methods of collection and of interpretation of data. The NEPAD Science Forum, working with the proposed African Science, Technology and Innovation Observatory, is well placed to bring experts together to agree upon definitions and methods, and where none exist, to develop definitions and methods appropriate to African countries. A Working Group of National Experts on African Science and Technology Indicators (NEASTI), supported by the NEPAD Science Forum and the AOSTII, would provide a means of building and sharing expertise in an African environment.

An important application of this work is the use of the indicators to identify gaps that may require government intervention. The analysis of African indicators for science, technology and innovation can also identify areas for capacity building support by donor countries. The system of indicators would then provide the business case in support of donor involvement, and then provide a means of monitoring the change resulting from the aid. African countries would determine their own destiny in the area of science, technology and innovation, and would be well positioned to call upon the rest of the world to complement their efforts. Progress would be monitored by the use of African indicators.

In some areas, the comparison of indicators will go beyond Africa, to include other developing regions, as well as the developed world. In cases such as R&D, and product and process innovation, there is a case for using existing guidelines and methods, such as those developed by the OECD (2002: 16), and establishing a partnership with the UNESCO Institute for Statistics (UIS) to collect the data.

As the experience of developing indicators, data collection and interpretation methods, and means of dissemination evolve in Africa, NEPAD should seek more formal relations with the OECD, the UIS, other UN organizations, and regional organization in other parts of the world so that expertise can be shared and the influence of African indicator expertise can grow.

3. A Framework for Indicators

Indicators help in the understanding of how the economic and social system works. That knowledge helps policy makers to change the system. A basic framework is required to support this understanding, and capacity to act, in the areas of science, technology and innovation.

What follows is an outline for such a framework which should be developed and adapted as the ASTII work evolves. A basic framework is necessary to tell the story of technological and organizational change, and the resulting economic and social outcomes.

3.1 A Basic Framework

A systems approach links the framework to existing work and practice in the area of national and regional systems of innovation. It also provides a classification of indicators, which supports discussion of indicators and their development, and it provides a means of including the policy process.

A systems approach simply means that the world of science, technology and innovation is divided into actors, which engage in activities. There are linkages between the actors and their activities and there are outcomes, which may lead to impacts at some future time.

Actors

The actors in the system are people, governments, businesses, institutions of education, non-government organizations, and other organized groups that have the capacity to engage in the activities of interest.

Actors do not act with complete independence as they exist in a context influenced by cultural practices, and by physical constraints, such as lack of natural resources, or the lack of highly skilled people. Any attempt to understand the system requires some

attention to what constrains the system, and whether those boundaries can be moved and, if so, over what time period.

Activities

The activities of interest are those related to science, technology and innovation, including the policy activities to promote them and their outcomes. Here are some examples of activities.

Activity	Characteristics of the activity
Research and Development	Creating new knowledge
Invention	Finding a novel product (good or service)
Innovation	Bringing products to market
Diffusion of technologies and practices	Absorbing, adapting and adopting
Human resource development	Educating, training and life-long learning
Policy related to STI activities	Provision of incentives and regulations

Linkages

No activity happens in isolation from the economy or the society. Culture and politics can influence what research is done, and how it is done. However, linkages are an integral part of the system and they give rise to indicators that help in the understanding of how the system functions. Here are some examples of linkages.

Linkages providing:	Characteristics for the linkage
Knowledge, technologies and people for activities	Flow of codified, embedded and tacit knowledge
Research funding, venture capital, foreign direct investment	Flow of funds for new knowledge creation and for commercialization
Policy incentives or restrictions	Education policy, environmental regulation, health and safety regulation, industrial or science, technology and innovation policy, and tax policy

Outcomes

Finally, the activities and the linkages in the system give rise to outcomes. These provide a means of monitoring the success of policy interventions and benchmarking. They are more difficult to measure than indicators of activities and linkages, but the attempt to develop indicators of outcomes is fundamental if the knowledge of the workings of the system is to be gained. Here are some examples of outcomes.

Outcomes of activities resulting in changes in:	Characteristics
Publications	Codified knowledge
Patents, trademarks, copyrights	Tradable knowledge
Market share, or productivity	Commercial advantage
Skill levels, gender distribution, or employments levels in production	Human resource development
Level of exports or imports	Increased trade
Diffusion of ICTs	Bridging the digital divide
Social behaviour	Improved quality of life

Impacts

Over time, the outcomes of the activities start to have impacts. The diffusion of mobile phones means that businesses are managed differently, and that people lead their lives differently. Genetic modification, leading to drought-resistant food plans, is not just a research outcome, but the more abundant food reduces hunger, a Millennium Development Goal, and improves quality of life.

