AFRICAN INNOVATION OUTLOOK II

April 2014

SWEDEN

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For further information about ASTII, contact

African Science, Technology and Innovation Indicators Initiative

NEPAD Science, Technology & Innovation Hub

NEPAD Planning and Coordinating Agency

CSIR Building 10F

Meiring Naude Road,

Lynnwood, Pretoria

South Africa

Postal address:	P O Box 395, Pretoria 0001, South Africa
Tel:	+27 (12) 841 3904
Fax:	+27 (12) 841 4414
Website:	www.nepad.org

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The reference period for the R&D surveys is 2010 except for Burkina Faso (2009 and 2010), Mozambique (2011) and Zimbabwe (2012).

The reference period for the innovation surveys is 2008-2010. Exceptions are (Kenya 2008-11), Gabon and Lesotho (2010-12), Senegal (2009-11) and South Africa (2005-2007).

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Coordinator is also acknowledged for holding the fort while a substantive Coordinator was being sought.

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CONTRIBUTORS TO THE REPORT

The second edition of the African Innovation Outlook (AIO-II) was developed under the general direction of H.E. Dr Ibrahim Assane Mayaki, CEO of the NEPAD Agency.

CORE TEAM

The report was prepared and coordinated by a core team consisting of the following, in alphabetical order:

Prof Claes Brundenius

Prof Fred Gault

Dr Almamy Konte

Dr Luciana Marins

Dr Philippe Mawoko

Dr Neo Molotja

Prof Luke Mumba

Mr Rohan Pathirage

Mr Martin Schaaper

Mr Lukovi Seke

Dr Moses Sithole

Dr Bi Irié Vroh

ASTII NATIONAL FOCAL POINTS

The ASTII Focal Points shown with asterisks (*) undertook the surveys at national level and submitted data to ASTII.

COUNTRY	MINISTRIES	NATIONAL STATISTICS OFFICE AND OTHERS
1. **ALGERIA**	**Prof Mokhtar Sellami:** Directeur Développement Technologique et Innovation Direction Général de la Recherche Scientifique et Développement Technologique, Ministère de l'Enseignement Supérieur et Recherche Scientifique	
2. **ANGOLA***	**Dr Domingos da Silva Neto:** National Director, Scientific Research Ministry of Science and Technology	**Mr Nlando Mpaka:** Technician of Department of Demographic and Social Statistics
	Ms Emingarda Patricia Castelbranco: Head of Scientific Research Promotion, Department Ministry of Science and Technology	
3. **BENIN**	Dr Hounzangbe-Adote Sylvie: Directeur National: Recherche Scientifique & Technologique, Direction Nationale de la Recherche Scientifique et Technique, Ministère de l'Enseignement Supérieur et Recherche Scientifique	
	Dr Joslyn Kouton: Chef du Service de Coordination et de Suivi-Evaluation des Activités de Recherche, Direction Nationale de la Recherche Scientifique et Technique, Ministère de l'Enseignement Supérieur et Recherche Scientifique	
4. **BOTSWANA**	**Ms Lesego Motoma:** Director, Department of Research, S&T, Ministry of Infrastructure, Science and Technology	**Ms Ketso Makhumalo:** Statistics Botswana
	Dr Abraham Mathodi: Principal Research Officer (M & E) Department of Research, Science and Technology	
5. **BURKINA FASO***	**Prof Compaoré R.A. Maxime:** Secrétaire Général, Ministère de la Recherche Scientifique et de l'Innovation	**Dr Placide Some Sankar:** Ingénieur Statisticien Economiste, Institut National de la Statistique et de la Démographie

COUNTRY	MINISTRIES	NATIONAL STATISTICS OFFICE AND OTHERS
6. **BURUNDI**	**Dr Tatien Masharabu:** Director-General: Science, Technology & Research, Ministry of Higher Education and Scientific Research	
7. **CAMEROON**	**Dr Roger Noël Iroume:** Inspecteur Général #2, Ministère de la Recherche Scientifique et de l'Innovation	**Dr Séverin Tchomthe:** Ingénieur Statisticien Economiste, Institut National de la Statistique
8. **CAPE VERDE***	**Dr Emanuel Borges:** Head: Data Collection and Processing, Ministry of Higher Education, Science and Innovation	**Mrs. Alicia Maria da Cruz Mota:** Statistician, National Institute of Statistics
9. **CHAD**	**Dr Moussa Isseini:** Directeur de la Recherche Scientifique et Technique, Ministère de l'Enseignement Supérieur et de la Recherche Scientifique	**Dr Fata Rouane:** Ingénieur Statisticien Economiste, Institut National de la Statistique, des Etudes Economiques et Démographiques Chef de Service des Etudes et Statistiques Sociales
10. **CONGO**	**Prof Clobite Biona Bouk:** Conseiller du Ministre, Ministère de la Recherche Scientifique et Innovation Technologique	
11. **CONGO, Dem. Rep.**	**Dr Maurice Iyanza Mbako:** Directeur & Coordonnateur: Etudes et Planification, Secrétariat Général de la Recherche Scientifique, Ministère de l'Enseignement Supérieur	**Mr Mingiedi Matondo Boaz:** Comptable National, Institut National de la Statistique
12. **EGYPT***	**Prof Dr Maged Al-Sherbiny:** President of Academy of Scientific Research and Technology, Academy of Scientific Research and Technology	
	Dr Nora Adel Zaki: Technical manager, Academy of Scientific Research and Technology	
13. **ETHIOPIA***	**Dr Getachew Atintie:** Director, Plan Preparation and Implementation Directorate, Ministry of Science and Technology	
	Ms Zebiba Abdo Ibrahim: Senior expert: Plan Preparation and Implementation Directorate, Ministry of Science and Technology	

COUNTRY	MINISTRIES	NATIONAL STATISTICS OFFICE AND OTHERS
14. **EQUATORIAL GUINEA**	**Dr Ondo Mba Teodoro:** Directeur Général, Ministère de l'Education & Recherche Scientifique	
15. **GABON***	**Dr Anasthasie Obono Mba, épouse Essono:** Directeur de la Planification, Ministère de l'Education Nationale, de l'Enseignement Supérieur, de l'Enseignement Technique et de la Formation Professionnelle	**Mr Jean Nestor Nguema Mebane:** Ingénieur Statisticien-Economiste en Chef, Direction Générale de la Statistique, Ministère de l'Économie et des Finances
16. **GHANA***	**Dr Emmanuel K. Tetteh:** Research Scientist, Science and Technology Policy Research Institute	**Mr Johnson Kagya Owusu:** Senior Statistician, Ghana Statistical Service
17. **KENYA***	**Dr Richard Mavisi Liahona:** Assistant-Director, Directorate of Research Management and Development, Ministry of Higher Education, Science and Technology	**Ms Rosemary Uside-Kongani:** Statistician, Kenya National Bureau of Statistics
18. **LESOTHO***	**Dr Lefa Thamae:** Director, Science & Technology, Ministry of Communications, Science & Technology **Dr Tsepo Ntho:** Senior Research Officer, Department of Science and Technology, Ministry of Communications, Science & Technology	**Ms Malehloa Molato:** Statistician, Bureau of Statistics
19. **LIBERIA**	**Mrs Sangay Faeflen:** Director, Science and Technology, Ministry of Education **Mr Prince Drubo Quayeson:** Science Coordinator, Division of Science and Technology, Ministry of Education	**Mr Francis F. Wreh:** Deputy Director General for Statistics and Data Processing, Liberia Institute of Statistics and Geo-Information Services
20. **MALAWI***	**Dr Patrick Mphadzula:** Acting Director, Department of Science and Technology, Ministry of Education, Science and Technology	**Ms. Angela Msosa:** Chief Statistician, National Statistics Office
21. **MALI***	**Prof Mohamed Dicko:** Chef de Division, Recherche Scientifique, Centre National de la Recherche Scientifique et Technologique	**Mr Modibo Traore:** Chef de division statistiques environnementales, Département des statistiques agricoles et environnementales

COUNTRY	MINISTRIES	NATIONAL STATISTICS OFFICE AND OTHERS
22. **MAURITIUS**	**Dr Ricaud Auckbur Gervais Danyel:** Director: Ministry of Tertiary Education, Science, Research and Technology	**Mr Dharsing Pothegadoo:** Statistician, Statistics Mauritius
23. **MOZAMBIQUE***	**Dr Mety Oreste Gondola:** Deputy National Director , Directorate of Planning, Statistics and Cooperation, Ministry of Science and Technology	**Dr Xadreque Maunze:** Chief of Department of Demographic Studies, National Institute of Statistics
	Mr Maximiano Dgedge: Head of Statistics Department, Ministry of Science and Technology	
24. **NAMIBIA***	**Dr Alfred Adriaan van Kent:** Director, National Research, Science, Technology & Innovation, Ministry of Education	**Ms Linda-Vute Shitenga:** Statistician, Central Bureau of Statistics
	Mr Collins Mushe: Senior Programme Officer, National Commission on Research, Science and Technology, Department: Research, Science and Technology Coordination and Support	
	Dr Eino Mvula: Chief Executive Officer, National Commission on Research Science and Technology	
25. **NIGER**	**Dr Hassirou Mouhamadou:** Directeur de la Recherche Scientifique, Ministère des Enseignements Moyen et Supérieur et de la Recherche Scientifique	
	Mr Amadou Illya: Chef de la Division de la Recherche Scientifique, Ministère des Enseignements Moyen et Supérieur et de la Recherche Scientifique	
26. **NIGERIA***	**Dr Willie O. Siyanbola:** Director-General/Chief Executive Officer, National Centre for Technology Management	
	Mr David Adeyeye: Senior Planning Officer, Planning and Coordination Department, National Centre for Technology Management	

COUNTRY	MINISTRIES	NATIONAL STATISTICS OFFICE AND OTHERS
27. **RWANDA**	**Dr Twiringiyimana Remy:** Acting Director General, Science Technology and Research, Ministry of Education	**Dr Gasingirwa M.Christine:** Kigali Institute of Science and Technology
28. **SENEGAL***	**Dr Nouhou Diaby:** Conseiller Technique du Ministre, Ministère de l'Enseignement Supérieur et de la Recherche	**Mr Samba Ndiaye:** Statisticien: Direction des Statistiques Démographiques et Sociales, Agence Nationale de la Statistique et de la Démographie
	Dr Toumane Doumbouya: Coordinateur des Centres de Recherche et d'Essais (CRE), Direction de la Recherche Technologique, Ministère de l'Enseignement Supérieur et de la Recherche	
29. **SOUTH AFRICA***	**Dr Godfrey Mashamba:** Chief Director/General Manager, S&T Investment, Department of Science and Technology	
	Ms Rose Msiza: Deputy Director: Science and Technology Indicators, Department of Science and Technology	
30. **TANZANIA***	**Mrs Blandina Mkayula:** Senior Education Officer, Ministry of Science, Technology and Higher Education	**Dr Dugushilu Mafunda:** Principal Research Officer, Tanzania Commission for Science and Technology
		Mr Festo Maro: Senior Researacher, Tanzania Commission for Science and Technology
31. **TOGO***	**Prof Messanvi Gbeassor:** Director: Scientific and Technical Research, Ministry de l'Enseignement Supérieur	**Mr Bika Koudjo Dzidéfo:** Ingénieur des Travaux Statistiques, Direction générale de la statistique et de la comptabilité nationale
	Dr Amegnona Agbonon Maître de Conférences Facultés des Sciences (Associate Professor), Université de Lomé	

COUNTRY	MINISTRIES	NATIONAL STATISTICS OFFICE AND OTHERS
32. **TUNISIA**	**Dr Rachid Ghrir:** Directeur Général, Ministère de l'Enseignement Supérieur, Recherche Scientifique et Technologique	**Dr Arbia Ben Othman :** Observatoire National des Sciences et de la Technologie, Ministère de l'Enseignement Supérieur, Recherche Scientifique et Technologique
33. **UGANDA***	**Mr Suudi Kizito:** Senior Engineer, Ministry of Trade, Industry and Cooperatives	**Ms Imelda Atai Musana:** Principal Statistician and Head, Business and Industry Statistics, Uganda Bureau of Statistics
		Dr Richard Lutalo: Senior Science Officer, Uganda National Council for Science and Technology
34. **ZAMBIA***	**Ms Dorothy Kasote (Deceased):** Principal Systems Analyst, Ministry of Education, Science, and Vocational Training	**Ms Nchimunya Nkombo:** Principal Statistician, Central Statistics Office
		Mr Filipo Zulu: Programme Officer – Policy, Regulation Monitoring and Evaluation, National Science and Technology Council
	Dr Lackson Tonga : Chief Science and Technology Officer, Ministry of Education, Science, and Vocational Training	**Dr H. Kaunda:** Senior Statistician, Ministry of Commerce, Trade and Industry
35. **ZIMBABWE***	**Dr Willie Ganda:** Director, Research Development and Innovation, Ministry of Higher and Tertiary Education, Science and Technology Development	
	Mr Musari Charles: Acting Deputy Director, Research and Development, Information Services, Ministry of Higher and Tertiary, Education, Science and Technology Development	

ASTII SECRETARIAT

The Secretariat for the ASTII programme consisted of:

Prof Luke Mumba (ASTII Programme Coordinator)

Mr Lukovi Seke (Research Assistant)

Mrs Manana Masholugu (Personal Assistant to the Programme Coordinator)

COORDINATING TEAM

The overall coordination for the production of the Outlook consisted of:

Prof Aggrey Ambali, Head and Advisor, NSTIH

Prof Luke Mumba, ASTII Programme Coordinator, NSTIH

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ACRONYMS

AfDB	African Development Bank
AIMS	African Institute for Mathematical Sciences
AIO	African Innovation Outlook
AMCOST	African Ministerial Council on Science and Technology
AMU	Arab Maghreb Union
AOSTI	African Observatory for Science, Technology and Innovation
ARC	Average of Relative Citations
ARIF	Average Relative Impact Factor
ASTII	Science, Technology and Innovation Indicators
AU	African Union
AUC	African Union Commission
BERD	Business enterprise sector
CEN-SAD	Community of Sahel-Saharan States
CeSTII	Centre for Science, Technology and Innovation Indicators
CI	Collaboration Index
CIS	Community Innovation Survey
COMESA	Common Market for Eastern and Southern Africa
COSTECH	Tanzanian Commission for Science and Technology
CPA	Consolidated Plan of Action
CREST	Centre for Research on Science and Technology
EAC	East African Community
ECA	United Nations Economic Commission for Africa
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
EU	European Union
FDI	Foreign direct investment
FTE	Full-time equivalent
GDP	Gross domestic product
GERD	Gross domestic expenditure on research and experimental development
GI	Growth index
GOVERD	Government sector

HC	Headcount
HERD	Higher education R&D expenditure
HSRC	Human Sciences Research Council
ICR	International Collaboration Rate
ICT	Information and communication technology
IGAD	Intergovernmental Authority on Development
IERI	Institute for Economic Research on Innovation
ISCED	International Standard Classification of Education
MDG	Millennium Development Goal
NPCA	NEPAD Planning and Coordination Agency
NCR	National collaboration rate
NEPAD	New Partnership for Africa's Development
NEPAD OST	NEPAD Office of Science and Technology
NESTI	National Experts on Science and Technology Indicators
NSI	National system of innovation
NSTIH	NEPAD Science, Technology and Innovation Hub
OECD	Organisation for Economic Cooperation and Development
PNP	Private non-profit organisation
PPP	Purchasing power parity
PRI	Public research institution
R&D	Research and development
RCR	Regional collaboration rate
REC	Regional economic community
RPI	Research Policy Institute
SADC	Southern African Development Community
SI	Specialisation Index
SIDA	Swedish International Development Cooperation Agency
STI	Science, technology and innovation
UIRI	Uganda Industrial Research Institute
UIS	UNESCO Institute for Statistics
UN	United Nations
UNCST	Uganda National Council for Science and Technology
UNESCO	United Nations Educational, Cultural and Scientific Organisation
UNU	United Nations University
UNU-MERIT	United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology

PREFACE

The NEPAD African Science, Technology and Innovation Indicators (ASTII) Initiative originated from the first African Ministerial Council on Science and Technology (AMCOST) meeting in Johannesburg, 2003 which resolved to "Develop and adopt common sets of indicators to benchmark our national and regional systems of innovation". If appropriately applied, STI indicators can be useful tools for any nation or business, as they can result in cost effective strategic planning of available resources, priority setting on resource use, and monitoring and evaluation of programmes and activities. In September 2005, AMCOST adopted the AU's Africa Science and Technology Consolidated Plan of Action (CPA) which has a specific programme of work on the development and use of STI indicators. The ASTII Initiative was launched in 2007 by the New Partnership for Africa's Development (NEPAD) as one of the programme areas of the CPA to improve policy conditions and build innovation mechanisms.

The first phase of the initiative took place in 19 African countries and was successfully completed with the production and release of the first African Innovation Outlook (AIO-2010) in May 2011. The release of the AIO-2010 coincided with the ushering in of the second phase of ASTII. ASTII Phase-II has, among other achievements, seen improved human capacity on STI indicators in 35 AU member states, the release of three policy briefs and four research papers on matters emerging from AIO-2010, and the publication of the second edition of the African Innovation Outlook (AIO-II). In the second phase, the participation of AU member states increased by 54%, from 19 countries to 35. Of the 35 countries participating in ASTII Phase-II, 21 (60%) conducted national surveys and have contributed data to this report. These figures are a confirmation of the growing demand by AU member states for reliable indicators for strategic planning and monitoring of the state of STI and competitiveness of their economies. It is an honour to have witnessed ASTII growing from a mere intention to concrete and tangible outputs. We commend and encourage the collaborative efforts of the 21 AU member states that have contributed data in this round of R&D and Innovation surveys for bringing this second edition of the AIO to reality. Overall, the countries participating in ASTII have demonstrated high commitment to the objectives of the initiative which has accounted for the good progress that the programme has registered. The interest shown by countries is growing and the programme continues to work on developing the capacity of AU member states to conduct surveys.

ASTII interventions have contributed to the number of AU member states that now have national STI indicators and statistics as a basis for developing their policies. Countries like Kenya and Nigeria have recently carried out STI policy reviews based on the messages that have emerged from their national survey data. Legitimisation of STI data as part of national statistics has resulted in a high degree of independence among the member states which were traditionally dependent on sources outside the continent for status reports on STI in their countries.

As was the case with the previous AIO, a number of challenges emerged in producing this second edition of the Outlook and in implementing ASTII-II; and a number of lessons have been learned. We encourage countries to use this cumulative knowledge to improve the collection of STI measurements, analysis and usage to inform STI policy making processes in Africa. The process leading to the production of this report indicates that there is more work to be done in order to produce comparable statistics across the continent. In this regard, extensive human capital development is recommended. There is also a lack of continuity in countries' participation in the round of surveys which affects data series and makes comparisons difficult. We recommend that AU member states continue to mobilise stakeholders to ensure ownership and institutionalisation of STI measurements within their countries.

As indicted in this Outlook, ASTII has stimulated AU member states to start developing STI indicators. It has enabled some countries to start conducting R&D and innovation surveys and to build national capacities for indicators to inform STI policy formulation and review. AU member states have made strides to create better knowledge and understanding of the value of STI indicators and are moving towards institutionalising ASTII through national focal points. We commend the numerous AU member states that have invested their resources in implementing the ASTII programme and we encourage those AU members that have not yet moved in this direction to do likewise. We also commend the role that CeSTII of the Human Sciences Research Council of South Africa continues to play in providing skills training to other English speaking AU member states and sharing its experience of STI measurement in Africa. We cannot forget the contributions of experts from the Kenya National Bureau of Statistics (KNBS); the Uganda National Council for Science and Technology (UNCST); and the National Centre for Technology Management (NACETEM) in Nigeria in sharing their experiences on STI indicators with their peers on the ASTII project and in technical meetings. It is through this kind interaction and collaboration that Africa will be able to develop indigenous capabilities to address African STI-specific problems crucial for the socio-economic transformation of the continent.

Our profound expressions of appreciation and special gratitude are extended to the Government of Sweden and the Swedish International Development Cooperation Agency (SIDA) for making generous resources available for the execution of the ASTII initiative. Equally encouraging has been the collaboration with partner institutions with vital experience in STI indicators which have gone a long way to support the implementation of the ASTII initiative. In particular, we are indebted to the Research Policy Institute (RPI) of the University of Lund and the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Institute for Statistics for sharing their experience on STI measurements in OECD countries and in Africa.

In the coming years, NEPAD-ASTII in collaboration with AOSTI will intensify efforts to expand the ASTII initiative to all AU member states as well as to widen the scope of the initiative to include coverage of innovations in the informal sector and the use of indicators in policy making and sustainable development. We appeal to African governments and other stakeholders to institutionalise STI data collection and production of indicators in their countries and institutions.

HE Dr Ibrahim Assane Mayaki
CHIEF EXECUTIVE OFFICER
NEPAD AGENCY

HE Dr Martial De-Paul Ikounga
COMMISSIONER
AUC-HUMAN RESOURCES, SCIENCE AND TECHNOLOGY

EXECUTIVE SUMMARY

INTRODUCTION

Science, technology and innovation (STI) are engines of growth in any economy. Realising that Africa can also benefit from STI activities, in 2005 the African Ministerial Council on Science and Technology (AMCOST) adopted Africa's Science and Technology Consolidated Plan of Action (CPA) which articulates the African Union (AU) agenda for harnessing STI to boost economic growth and improve the lives of African people.