4. African Science, Technology and Innovation Indicators (ASTII)

4.1 Core Indicators

Core indicators are those that many countries in Africa can produce. They may not be the best indicators to describe African development. However, they are well defined, and the methods for their production is well known, and they provide a basis for international comparisons outside of Africa. They have another advantage. They allow the proposed Observatory to use the collection of the core indicators as a means of identifying experts in African countries, and opportunities for capacity building, before moving on to the development of the concepts and definitions needed to build indicators that are unique to Africa and which require more work

Some core indicators for consideration are the following.

Knowledge Creation

- R&D Expenditures on performance, and on funding, for each sector of the economy.

- Researchers, technicians, and support staff engaged in R&D, by sector of the economy.

Knowledge Transfer

- Patents, by country of origin.
- Publications, by country of origin

Knowledge Use

- Percentage of firms that have introduced new or significantly improved products to the market over the last three years, or new or significantly improved processes for the production of products, or their delivery, new market development, and organizational change or the use of new or significantly improved business practices over the last three years.
- Penetration rates for information and communication technologies (ICTs) and their applications.
- Penetration rates of appropriate technologies. These could include the use in agriculture of tractors and animal drawn implements, the use of improved wood stoves in households, the availability of electricity in rural regions, and energy use, more generally. Other indicators could be developed.

Knowledge Infrastructure

- University graduates in subjects related to science, technology and innovation.

Knowledge Governance

- Government policies related to R&D, invention, innovation, diffusion, and education and training of human resources for science and technology.

4.2 Wider Scope for Indicators

An African success is the spread of food franchises which not only sell food, but make money. They are using technologies and management practices to create wealth and they could be a subject of an early study by the staff of the Observatory, to provide ideas and best practices.

Another success is the spread of mobile phones and their use in business and in mobile banking. Indicators of diffusion of mobile technologies and of their use would inform policies on ICT diffusion and on entrepreneurship.

Indicators could be developed for each of the areas noted in Section 2.3 where there will be knowledge and experience in African countries.

While science, technology and innovation activities are key to achieving the UN MDGs, as noted in Section 2, some of indicators related to the MDGs are of use for better understanding of these same activities. Examples are the percentage of people in a country below an agreed poverty line (MDG 1), the availability to children of a full course of primary schooling (MDG 2), and the participation rate, by gender, in primary

and secondary education (MDG 3). A set of such indicators would provide a context for interpreting more STI specific indicators.

4.3 The Process of Indicator Development

Most science, technology and innovation indicators have their origin at the OECD where experts meet regularly, both statisticians and policy makers, to discuss concepts and definitions, and to develop manuals, handbooks, and guidelines to guide member countries in the production of statistics for indicators, and the interpretation of the indicators. Statistics are then gathered in co-operation with the UNESCO Institute of Statistics for non-OECD countries, indicators are published in OECD publications, and they are then used for monitoring and benchmarking and in support of foresight, and evaluation.

The proposed Observatory can be the equivalent organization for Africa, managing expert committees from African countries and producing manuals, the AIO, and providing capacity building, all as part of improving the understanding of the dynamics of African innovation systems.

4.4 International Collaboration and an African Voice

Specific technologies are attracting world interest and the most immediate example is the set of technologies and applications related to the information society, as part of the UN World Summit on the Information Society (WSIS). WSIS was last held in Geneva in 2003 and the next meeting is scheduled for Tunis in November 2005. At a thematic meeting on indicators in Geneva in 2005, a set of core indicators was agreed (WSIS 2005) and these should be taken note of by the proposed Observatory and integrated into the AIO, even if they are being gathered by other international organizations.

This raises the importance of international collaboration to share expertise and to reduce burden on respondents. The UNESCO Institute for Statistics (UIS) is well positioned to collect data on R&D and on education from countries in Africa, and it can provide help in capacity building. An important role for the Observatory would have to be managing the collection of statistics on science, technology and innovation from African countries, and sharing the collection, analysis and dissemination activities. The UIS is not alone in this area, as more and more international organizations are taking an interest in data collection and indicator development.

However, for there to be a dialogue about indicator development with UN organizations, Eurostat, the OECD, and national organizations outside of Africa, there must be a single African voice for the development and application of indicators of science, technology and innovation activities.

5. A Comprehensive Programme of Indicators

A knowledgeable and active Secretariat is essential to the development of comprehensive programme of indicators. The skills required by the Secretariat include knowledge of the subject matter, as well as the diplomatic and organizational skills needed for dealing with policy departments, regulators, and statistical offices in participating countries. Entrepreneurial and communication skills are also needed for the production and distribution of publications such as the African Innovation Outlook.