The challenges are how to link science, technology and innovation to poverty reduction, job creation, sustainable livelihoods and the improved well-being of citizens. How should capacity and competencies be built in order to innovate? As countries engage in knowledge intensive activities, how will Africa expand its knowledge? Understanding the concepts of STI should support prudent policy formulation and research agendas that address economic and social challenges. Assessing STI is fundamental to formulating policies but in the absence of relevant indicators this is difficult. Most African countries do not have STI indicators or adequate means to produce them, with the reasons for this inadequacy differing from country to country. The lack of STI indicators is of serious concern when evidence-based decisions and policies have to be made. The development of the CPA, which outlined among other things the need to develop STI indicators in Africa, is a result of this concern. The implementation of the CPA to develop STI indicators bore fruit when the African Science, Technology and Innovation Indicators (ASTII) initiative was launched in 2007.

The first phase of the ASTII initiative was implemented in 19 countries: Algeria, Angola, Burkina Faso, Cameroon, Egypt, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia. The outcomes of this phase include building STI capacity and related activities in Africa and the publication of the first African Innovation Outlook (AIO) in 2010 (AU-NEPAD, 2010). The AIO was launched as a first of the series aimed at publishing STI indicators in Africa. The publication presented research and development (R&D), innovation and bibliometric indicators. The baseline year for the data was 2007 although some countries submitted data collected for the 2008 financial year. The report also highlighted structural issues that constrain economic growth and human development and the role of STI in resolving some of these issues.

The number of countries participating in this phase increased from 19 to 35 between 2011 and 2013. New countries joining the project were Benin, Botswana, Burundi, Cape Verde, Chad, Congo, the Democratic Republic of Congo, Equatorial Guinea, Liberia, Mauritius, Namibia, Niger, Rwanda, Togo, Tunisia and Zimbabwe. Focal points were identified and training on how to conduct surveys was provided.

The first intergovernmental meeting on ASTII held in Maputo in 2007 decided that countries should use the already established Frascati and Oslo Manuals to collect data while efforts are made to develop guidelines for collecting and interpreting data for indicators in African countries (NEPAD, 2007). Both the first and second phases of the ASTII initiative used the OECD's Frascati Manual for conducting the R&D surveys while the innovation surveys used the OECD/Eurostat Oslo Manual.

This report presents the results of the R&D and innovation surveys and bibliometric studies as well as information on the status of STI policies and/or strategies of each country.

In the case of R&D surveys, the baseline year is 2010, though some countries provided more recent data. Angola, Cape Verde, Egypt and Lesotho provided R&D data for 2011 and data from Zimbabwe is for 2012.

Six countries (Egypt, Ghana, Mali, Tanzania, Uganda and Zambia) provided innovation data for the period 2008-2010; Gabon and Lesotho data are for 2010-2012; while data for Kenya, Senegal and South Africa is for 2008-2011, 2009–2011 and 2005-2007 respectively.

Bibliometric data was sourced from the study undertaken by AOSTI and the results presented in this report are for the countries participating in the ASTII initiative. Chapter 2 generally speaks to STI policy activities in the selected African countries.

MAIN FINDINGS

Chapter 1: Introduction and background

This chapter outlines the rationale for the NEPAD-ASTII programme and the creation of the African Observatory of Science, Technology and Innovation (AOSTI), the methodologies used and other activities leading to the production of this report.

Chapter 2: Science, Technology and Innovation activities in Africa

Most countries in Africa have Ministries of Science and Technology (and Innovation). Most are stand-alone while some are combined with Ministries of Education and other Ministries such as Communication and Finance. ST&I polices tend to be decided at this level with most countries having such policies although those of Lesotho and Senegal, designed in 2006, are still to be passed by the Council of Ministers or Cabinet. There are common issues in most countries that require policy intervention. These include STI governance and capacity, human resource development, boosting R&D performance and promoting innovation. Relatively few countries have stand-alone innovation policies or strategies. While science remains crucial to innovation, innovation goes beyond research and development. Therefore innovation policies have to move beyond science and technology to embrace the multidimensional nature of innovation.

Chapter 3: Research and experimental development

This chapter presents the results of the R&D surveys and highlights investments in R&D in terms of expenditure and personnel.

The following 19 countries provided R&D data: Angola, Burkina Faso, Cape Verde, Egypt, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Namibia, Senegal, South Africa, Tanzania, Togo, Uganda and Zimbabwe. Data for Egypt and Namibia are partial (incomplete personnel and expenditure data) and data for Gabon relate to personnel only.

Gross domestic expenditure on research and experimental development (GERD): GERD is an indicator widely used in assessing national scientific and technological strength, and provides information on how much a country invests in R&D. Used in conjunction with measures of gross domestic product (GDP), it illustrates R&D intensity or GERD as a percentage of GDP.

- The survey results show that R&D intensity in most of African countries is still far below the 1% which is the current target for AU member countries. GERD/GDP ratios vary widely across the continent, as indicated by the reported data. However, data from some countries is partial and the true value of the expenditure may therefore be under-reported.
- **GERD by sector of performance:** 13 (68%) of participating countries performed their R&D in the public sector (higher education and or government sector). Kenya, Malawi and Mali reported public R&D intensity above 0.50%. Under-investment is very pronounced in the business sector across Africa.
- **GERD by sources of funding:** Government continues to be the main source of funding for R&D activities in Africa. This is particularly so in Ghana where 68.3% of its R&D expenditure was funded by government. Except in South Africa where business-funded R&D amounted to 40.1% of the total, funding from the business sector in other countries is low. Kenya, Mozambique, Senegal and Uganda have more than 40% of their R&D financed from abroad. At 12.1 %, South Africa was the least dependent on foreign funding for its R&D performance.
- **GERD by type of research:** Kenya and Zimbabwe devoted more than 50% of their R&D expenditure to basic research, followed by Togo at 37.6% and Uganda at 34.7%. Lesotho, Malawi and Mozambique spent between 60% and 70% of the total on applied research. Countries spending more than 15% on experimental development research expenditure activities include Ethiopia, Ghana, Kenya, South Africa, and Uganda.

R&D personnel: These are all persons employed directly on R&D as well as those providing related services such as R&D managers, administrators and clerical staff.

- **Total R&D personnel:** Egypt, Kenya and South Africa reported the largest absolute numbers of R&D personnel and the highest numbers in proportion to population per million inhabitants. Egypt reported 1 688 R&D personnel per million inhabitants, followed by Kenya (1 529) and South Africa (1 108). Ten out of the 17 countries that provided R&D personnel data indicated that researchers make up more than 50% of their R&D personnel. This ranged from 55.6% reported by Ethiopia to 87.7% reported by Cape Verde.
- **Participation by women in R&D activities:** This was about 30% for R&D personnel and 24% for researchers in the countries that submitted data.
- **Sectoral distribution of R&D researchers:** Across all countries, between 60% and 80% of researchers were employed in higher education. The only exceptions were Uganda, with 50% of its researchers based in the business sector, and Mali which had an even spread of researchers across all sectors.
- **Percentage of R&D personnel with Doctorates:** None of the countries reported more than 50% of R&D personnel with doctoral degrees.

- **Full-time equivalent (FTE):** This is a measure of the total volume of R&D performed by the R&D personnel. Data, as presented, are difficult to interpret; however time spent on R&D by the personnel involved is on average above 50%.
- **Field of science:** Few countries track R&D personnel by this criterion. Countries with researchers performing engineering and technology research were Cape Verde (35.9%), Mozambique (22.0%) and Malawi (20.2%). Burkina Faso's researchers were primarily involved in the medical and health science fields (42.0%). The largest percentages of researchers in Lesotho (54.8%) and Kenya (40.5%) were in agriculture, 50.7% in Senegal were in social science and 30.0% in Zimbabwe were in the natural sciences.

Chapter 4: Innovation

This chapter summarises the results of the innovation survey in the countries participating in the ASTII project and which conducted the surveys: Egypt, Gabon, Ghana, Kenya, Lesotho, Mali, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia.

Findings

Innovation is pervasive: As in the first edition of the AIO, product and process, non-technological, organisational and marketing innovations were taking place in all of the participating countries. In all countries, some of the goods and services resulting from the innovations were sold outside the country.

Not all innovation activities resulted in completed projects: The innovation rate was relatively high in the reporting countries, ranging between 40.1% and 77.0%. The proportion of firms with on-going innovation activities was higher, ranging from relatively low (5.7%) to high (70.8%). It should of course be noted that innovation activities can take considerable time to implement and that some may have begun towards the end of the reference period. The proportion of firms with abandoned innovation activities was generally low, ranging from 0.47% to 25.3%, indicating that the factors reported by firms as highly important barriers of innovation affected a low to moderate proportion of firms across the participating countries.

Innovations by most firms originated from within the country: In all the reporting countries, the majority of both product and process innovations were developed within the country, indicating a relatively large commitment to innovation activities.

Acquisition of machinery and/or intramural R&D formed the largest share of expenditure on innovations: In most of the countries providing data on expenditure on the various innovation activities, acquisition of machinery had the largest share of the total expenditure, followed by intramural R&D. Intramural R&D activities could be indicative of a commitment to innovation.

Innovation is a connected activity: In most countries, firms sought ideas about innovation from clients or customers, followed by suppliers of equipment and competitors. Institutional sources such as universities, technical colleges and government and private research institutions were low on the list. These results corroborate those from the surveys reported in the 2010 AIO and in other community innovation survey-like enquiries in other parts of the world (Eurostat, 2008: Tables 5.12 and 5.37; cited in AIO, 2010).

Innovations had an impact: In most countries, firms regarded improved quality of goods or services as the principal impact of innovation. Others in the first four positions in the list, in different positions for different countries, were: increased range of products; increased flexibility of production; increased capacity to produce; increased market share; meeting government regulatory requirements; reduced labour costs per unit of labour; reduced environmental impacts; and improved effect of working conditions on health. In addition, all countries reporting innovation-active firms exported some of the goods and services resulting from the innovations.

There are barriers to innovation: Lack of funds within the enterprise or group was a barrier to innovation for the majority of firms in most reporting countries. Gabon also cited knowledge and market barriers.

Some firms acquired intellectual property (IP) rights in innovations: In most of the reporting countries, registering a trade mark was the most frequently used method of claiming IP rights to innovations developed by firms. Tanzanian and Ugandan firms also to a considerable extent registered their industrial designs, with Ugandan firms securing patents within the country, claiming copyright and applying for patents outside the country.

Innovation and R&D: Although there were some difficulties with countries providing data on R&D performance, South Africa provided these data and it confirmed the findings reported by countries in the AIO 2010 that more firms innovated than did R&D. This is an important consideration for the development of innovation policy.

Interpreting the findings

AIO 2010 gave reasons why the results of the first round of surveys could not be compared across countries (AU-NEPAD, 2010). This remains the case in this second round, for reasons largely the same as those highlighted in AIO 2010. These were:

- **The reference periods are not perfectly comparable:** South Africa's data, for example, was based on a survey covering the reference period 2005 to 2007 and not to 2010 as with most of the other countries.
- **There is inconsistency in determining the firm size cut-off points:** In some countries, the method and bases for determining the firm size cut-off points did not strictly follow the guidelines in the Oslo Manual. For example, due to lack of data on the number of employees in the official business register, South Africa used firm revenue, while most other countries used number of employees, Uganda and Zambia used both revenue and number of employees. Furthermore, among the countries that used number of employees, countries used different cut-off points.
- **Sector coverage differed between countries:** Although all countries covered manufacturing, some covered mining and service industries while others included sectors such as higher education and research establishments.
- **Sampling methods differ:** Most countries, except South Africa and Uganda, did not use a stratified random sample or project the sample results to the population of firms. Egypt used a representative sample.

Sample sizes differed across countries: Some countries had very small sample sizes compared to others.

As in AIO 2010, some of findings in the conclusions section are robust. These include:

- the importance of clients and customers as a source information about innovations and as collaborators
- improved product quality as the most important benefit of innovation
- lack of funds as the main barrier to innovation
- registration of a trade mark as the main form of IP rights acquisition.

However, in this second round of surveys as in the first, for the reasons highlighted above the propensity to innovate and the numbers of firms with abandoned and on-going innovation activity, expressed as a percentage of firms with such activity, should not be used for making comparisons across countries and regions.

The results of the surveys give a picture of the African innovation landscape but with some gaps. To make comparisons, the reader should therefore read the information on specific participating countries. The current surveys and their results show that African countries are not adopting standard methodologies to produce indicators of their innovation activities. Stricter use of the Oslo Manual guidelines would enable greater comparability.

Using the findings

The findings in this report largely confirm those of the first round of surveys which led to the AIO 2010 publication (AU-NEPAD, 2010). The points highlighted in that publication therefore still largely apply. For instance, the importance of the link between the product-innovative firm and its clients or customers may suggest the need for a policy or strategy to support collaboration. An implication of the finding that acquisition of machinery was one of the leading innovation activities is that tax incentives may be needed to encourage investment in specific categories of machinery and equipment such as ICTs (AU-NEPAD, 2010). A related finding of the second round of surveys is that, in most countries, intramural R&D is one of the major innovation activities in which firms invested. This indicates that there is the need to promote intramural R&D further through options such as tax incentives and support for human capacity development.

Chapter 5: Assessment of the scientific productivity of selected African countries within the African Union

This chapter is an exert of the detailed bibliometric study of the scientific production of the African Union conducted by the African Observatory of Science, Technology and Innovation (AOSTI). It focuses on the scientific outputs of some of the African countries that participated in the ASTII programme. Despite its limitations, bibliometrics provides a wealth of information that when used with other indicators, reveals the trends and developments in a science system. In the present instance, bibliometrics has shown that AU member countries' combined scientific output remained lower (at around 2% of the world total). However the average growth rate of scientific production in Africa is faster than that of the world as a whole with Egypt, Kenya Nigeria, and South Africa continuing to produce the largest number of publications in the AU. However, the normalisation of the raw production figures by various parameters such shows different rankings of the countries as revealed by the analysis by AOSTI.

There has been an increase in the number of publications across all fields of science. The output is particularly high in the fields listed below, where the Specialisation Index (SI), Average Relative Impact Factor (ARIF) and

Average of Relative Citation (ARC) scores are above the world average:

- Health sciences: general and internal medicine, tropical medicine, microbiology, virology, health policy and services
- Applied sciences
  - Agriculture: horticulture and forestry
  - Engineering: chemical engineering, mining and metallurgy.

Possibly due to their low coverage in international databases, the level of output in the social and economic sciences and in the humanities is relatively low. However, such research outputs are important because they address local issues and relate to national policy goals.

Information about patterns of collaboration in the AU member countries indicates that scientists in Africa rarely collaborate with one another but instead seek international partnerships. Most of the scientists who collaborate internationally have ARC scores above the world average and are based in top performing institutions within the AU.

Chapter 6: Conclusions and recommendations

This report shows that African countries are willing to develop their national systems of innovation (NSIs), to develop indicators to monitor and benchmark themselves with one another and to move with the world towards knowledge based economies. Recommendations about how to further enable this are made in this chapter.

CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

There is a substantial number of studies world-wide that show that science, technology and innovation are drivers of economic growth leading to economic prosperity.

Viewed in the context of the developing countries, the studies show that innovation may lead to socio-economic transformation and rapid progress leading to sustainable development (Kraemer-Mbula & Wamae, 2010). While most African economies are still based largely on natural resources, many countries worldwide rely increasingly on knowledge for wealth creation, growth and competitive advantage (Houghton and Sheehan, 2000). The recently developed AU Science, Technology and Innovation Strategy for Africa (STISA 2024) articulates its mission as "to accelerate transition of Africa to a knowledge led, knowledge based economy" (AU 2013). STISA 2024 was developed to ensure that STI forms an integral part in achieving the AU's development targets.

African leaders are aware that investing in science and technology is one of the means to drive economic growth and address social challenges. Questions with implications for policy-making include how to link science, technology and innovation to poverty reduction, job creation, sustainable livelihoods and the improved well-being of citizens; how to build capacity and competencies to innovate; and how to expand knowledge. Policy must balance competing domestic social and economic needs at the same time as considering the realities of globalisation. The outcomes of these policy decisions will determine the types of innovation that will take place in Africa.

It is in this context that more countries in Africa began to review their STI strategies and policies (NEPAD-AOSTI, 2013c) and, as required, develop new ones. This process was encouraged by commitments from the African Heads of States to promote and support research, innovation and associated human resources (AU, 2007). AMCOST was established in 2003 to develop a strong political constituency and leadership to promote the development of Africa's science and technology and to take collective decisions on these issues. At its inaugural meeting, AMCOST pledged to raise R&D expenditure to at least 1% of GDP and called for the development of indicators to monitor and benchmark STI activities in African countries.

1.2 THE DEVELOPMENT OF STI INDICATORS IN AFRICA

The ability to measure science, technology and innovation indicators has many benefits. Indicators are used not only for comparative purposes but are also an essential guide to national policy formulation, assisting with the development of performance standards and increasing a sense of accountability (Gaillard, 2010).

AMCOST's mandate includes enabling African countries to apply science and technology to the transformation of their economies, and to attain the Millennium Development Goals (MDGs). AMCOST adopted Africa's Science and Technology Consolidated Plan of Action (NEPAD 2005) to guide its processes and to consolidate science and technology programmes of the African Union Commission (AUC) and the New Partnership for Africa's Development (NEPAD).

An intergovernmental committee was established to oversee the establishment of a common framework for developing STI indicators (NEPAD, 2005). In the absence of local STI instruments and guidelines, a decision was taken by the AU member states' representatives that African countries would use existing internationally recognized guidelines[1] in undertaking their national surveys of Research and Experimental Development (R&D) and the innovation surveys. This led to the development of the African Science, Technology and Innovation Indicators (ASTII) initiative which is coordinated from the NEPAD Science, Technology and Innovation Hub (NSTIH)[2] followed by the African Observatory of Science and Technology Innovation (AOSTI).

The African Science, Technology and Innovation Indicators (ASTII) initiative

The purpose of this initiative is to build Africa's capacity to develop and use STI indicators. Specific objectives are to:

- develop and cause the adoption of internationally compatible STI indicators
- build human and institutional capacities to use STI indicators and related survey techniques
- enable African countries to participate in international STI indicator programmes
- inform African countries about the state of STI in Africa

African Observatory of Science and Technology Indicators (AOSTI)

AOSTI is intended as a continental repository for STI statistics and as a source of analysis in support of evidence-based policy making in Africa. It was launched in 2011 and is based in Malabo, Equatorial Guinea.

AOSTI's objectives are to:

- enable African countries to develop their STI capabilities and to direct such capabilities to solving pressing economic, social, environmental and other development challenges
- strengthen national capacities for STI policy formulation, implementation, evaluation and review
- improve the quality and dynamism of African NSIs and related STI policies
- provide African decision-makers with up-to-date information on global scientific and technological trends to enable them to engage effectively in policy-making on STI issues
- strengthen national capacities for technology prospecting, acquisition or procurement
- reinforce regional and international STI cooperation.

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1 *Proposed Standard Practice for Surveys on Research and Experimental Development* known as the Frascati Manual (OECD 2002), and *the Guidelines for Collecting and Interpreting Innovation Data* known as the Oslo Manual (OECD/Eurostat, 2005).

2 NEPAD Science, Technology and Innovation Hub (NSTIH), formerly the NEPAD Office of Science and Technology (OST).

Progress made with the STI developments to date

ASTII: the first phase of the ASTII initiative began in 2008 and was completed in 2010. Activities of ASTII included establishing National Focal Points to implement ASTII projects at national level; harmonising the survey instruments for national R&D and innovation surveys; and producing the AIO 2010 report. The countries participating in the first phase were Algeria, Angola, Burkina Faso, Cameroon, Egypt, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia. These countries opted to collect R&D and innovation data, or one of the two.

AOSTII has launched a series of projects and studies and produced a number of publications including Science, Technology and Innovation Policy-Making in Africa: An Assessment of Capacity Needs and Priorities (NEPAD-AOSTI, 2013c) and the policy brief Scientific productivity of the African Union Member States (2005 to 2010) (NEPAD-AOSTI, 2013a). ASTII and AOSTI work in synergy to ensure that the African continent has robust STI datasets. The aggregate data from the R&D and innovation surveys in the ASTII projects will ultimately be deposited with AOSTI.

1.3 ASTII PROJECT: PHASE 2

The second phase of the ASTII initiative was launched in Addis Ababa, Ethiopia in 2011. The number of countries participating in training workshops on both R&D and innovation data collection and analysis increased from 19 to 28 in 2012 and to 35 in 2013 (Table1.1). Countries joining in 2012 were Burundi, Cape Verde, Equatorial Guinea, Liberia, Mauritius, Rwanda, Togo, Tunisia and Zimbabwe; and those joining in 2013 were Benin, Botswana, Chad, Congo, the Democratic Republic of Congo, Namibia and Niger. A total of 21 countries have contributed survey data to the AIO-II report. Three policy briefs were produced in this phase including one on Monitoring Africa's progress in Research and Experimental Development (R&D) investments (NEPAD-AOSTI, 2013b).