To identify the magnitude of the requirement, there are 24 staff in the OECD Economic Analysis and Statistics Division (EASD), and about the same in the Information, Computer and Communications Policy Division (ICCPD). The staff distribution is about 60% professional, 30% technical and 10% clerical. They deal with 30 member countries and active observer countries, such as China, the Russian Federation, and South Africa. They manage committees, write committee papers of a high quality, manage and contribute to the development and revision of manuals, and they produce the OECD Outlooks (OECD 2003, 2004, 2004a), Scoreboards (2003a) and the Main Science and Technology Indicators (2004b).

At Eurostat, serving 25 member countries, there are 16 people responsible for Research, Development and Innovation indicators, and about the same number dealing with the information society. The staff distribution is about 60% professional, 25% technical and 15% clerical. The smaller staff reflects some of the benefits of close collaboration with the OECD, and a differences in the publication programme. The research, development and innovation group does not produce an outlook or a scoreboard, although it does contribute to publications in other parts of the Commission (European Commission 2003), it does publish a bulletin (Eurostat 2004)) and occasional publications such as the one on the third Community Innovation Survey (Eurostat 2004a)

The UNESCO Institute for Statistics, by contrast, has only 6 people working on science, technology and innovation indicators for the non-OECD world and 5 dealing with the information society at the headquarters in Montreal. However there is additional support from policy colleagues at UNESCO headquarters in Paris, and there are UIS staff in regional offices. In Africa, Nairobi is the regional S&T office, and there are statisticians in Dakar and Harare. UIS is implementing its strategy (UIS 2003) for science and technology statistics and is open to collaboration on the NEPAD STII initiative.

For NEPAD to deal with more than 50 countries in Africa, in a way similar to that of the OECD, about 50 people (30 professional, 15 technical, and 5 other support staff) would be required, and that is before the need to provide capacity building expertise to participating countries is met. This may be a long term goal, rather than an immediate objective, but for there to be a comprehensive indicators programme, there must be agreement on the long term goal, and on how to get there, backed up by the commitment of resources. It may also not be necessary to develop such a large organization if some objectives can be accomplished through collaboration with other national and international organizations.

The implementation strategy, with options for the indicators programme, is dealt with in 'Towards an African Observatory of Science, Technology and Innovation'. The requirement for a professional and well supported staff is stated here as, without such an investment, a comprehensive programme of indicators is not possible.

6. African Indicator Manuals

A manual is a process. It begins with the subject of common interest, and discussion based on country experience. After a period of experimental surveys and analysis, and policy development, common issues emerge. This is the point at which knowledge based on the common experience is codified and made available in the form of a manual. The manual makes it easier to communicate the accepted concepts, definitions and methods for the collection, analysis, interpretation, and use of the data. It also supports the publication of statistics gathered using the manual as a guide and the publications provide feedback to the process.

As surveys, applications of the resulting indicators, and the monitoring of the results of evidence-based policy evolve, gaps are identified and experts begin the process of revision of the manual, leading to the next edition and iteration of its use. To facilitate this, the African Innovation Outlook is essential.

From the African perspective, the key issues are the sharing of common interests and experience. For this to happen, the proposed African Observatory for Science, Technology and Innovation has to be established, the experts identified, and the sharing of the African experience begun.

There is experience in Africa of measuring R&D expenditure and personnel and this could be used to develop a manual that included African examples and African applications of R&D policy. Ideally, this would draw upon the Frascati Manual (OECD 2002) for concepts and definitions, but it would be quite different when it came to survey methods and to policy. Survey methods have to be adapted to situations in African countries (UNI-INTECH 2004), and the inclusion of policy instruments and governance of knowledge in the manual would distinguish it from the OECD 'Frascati Family' of manuals.

Innovation measurement provides more scope for development of shared experience in African, experience which could be shared more broadly. The 1997 Oslo Manual (OECD/Eurostat 1997) deals with two kinds of innovation: product and process. The third edition to be approved in 2005 will add two more kinds of innovation: market development, and organization, including new uses of business practices. During the next few years OECD and EU countries will be learning how to measure market related innovation and orgnanizational innovation and there is great scope here for the development and use of African experience in world fora. Again, the inclusion of policy instruments as part of understanding the innovation systems would be key to African leadership.

The mobility of human resources related to science and technology is an issue for Africa and there is a leadership opportunity in developing measures of the production and flow of graduates within Africa and to and from other countries. This would fit well with OECD and EU initiatives in this area.

Technology diffusion and the social and economic impact of that diffusion is an area that could be developed, along with measures of globalization.

In ten years, there should be a well respected Working Group of National Experts on African Science and Technology Indicators (NEASTI) and the first members of a growing family of African manuals on measuring technological and related social change and a record of measurement and analysis in the African Innovation Outlook. Achieving this is the challenge

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Appendix 1:

Members of the Experts' Working Group on African Science, Technology and Innovation Indicators (Meeting May 3-5, 2005)

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