TABLE 1.1: AU MEMBER STATES PARTICIPATION OVER TIME: 2007-2013

2007–2010		2012	2013
Algeria	Malawi	Cape Verde	Benin
Angola	Mali	Equatorial Guinea	Botswana
Burkina Faso	Mozambique	Liberia	Burundi
Cameroon	Nigeria	Mauritius	Chad
Egypt	Senegal	Namibia	Congo
Ethiopia	South Africa	Niger	Congo, Dem. Rep.
Gabon	Tanzania	Togo	Rwanda
Ghana	Uganda	Tunisia	
Kenya	Zambia	Zimbabwe	
Lesotho			

1.3.1 SCOPE

1.3.1.1 Core indicators

The following indicators were compiled from the R&D survey:

- Gross domestic expenditure on R&D (by source and sector of performance)
- R&D personnel by level of formal qualification and occupation, gender, headcount and full-time equivalent
- Researchers by field of science

1.3.1.2 Indicators from the innovation survey

The ASTII innovation survey followed the guidelines of the OECD's Oslo Manual (OECD/Eurostat 2005). The survey format was based on the Eurostat Community Innovation Survey (CIS) and the questionnaires were adapted according to each country's data requirements. The following topics were addressed in the survey instrument:

- Product innovation (goods or services)
- Process innovation
- On-going or abandoned innovation activities
- Innovation activities and expenditure
- Sources of information and cooperation for innovation activities
- Effects of innovation during the last two years
- Factors hampering innovation activities
- Intellectual property rights
- Organisation and marketing innovations

1.3.1.3 Bibliometrics indicators

Bibliometrics indicators were summarised from a bibliometrics study[3] conducted by AOSTI. The indicators were:

- Number of scientific publications/scientific output
- Number of publications per capita
- Growth, impact factor, specialisation and citations
- Scientific output by domain, field and subfield of science
- Collaboration
- Characteristics of the most active scientists.

3 The full report can be requested from AOSTI.

1.3.1.4 Focal Points: structures and functions

Organising survey processes in the context of ASTII required coordination by each country's Focal Point. These were made up of the people directly involved in administering the surveys, drafting national reports and developing inputs for the AIO. Each Focal Point therefore included experts from ministries responsible for STI, national statistical offices, local universities and research institutes and the public sector.

The core characteristics of the Focal Points were:

- Being cross-sectoral, inter-ministerial and multidisciplinary in scope
- Being able to convene meetings of all relevant stakeholders
- Having legislative, or at least administrative, authority to collect statistics or cause them to be collected and to participate in national sectoral surveys relevant to the ASTII initiative
- Possessing a critical mass of expertise for the development of STI indicators or having the ability to mobilise such expertise from other institutions
- Being able to prepare, or cause to be prepared, national STI survey questionnaires
- Organising training for, and assembling, national teams to conduct surveys
- Entering into agreements with NEPAD on project-related matters
- Preparing and submitting to NEPAD authorised national STI surveys and/or indicators
- Participating in meetings of the Intergovernmental Committee on STI Indicators.

The Focal Points maintained strong links with their governments to ensure the relevance of the indicators to national policy formulation and implementation processes. Participation by national statistical offices ensured the professional independence of the process and guaranteed the official character of the statistics (AU, 2007).

1.3.1.5 Training workshops

The training workshops were based on the Frascati and Oslo Manuals as they relate to R&D and innovation surveys. The workshops made use of the CIS questionnaires for the innovation survey. The questionnaires were adapted from the South African survey instrument which was also based on CIS, and the use of this model was intended to support comparisons with countries outside Africa. The workshops also used the Training Guide, standard presentations of the Frascati Manual and Oslo Manual as well as the Guide to Measuring R&D in Developing Countries developed by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Institute for Statistics (UIS). Similarly, the R&D survey instrument was also adapted from the South African R&D survey questionnaire and used as a template.

Participants were introduced to the methods used to do the following: profiling innovative firms; developing models to identify determinants of the decision to innovate; studying the relevance of particular factors that constrain or stimulate innovation at the firm level; relating firm-level performance to innovative behaviour; providing the basis for benchmarking innovative performance across sectors and countries; and analysing the impact of policies on such behaviour.

Relevant and practical statistical concepts that support R&D and innovation indicators were also introduced, including practical elements of sampling and sampling frames availability, weighting, sampling errors, the selection of units of analysis, sources of data, data collection, quality and storage of data, descriptive and inference statistics, matters of non-response, interpretation and reporting of results, and the metadata that underpin the construction of indicators.

At least two senior officials from each of the Focal Points attended each workshop. The intention was that the trainees would then perform the role of trainers in their home countries. This training process served as a forum for interaction between users and producers of R&D and innovation statistics. The countries that had taken part in the first phase also participated in the second phase workshops.

Key outcomes of the training workshops were:

- R&D and innovation survey instruments were harmonised to enable comparability of data among the participating countries
- Data collected by the countries were discussed at the workshops to improve the flow of knowledge on R&D and innovation
- A roadmap for the production of the African Innovation Outlook II was agreed upon
- Advice was provided on how to improve data quality.

Countries decided whether to conduct both the R&D and innovation surveys or one of the two. The ASTII surveys were distributed as follows:

- Egypt, Gabon, Ghana, Kenya, Lesotho, Mali, Senegal, South Africa, Uganda and Tanzania decided to undertake both the R&D and innovation surveys
- Angola, Burkina Faso, Cape Verde, Ethiopia, Malawi, Namibia, Togo and Zimbabwe decided to conduct R&D surveys
- Nigeria and Zambia conducted only the innovation survey.

The results of the R&D surveys and the innovation surveys are presented in Chapter 3 and Chapter 4 respectively.

1.3.2 ASTII ADVISORY COMMITTEE AND RESOURCE PERSONS

The Advisory Committee of experts provided on-going support and advice to the Focal Points and to the NSTIH on all aspects of the surveys and STI indicators. The committee had representatives from AOSTI, CeSTII, NEPAD, RPI and UIS as well experts from Egypt, Gabon, Kenya, Nigeria and Tunisia. The committee assisted with the design, selection and presentation of modules for the training workshops; and advised on the statistical methodologies, and their application, which formed the basis for constructing R&D and innovation indicators.

1.4 THE STRUCTURE OF THE AIO REPORT

AIO-II presents R&D and innovation indicators developed from the surveys conducted by the national Focal Points and validated by the authorised national bodies. The report is structured into six chapters containing complementary indicators extracted from STI and other relevant sources.

Chapter 1 describes the genesis of the ASTII project, the achievements of Phase I and progress made with Phase II. It introduces AOSTI and its activities and how it relates to the ASTII project. The chapter also describes the purpose of the AIO, and the roles and structures of the national Focal Points.

Chapter 2 describes the STI activities in Africa; related policies and political decisions; and future plans for STI activities on the continent.

Chapter 3 summarises the results of the R&D surveys conducted in Angola, Burkina Faso, Cape Verde, Egypt, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Namibia, Senegal, South Africa, Tanzania, Togo, Uganda and Zimbabwe. The survey data were analysed and, where applicable, tables of relevant indicators constructed. Indicators of interest include: gross domestic expenditure on R&D (by sources of funds and sector of performance); R&D personnel (by level of formal qualification and occupation, science field, gender, headcount and FTE); and researchers (by gender and field of science). Shortcomings are highlighted to assist with improving the next round of surveys. Where data were not available or were not compatible, this is indicated.

Chapter 4 describes the innovation surveys in Egypt, Gabon, Ghana, Kenya, Lesotho, Mali, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia.

Chapter 5 provides a summary of the study undertaken by AOSTI on the outputs of the scientific and technological productivity of AU member countries participating in the ASTII project. The study is the first of a series on the scientific production and performance of African countries and forms part of AOSTI's broader mandate to develop and manage science, technology and innovation indicators.

Chapter 6 gives the conclusion and sets out recommendations for data collection. These include suggestions about improving the surveys so that the resulting data enable accurate and meaningful comparisons of countries' STI activities.

CHAPTER 2: SCIENCE, TECHNOLOGY AND INNOVATION POLICY ENVIRONMENT IN AFRICA

2.1 INTRODUCTION

Science, technology and innovation have shaped human history and today remain key drivers of economic growth and transformation in every society. Deliberate investment in STI is therefore crucial for any country to realize its short, medium and long-term development objectives. Africa's strength is in its natural resources and it has enormous potential to exploit these through diversifying its economies and building innovation capacity and competencies that will turn these resources into wealth.

As the world moves towards knowledge based growth, it is critical for Africa, as for any part of the global economy, not to be left behind. Strengthening STI must therefore be a priority and African governments are increasing their understanding of the geopolitics of science, technological advances and innovation in the global knowledge economy, and taking leadership of STI policies and processes in Africa for African development. STI strategies which give due consideration to Africa's environment and concerns can be some of the most effective weapons for reducing, and eventually eliminating, poverty.

This chapter describes STI activities in Africa, related policies and political decisions and future plans.

2.2 DECLARATIONS TO ADVANCE SCIENCE, TECHNOLOGY AND INNOVATION IN AFRICA

In recent years, there has been an increased emphasis by African governments, scientists, policy makers, private sector actors and civil society organisations on STI as a driver of technical and economic change. Political statements are anchored in decades of attempts by African governments to speed up development through the application of STI. Declarations and articulations made over the years illustrate the importance assigned to STI as an enabler of development. These include the Lagos Plan of Action for the Economic Development of Africa, 1980 – 2000, the Kilimanjaro Declaration of 1987, the Khartoum Declaration of 1988, the Addis Ababa Declaration of 2007 and others (Table 2.1).

TABLE 2.1: DECLARATION AND PLANS OF ACTIONS DEVELOPED FOR AFRICAN COUNTRIES

Declaration/plan of action	Aim	Action Plan	Period
Lagos Plan of Action 1980	To increase Africa's self sufficiency	To take urgent action in providing political support necessary for the success of the measures to achieve the goals of rapid self-reliance and self-sustaining development and economic growth.	1980 - 2000
Kilimanjaro Declaration 1987	To implement and promote science and technology policies	Developing science and technology Centers of Excellence, educating personnel in the field of S&T, promoting indigenous technologies and mobilizing funds for STIs.	1987
Khartoum Declaration 1988	To develop human capacities	To restore the economic status of African countries which were experiencing a period of economic crisis, by developing human capacities.	1986 - 1990
Addis Ababa Declaration 2007	To advance the development of the continent by promoting research in all fields, in particular in science and technology	Increase funding for national, regional and continental programmes for science and technology and support the establishment of national and regional centres of excellence in science and technology.	-

2.3 THE NEW PARTNERSHIP FOR AFRICA'S DEVELOPMENT

NEPAD was launched by the AU in 2001. The organisation's mandate is to provide expertise in developing policies for economic development and co-operation among African nations. NEPAD's expert group on STI works by promoting STI partnerships and collaboration. It also promotes education and knowledge sharing to strengthen capacity in science and technology. AMCOST was formed under the auspices of NEPAD and the AU to assist with the development and application of science and technology.

2.3.1 THE AFRICAN MINISTERIAL CONFERENCE ON SCIENCE AND TECHNOLOGY (AMCOST)

The AU Department of Human Resources, Science and Technology works through AMCOST to direct continental policy and R&D programmes in science and technology. AMCOST is assisted by a steering committee responsible for formulating and coordinating the implementation of programmes. The Science and Technology Consolidated Plan of Action (CPA), which has completed its five year term and is currently under review, guides AMCOST's processes.

The CPA emphasises the development of an African system of research and technological innovation through flagship R&D programmes and through programmes dedicated to improving policy interventions, including the development of indicators. The flagship programmes, with five-year implementation periods, include biodiversity, biotechnology and indigenous knowledge; energy, water and desertification; material sciences, manufacturing, laser technologies and post–harvest technologies; ICT and space sciences; and mathematical sciences. The CPA promotes science, technology and innovation planning at national, regional and continental levels in support of the social and economic transformation of the continent. Its overall goals are:

- To enable Africa to harness and apply science, technology and related innovations to eradicate poverty and achieve sustainable development
- To ensure that Africa contributes to the global pool of scientific knowledge and technological innovations.

Indicators are required to assess whether these goals are met and the CPA clearly articulates the need to develop such indicators. The CPA highlights programmes for improving policy conditions and related capacities as well as the necessary mechanisms to promote technological innovation. ASTII and AOSTI are specifically developed as research and capacity building initiatives that will improve the quality of science, technology and innovation policies at national, regional and continental levels.

Indicators describing the science, technology and innovation system of a country and supporting the policy processes and public debate are developed through the ASTII initiative. ASTII would also be the platform to adopt common definitions and methods of data collection and analysis that will lead to the development of comparable indicators among African countries. An intergovernmental committee of national experts in STI oversaw these processes and will ensure that capacity is built in this field.

AOSTI's role is to collate, compile, validate and manage the collection of statistics on science, technology and innovation from African countries. The Observatory will also build capacity 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.

2.4 SCIENCE AND TECHNOLOGY AT THE REGIONAL LEVEL

Eight Regional Economic Communities (RECs) have been established to encourage regional integration within Africa, increase the flow of foreign investment into the continent and assist with sustainable economic development. These are the Arab Maghreb Union (AMU), the Common Market for Eastern and Southern Africa (COMESA), the Community of Sahel-Saharan States (CEN-SAD), the East African Community (EAC), the Economic Community of Central African States (ECCAS), the Economic Community of West African States (ECOWAS), the Intergovernmental Authority on Development (IGAD) and the Southern African Development Community (SADC).

The purpose of the RECs is to promote integration of member countries through collaboration with each other and other similar bodies; develop human resources for STI; encourage free movement of science and technology personnel; increase investment in R&D; and create a culture of science and technology. There are regular surveys to assess the regional integration of the economic communities in Africa, with the results of the fifth survey published in 2012 (UNECA, 2012). These indicated that integration is happening slowly and challenges are experienced. In the past, regional technological collaboration and development have not succeeded because of a failure to institutionalise S&T programmes into the RECs and because of a weak emphasis on the role of science and technology by the regional leadership (Mugabe, 2006).

The leadership of NEPAD has been crucial in improving this situation, with the implementation of the CPA laying a foundation for expanding the scope of the continent's S&T activities. Studies of the science systems of almost all AU member states indicate the critical lack of resources and capacity for STI. It should be NEPAD's role to provide leadership to address this.

Treaties and protocols that the RECs have entered into locally and internationally provide for the practice and application of science and technology. The following are some of the commitments on STI made by the regional African organisations.

2.4.1 INITIATIVES OF THE EAST AFRICAN COMMUNITY

The East African Community (EAC) was established in 1967 to promote trade between countries in the Great Lakes Region and in and around the Horn of Africa. The organisation collapsed in 1977 but was re-established in 2000. Article 5 of the EAC Treaty provides for the promotion of STI within the partner states:

> The objectives of the Commission shall be to promote and coordinate the development, management and application of Science and Technology in the partner states.

The Treaty also encourages the development of policies to enable cooperation amongst the member countries for their mutual benefit. It supports the establishment of institutions in the various disciplines of science and technology; the use and development of indigenous science and technologies; the exchange of scientific information and personnel; the promotion and publication of research and scientific findings; and the establishment of common ethical guidelines for research.

2.4.2 THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

Established in 1992 by 10 states, SADC now has 14 member states. The organisation has developed a protocol which aims to foster co-operation and promote the development, transfer and mastery of science, technology and innovation. The protocol outlines possible areas of cooperation; mechanisms for coordinating and facilitating such cooperation; and how it will be funded. It also calls for cooperation in STI between member countries and AU, NEPAD and European Union (EU) states.

2.4.3 THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES

ECOWAS functions at the same level for West African states as the SADC and the EAC in their respective regions. Founded in 1975, the organisation has fifteen member countries. ECOWAS' mandate is to promote economic integration across West Africa. Its protocols provide for cooperation in STI and encourage members to strengthen national scientific, technological and socioeconomic capabilities to improve the quality of life of their populations. This is to be achieved through the proper application of science and technology to agriculture, transport and communications, industry, health and hygiene, energy, education and the conservation of the environment; reducing the member states' dependence on foreign technology; and strengthening existing scientific research institutions.

2.4.4 THE COMMON MARKET FOR EASTERN AND SOUTHERN AFRICA)

COMESA was founded in 1993 as successor to the Preferential Trade Area (PTA) for Eastern and Southern Africa. In the field of STI, COMESA supports its member states in:

> building up basic scientific and technological research capabilities to assure a critical mass while maintaining regional and international contacts; joint industrial support institutions and other infrastructure to promote R&D transfer, adaptation and the development of technology, promote commercialisation of research results and encourage collaboration in the establishment of innovative firms in biotechnology and energy generation including nuclear plants.

2.4.5 STI POLICIES, STRATEGIES AND PLANS OF ACTION AT THE COUNTRY LEVEL

Many African countries have developed STI policies and strategies and plans to oversee their implementation. The list in Table 2.2 is not exhaustive as some countries have more than one strategy, supplemented by other strategies and instruments. Mali, Senegal and Togo are still working towards producing their national STI policies. Lesotho has had an STI strategy since 2006 but it still requires cabinet approval. However, while countries may have plans and policies awaiting implementation, having STI policy does not imply automatic translation into performance. The science system is different from the innovation system; in addition, not all of the policies address innovation as a separate objective.

TABLE 2.2: STI STRATEGIES, POLICIES AND PLANS: SELECTED AFRICAN COUNTRIES

Angola	National Policy for Science, Technology and Innovation, 2011	The broader goals of the policy are to organise and develop the National System for Science, Technology and Innovation; application of STI in the sustainable development of Angola and funding of the STI system.
Burkina Faso	Secondary and Higher Education, and Scientific Research Sub-sectoral Policy, 2010-2025	The overall objective of the policy is to develop a coherent, effective educational system, adapted to the national context, ensure proper governance, and secondly, to promote research for development. Specific objectives include strengthening equity and promoting R&D.
Egypt	Developing Scientific Research (2007–2016) Plan	The objective of the plan is to restructure S&T governance, to improve S&T national capabilities, to disseminate S&T culture across society; to foster cooperation with developed economies; and to strengthen national S&T capabilities. Egypt collaborates with Germany, Japan, Italy, France and the United States of America.
Ethiopia	Science, Technology & Innovation Policy: Building Competitiveness through Innovation, 2010	The overall objective of the policy is to create a sound science and technology foundation and to coordinate the national technological capability-building efforts so as to enhance competitiveness of the economy and reduce technological dependence of the country. The policy highlights the critical policy issues such as the national and regional innovation systems; technology transfer; human resource development; business enterprises; R&D; financing and incentives; national quality infrastructure; university-GRI-industry linkage; IP rights; science and technology information; environmental technologies; and international cooperation.

Ghana	National Science, Technology and Innovation Policy, 2010	The objective of the policy is to ensure that science and technology drives all sectors of the economy. The main themes include promoting competitiveness in productive sectors of the economy; creating job opportunities and employment; expanding industrialisation; enhancing the quality of life through innovation; developing scientific human resources; expanding infrastructure; promoting an information society; optimising the sustainable use of natural and environmental resources; and commercialising research findings.
Kenya	ST&I Policy and Strategy, 2007–2012; Kenya Vision 2030	The policy and strategy will be focused on the following thrusts: institutional re-engineering, strategic resource mobilisation, strategic knowledge and technology governance and cross-cutting issues. These are elaborated through the following strategic objectives: governance framework; human resource development; education and training; R&D; ST&I infrastructure; linkages, collaborations and partnerships; indigenous resources and traditional knowledge; generation and management of IP; technology development, transfer and diffusion; environment and natural resources management; public communication and advocacy for ST&I; funding measures and mechanisms; Performance Management Framework (PMF) and impact assessment structure for implementing and evaluating the ST&I policy and strategy. Vision 2030 takes into consideration the goals and objectives of the STI policy and strategy.
Lesotho	Lesotho Science and Technology Policy, 2006–2011	Strategic objectives include the development of human resources in STI; promoting a culture of innovation to develop technology; job creation and poverty reduction; building a vibrant information society and promoting commercialisation of indigenous knowledge systems. Lesotho aims to direct a large proportion of national resources to science and technology education, fight against HIV/AIDS, SMME development and support product and export oriented industries.
Mali	National policy for higher education and scientific research, 2007	Strengthen the social and economic value of the ESR adapting maximum offering training and research to current and future needs of the country and improving its quality; regulate the flow of students entering higher education in order to establish the best possible compromise between the needs of the labor market, social demand, and available means; and optimise the use of available resources by focusing as much as possible resources to teaching and research expenditure, leading to an acceptable social spending limit and to make best use of the potential of the private sector.
Mozambique	Mozambique Science, Technology and Innovation Strategy, 2006–2016	The strategic objectives include promoting STI within the industrial and public sectors, promoting technology transfer, development of human resources, building and improving the policy instruments, institutions and infrastructure of the S&T system.
Nigeria	Science, Technology and Innovation Policy, 2012	The specific objectives of the policies are acquisition of knowledge to adapt, utilise, replicate and diffuse technologies for the growth of SMEs, agricultural development, food security, power generation and poverty reduction. The policy document further mentions strategies to achieve the goals of the policy statements.
South Africa	Ten-Year Innovation Plan: Innovation Towards a Knowledge-Based Economy, 2008–2018	To articulate a national path of innovation, building on the NSI, in support of the transformation to a knowledge-based economy. The strategy identifies five grand challenges: biotechnology and pharmaceuticals, space, energy, security, climate and understanding of social dynamics.

Tanzania	The National Science and Technology Policy for Tanzania, 1996–2000	To promote S&T as tools for economic development, the improvement of human, physical and social well-being, and for the protection of national sovereignty. The strategic actions as outlined in the plan are as follows: increase STI sector financing and investment; develop and maintain STI human capital; build and maintain STI infrastructure; support research and development; technology incubation; STI safety regulations; ethics in STI; standards and quality; assurance in STI; increase public awareness and appreciation of STI; information management system; and sector coordination and partnerships.
Uganda	National Science Technology and Innovation Plan 2012/13–2017/18	The overall objective is to implement the plan for the achievement of Uganda's development aspirations which among others include: uplifting of the population from absolute poverty through provision of basic human needs, transformation of the economy from an agrarian to an industrial and knowledge-based economy, and enhancing Uganda's participation in global trade and development processes.
Zambia	National Policy of Science and Technology, 1996	The broad policy objective for science and technology is to embed science and technology as part of the culture of the key sectors for promoting competitiveness in the production of a wider range of quality goods and services. The strategies for achieving this broad policy objective include: recognising gender concerns; changing institutional structures; ensuring that research is guided by national developmental goals; and establishing a mechanism for increased innovation, transfer, diffusion and commercialisation of technology, especially for small and medium scale industries with an emphasis on indigenous technology.
Zimbabwe	Second Science, Technology and Innovation Policy Zimbabwe, 2012	To strengthen capacity development in STI; learn and utilise emergent technologies to accelerate development; accelerate commercialisation of research results; search for scientific solutions to global environmental challenges; mobilise resources and popularise science and technology; and foster international collaboration in STI.

2.5 OBSERVATIONS ON THE CURRENT STI POLICIES

Science systems in Africa have evolved very differently from one another and this has resulted in a variety of science landscapes. However, although African countries and regions differ in size, level of economic development and advances in science and technology, common themes emerge from the policy and strategy frameworks, whether implemented or proposed. These include governance of STI; capacity for science, technology and innovation; human resource development; promoting and funding R&D; and STI policy and measurements.

2.5.1 GOVERNANCE OF STI

The realisation that STI is important for economic growth has spurred African countries to establish Ministries responsible for science, technology, scientific research and innovation. Most are not stand-alone but are part of other Ministries such as Education (Angola, Cape Verde, Egypt, Gabon, Kenya, Malawi, Mali and Namibia). Others are combined with departments of Communications (Lesotho and Tanzania) and/or are part of national structures such as Uganda's National Council for Science and Technology which reports to the Ministry of Finance Planning and Economic Development.

Policy formulation and analysis generally take place within Ministries, Departments and agencies (MDAs). However, higher education institutions and public research institutions (PRIs) also undertake this process in some African countries.

In developing their policies and strategies, many countries have consulted internationally. UNESCO is actively involved in the revision of ST&I policies of the following countries: Botswana, Burundi, the Democratic Republic of Congo, Lesotho, Malawi, Namibia, Nigeria, Senegal, Togo, Zambia and Zimbabwe (UNESCO, 2010). South Africa engages with the OECD in most of its STI policy formulation processes.

The approach to formulating STI polices internationally has been rooted in the concept of the national system of innovation (NSI): a set of institutions, organisations and policies that interact in pursuit of a common set of social and economic goals. The rationale for an NSI is that it is able to identify areas where innovation can lead to improved performance and can identify gaps and mismatches hampering policy implementation. Most countries which have restructured their science and technology policies have followed this route; South Africa, Egypt, Ghana and Nigeria are examples.

According to UNESCO, smaller countries are more likely to have difficulty in formulating policies (UNESCO, 2010). However, assistance is available.

The African Technology Policy Studies (ATPS) network promotes STI policy research, dialogue and practise by offering capacity building programmes in Africa. The African Science Academic Development Initiative (ASADI) provides grants to academics to participate in the policy development process.

South African institutes such as the Institute for Economic Research on Innovation (IERI) and the Centre for Research on Science and Technology (CREST) offer modules on policy formulation and innovation studies.

2.5.2 STI CAPACITY

Many countries mention STI capacity as requiring intervention. A country's ability to innovate is influenced by the size of its science base. The research and experimental development results of countries participating in the first phase of ASTII indicated that R&D takes place mainly in the public sector, within government and by higher education institutions. These sectors combined accounted for over 50% of GERD (AU-NEPAD 2010). Few countries reported on the business sector and, for those countries that did report, that sector's R&D expenditure was generally low.

The countries where most R&D is carried out by public institutions generally have a very small number of research institutions. These include Lesotho, where R&D is concentrated in a single institution, the National University of Lesotho (Lesotho country report, ASTII 2013). Other countries with a similar situation are Mali, Namibia and Angola.

Senegal has a modest number of institutions that carry out research, with most of this being agricultural R&D. It has recently become home to the African Institute for Mathematical Sciences (AIMS) and will soon launch a science park (the National Agency for Applied Scientific Research) which will focus on ICTs, biotechnologies, the garment industry and aquaculture (UNESCO, 2010).

Egypt, South Africa, Tanzania, and Uganda are the countries with the largest infrastructure and facilities for science and technology. For instance, Egypt has 34 universities, 15 private and 19 run by government. It also has research centres and some centres of excellence. Egypt's STI system is highly centralised, with most research performed in the state-run universities and research institutes.

2.5.3 HUMAN RESOURCE DEVELOPMENT

STI requires skilled human capital. However, many countries in Africa have difficulty in developing enough of this type of capital to meet their own and the continent's social and economic needs. Although there are many and often complex reasons for this, the world will not wait for Africa. Human skills are particularly important to innovation because skilled people create knowledge (OECD, 2010). As the world moves increasingly to knowledge-based economies, skills must keep up with the demands that these changes bring.

Some examples of policy responses, interventions and initiatives to address this problem are given below:

Egypt: National Strategic Plan for Pre-University Education Reform: Egypt has an excess of engineers although the quality of their education has been questioned. To improve the quality, relevance and social outreach of its educational system, Egypt put in place its National Strategic Plan for Pre-University Education Reform (2007/08-2011/12).

South Africa: the National Research Foundation (NRF) has the following programmes to develop STI capacity:

- **SARChI:** The aim of the South African Research Chairs Initiative (SARChI) is to strengthen research and innovation capacity in public universities; enhance the training of a new generation of researchers; and further develop established researchers in all knowledge areas while responding to national priorities and strategies.
- **The Thuthuka programme:** This is a research-capacity building initiative aimed at developing and advancing research capacity among researchers from designated research communities. Thuthuka's three sub-programmes are: Women in Research, for which applicants must be post-Doctoral women researchers; assistance to entry-level researchers in obtaining a Doctoral degree; and the Research Development Initiative for Black Academics (REDIBA) which supports South African Black (African, Coloured, Indian) male researchers with Doctoral degrees to advance in their research careers towards positions of scientific and academic leadership.

2.5.4 PROMOTION OF R&D PERFORMANCE AND INNOVATION

Few country's STI policies mention the importance of innovation to their economy and the call to governments has been to support R&D and not innovation or both.

The level of investment is a key determinant of R&D growth and competitiveness. Other issues include the sectors in which R&D is carried out and the size of those sectors; and the influence of and relationship with multinationals, state-owned enterprises and SMEs. Business R&D expenditure is market-driven and may or may not provide for innovation expenditure. Public sector R&D can be highly important in creating knowledge and training future researchers; as a knowledge source, it can enhance capacity for R&D problem solving. Business sector and public sector R&D can successfully complement each other as each is specialised in particular aspects of the innovation system (Foray and Lissoni, 2009).

However, R&D in Africa is largely performed by the public sector and in many countries is concentrated in the agricultural sector. Funding comes either from government or from outside the country. Business sector R&D is more prominent in countries such as South Africa, Kenya, Tanzania and Ghana.

The Millennium Science Initiative (MSI) in Uganda is an example of how governments can directly or indirectly support R&D. Concluded in 2013, the MSI was a competitive grant funding facility implemented by the Uganda National Council for Science and Technology (UNCST), with an estimated annual commitment of US$4.2 million in research grants. The grants were awarded to multidisciplinary joint research teams and it also had a component to support graduate training (Masters and PhD). The initiative did not have specific priority areas for support but rather the project facilitated mainly innovative ideas in all fields of science and technology (in line with the national STI Policy) provided they met the selection criteria. The MSI also supported research, education and training in science and technology with linkages to industry by strengthening the Uganda Industrial Research Institute (UIRI), a key industrial incubation centre in the country. The overall lesson drawn from the Uganda MSI is that it was a good learning instrument for financing and managing science, technology and innovation (STI) for development.

African countries use a range of policy instruments from R&D tax incentives to equipment grants to boost R&D. At the continental level, the reviewed CPA is likely to widen the scope of flagship projects currently taking place and provide further incentives for countries to increase their investment in innovation. All such policy-making should be based on sound, evidence-based decisions aligned with the prevailing policy environment.

2.5.5 STI POLICY AND MEASUREMENTS

One of the issues hampering the development and implementation of effective STI policies in Africa is the lack of up-to-date, reliable data and indicators on the current status of S&T. In the case of R&D and of science and technology, defining and measuring them and choosing appropriate indicators to use are well understood and developed. The same is not the case with innovation (Gault, 2011a). However, the development of innovation indicators has great potential for social impact because innovation is not necessarily about high-technology products or dependent on R&D (Arundel, 2007) and can have more immediate impact than R&D (Gault, 2011b). Innovation is of interest not only to developed countries but in all contexts including in low-income or developing countries (OECD, 2012).

The concept of innovation can be defined differently depending on the social or economic perspective, and policy formulation and strategies are guided by varying understandings of the S&T and innovation concept. Countries differ in their history, culture, size and structures and the success of their innovation policies will depend on their priorities and how these are coordinated and implemented.

In terms of measuring the effects of innovation, however, the most widely-used set of guidelines is contained in the Oslo Manual.

2.5.6 POLICY IMPLEMENTATION

STI policy formulation and implementation require dedicated high level political support to succeed. Coordination should cut across all government ministries and care should be taken that business, higher education and other research institutes are part of the process to ensure implementation. Some African countries have parliamentary committees dedicated to STI while in many these are integrated into other portfolios such as health, agriculture and education (AOSTI, 2013). These include Egypt, Kenya, Nigeria, Uganda and South Africa.

The narrow view that focuses on science and technology policies, omitting innovation policies, often poses challenges when designing and implementing these polices. A lack of indicators to monitor progress and inform policy formulation is also a challenge for policy-makers.

Although many African countries have developed activities to review or formulate national policies, it can take them up to five years to complete the development of STI policies (AOSTI, 2013). A recommendation from the AOSTI report is that AOSTI can be of assistance to countries in addressing STI policy capacity building in the continent (AOSTI, 2013).

2.5.7 MONITORING AND EVALUATION

Statistical measurement is not the only tool for assessing an NSI or the outcome of policy interventions. Case studies and reviews can also be used. Examples of NSIs or policy reviews in African countries are:

- Review by UNCTAD of Angola's Science, Technology and Innovation Policy (STIP) (UNCTAD, 2008)
- Review of South Africa's NSI by the OECD (OECD, 2007)
- Review of Ghana's NSI by UNCTAD (UNCTAD, 2011)
- UNESCO STI Policy Reviews in Botswana (2008-2014) and Tanzania (2011)

2.5.8 CURRENT PRACTICES IN OECD AND OTHER COUNTRIES

Learning from peers can be very valuable. Box 1 illustrates policy trends in OECD and other countries since 2010.

BOX 1: POLICY TRENDS IN THE OECD AND OTHER DEVELOPED COUNTRIES

An overview of policy trends since 2010, in developed and some developing countries, shows the following themes:

- **Finding new sources of growth and competitiveness**
- **New industrial policy and targeting of strategic technologies/sectors**
    - **Strategies on nanotechnology, biotechnology and information and communication technologies (ICTs) are being broadened to include support for innovation in strategic technologies or sectors, including the traditional ones of agriculture and services.**

- **Grand challenges or global challenges such as climate change, health, energy and security**
- **Stable R&D expenditures**
- **Emphasis on demand-side innovation policies to supplement supply-side innovation policies such as public R&D investment**
- **Social cohesion to address inequalities while boosting economic growth**
- **Public support for basic research**
- **Human resources**
    - **The focus is on policies that encourage human resource development in S&T, international mobility and reduction of gender gaps**
- **Business support**
    - **Support to business innovation includes improving framework conditions, expanding indirect funding instruments such as R&D tax credits, improving conditions for entrepreneurship and the supply of risk capital, especially for small and medium-sized enterprises.**

OECD, 2012

2.6 SUMMARY AND RECOMMENDATIONS

NSIs in many African countries remain weak for a number of reasons. The result is that they cannot adequately take advantage of new opportunities arising from rapid scientific and technological development, intensifying regionalization and globalization, increased foreign direct investments (FDI) flows, political stability and better macroeconomic conditions within the continent.

A UNESCO document notes, “The frequency of cabinet reshuffles in many countries results in instability among top officials in the ministries responsible for S&T, in turn leading to shifting priorities and disturbances in programme execution. This results in weak strategies for innovation and technology transfer, which in turn foster inadequate higher education and research systems with little innovative or inventive potential” (UNESCO, 2010 p285). However, there is no doubt that African countries are making efforts to strengthen their systems of innovation as is demonstrated by their involvement in activities to review current STI policies or design new ones.

Across all African countries, the main recurring issue requiring to be addressed is human resource capacity. The presence of funding or infrastructure, or sound STI policy, will be meaningless without the capacity to use these resources. The efforts by the AU-NEPAD, AMCOST, AOSTI and the NSTIH to build capacity at all levels of promoting STI must be taken seriously and operationalised by member countries if sustainable prosperity is to be achieved across the continent.

CHAPTER 3: RESEARCH AND EXPERIMENTAL DEVELOPMENT

3.1 INTRODUCTION AND METHODOLOGY

R&D survey data are a valuable point of reference for understanding nations' scientific and technological capabilities to achieve inclusive domestic economic growth and equitable participation in the global knowledge economy. They also indicate the R&D and knowledge-creation strengths of sectors within economies. The rapidly growing economies of Africa will benefit from understanding their own technological capabilities as they work to bring sustainable development to the continent and to the global economy.

The data presented in this chapter were submitted by 19 countries: Angola, Burkina Faso, Cape Verde, Egypt, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Namibia, Senegal, South Africa, Tanzania, Togo, Uganda, and Zimbabwe.

The data were collected using the methods contained in the OECD's Frascati Manual (OECD, 2002). This is the methodology adopted by ASTII, the AU-NEPAD's African Science Technology and Innovation Indicators initiative. The two main types of R&D indicators developed on the basis of the R&D surveys carried out are gross domestic expenditure on research and development (GERD) and human resources devoted to R&D. These are both discussed in this chapter.

DEFINITIONS

Research and Experimental Development: creative work undertaken on a systematic basis in order to increase the stock of knowledge including the knowledge of man, culture, society, and the use of this knowledge to device new application.

Research and Development personnel: all persons employed directly on R&D as well as those providing direct services such as R&D managers, administrators and clerical staff. R&D personnel include researchers, technicians and equivalent staff and other support staff.

R&D expenditures: all expenditures for R&D performed within the national territory during a specific period, whatever the source of funds.

Frascati Manual, OECD (2002)

To estimate how much is spent on R&D in any country, it is necessary to have reliable data on the components of R&D spending in different sectors of the economy. The Frascati Manual recommends that such data be collected for four sectors: the business enterprise, government, higher education and private non-profit sectors.

This report is a milestone in R&D reporting in Africa in that more countries have participated in collecting data and thus improving the continent's ability to establish its own STI benchmarks and indicators. Nine countries participated, in addition to those that took part in the inaugural AIO (AU-NEPAD, 2010). Only eight countries of those that participated in the first phase submitted data and information for this report. The additional country data have added considerable value as it increased the available set of baseline national R&D datasets to include the newly participating countries of Angola, Burkina Faso, Cape Verde, Egypt, Ethiopia, Lesotho, Namibia, Togo and Zimbabwe.

Table 3.1 shows the categories of data provided by the participant countries under the four headings of government, business, higher education and private non-profit. Ghana, Kenya, Senegal, South Africa and Uganda all provided a full set of data for all four sectors. The analysis of datasets from Gabon was based only on personnel data. Data from Burkina Faso was not disaggregated by sector and Egypt provided a combined R&D expenditure figure for all sectors (excluding the private-non-profit sector). Expenditure data from Namibia are incomplete for the government and business sector.

TABLE 3.1: AFRICAN COUNTRIES CONTRIBUTING DATA TO THE AFRICAN INNOVATION OUTLOOK, AND THE SECTORS SURVEYED

COUNTRIES	YEAR	SECTOR DATA
Angola	2011	Government, higher education
Burkina Faso †	2009, 2010	Government, business, higher education, private non-profit
Cape Verde	2011	Higher education
Egypt †	2011	Government, business, higher education
Ethiopia	2010	Government, business, higher education
Gabon #	2010	Government#, business#, higher education#, private non-profit#
Ghana	2010	Government, business, higher education, private non-profit
Kenya	2010	Government, business, higher education, private non-profit
Lesotho	2011	Higher education
Malawi	2010	Government, higher education, private non-profit
Mali	2010	Government, business#, higher education
Mozambique	2010	Government, higher education, private non-profit
Namibia #X	2010	GovernmentX, business, higher education#
Senegal	2010	Government, business, higher education, private non-profit
South Africa	2010	Government, business, higher education, private non-profit
Tanzania	2010	Government, higher education,
Togo	2010	Government, higher education
Uganda	2010	Government, business, higher education, private non-profit
Zimbabwe	2012	Government, higher education

† Data not disaggregated by sector
X Data incomplete
Only human resources data provided
Burkina Faso: R&D expenditure data is for 2009 and R&D personnel data is for 2010
Egypt: R&D expenditure data not disaggregated by sector
Namibia: R&D expenditure data missing for the government sector and incomplete in the business sector
Source: ASTII R&D surveys 2010 or latest year available

The reporting below on GERD is deliberately prudent and relatively brief in its analysis, referring only to the most recent data as supplied by individual participating countries. The reasons for this brief analysis are principally explained by the paucity of metadata on national data sets relating to sampling, response rates, coverage, frame building, maintenance methods and reporting. Due to the limited and variable data supplied by some of the countries, comparison of data is made in fewer cases than would have been desired.

3.2 GROSS DOMESTIC EXPENDITURE ON RESEARCH AND EXPERIMENTAL DEVELOPMENT (GERD)

GERD is an indicator of a country's R&D capability based on actual expenditure recorded through confidential surveys run after these expenditures have been incurred. These data are therefore based on actual expenditure rather than R&D budgets.

GERD data are widely used in assessing national scientific and technological strength. This strength can in turn lead to the production of innovative products and services with the potential to grow and to strengthen national economies. It is the continuum of R&D leading to real production that in part underpins the analysis of GERD data as a potential indicator of future economic growth and development. It is also widely accepted that R&D capability in itself can lead to knowledge diffusion, technology absorption and the transfer of the skills and knowledge needed for accelerated growth and development. GERD thus indicates growth and development latency.

3.2.1 GERD AS AN INDICATOR OF R&D ACTIVITIES

Leading industrialized countries may invest 2% or more of GDP in R&D. The target for investing in R&D for African countries was 1% by 2010 (AU, 2007; NEPAD, 2007). This target highlighted the importance assigned to investing in R&D in policy debates across Africa. The establishment of the ASTII initiative through the CPA programme contributed to the development of national policies that contribute to reaching this target. The lack of data in many instances makes it more difficult to assess whether African countries have made progress towards investing at least 1% of GDP in R&D (NEPAD-AOSTI, 2013b).

However, many countries (Table 3.1) did not report GERD from all sectors. In the current report, therefore, data have been grouped according to the submissions received. Caution is advised in interpreting these data as some countries have displayed considerable variability in their previous (2007) and current (2010) national data submissions.

The reported data show that, for the countries that provided comparable data, GERD/GDP ratios varied widely. Kenya reported a GERD/GDP figure of 0.98%, followed by South Africa (0.76%), Senegal (0.54%), Uganda (0.50%), Egypt (0.43%), Ghana (0.38%), Ethiopia (0.24%) and Burkina Faso (0.20%). In general, the results indicate that Africa is still lagging behind the 2010 world average of 1.77% .

GERD data have been made comparable by conversion to US $ currency values and have been adjusted according to purchasing power parity (PPP) data sourced from the African Development Bank. These adjustments enable comparisons across countries.

GERD as a percentage of GDP is a widely-used international indicator. In Table 3.2, it is complemented by data on GERD per capita. In US$ terms (PPP), R&D per capita is as follows: South Africa (80.21 PPP$), Egypt (26.94 PPP$, excluding the private non-profit sector), Kenya (16.09 PPP$), Senegal (10.50 PPP$), Uganda (7.11 PPP$), Ghana (6.16 PPP$), and Burkina Faso (2.38 PPP$).

TABLE 3.2: GROSS DOMESTIC EXPENDITURE ON RESEARCH AND DEVELOPMENT (GERD), 2010

COUNTRIES	SURVEY YEAR	GERD (PPP$ M)	GERD % OF GDP	GERD PER CAPITA (PPP$)
Burkina Faso †	2009	38.1	0.20%	2.38
Egypt† ǂ	2011	2223.35	0.43%	26.94
Ethiopiaǂ	2010	208.74	0.24%	2.51
Ghana	2010	150.2	0.38%	6.16
Kenya	2010	652.0	0.98%	16.09
Senegal	2010	130.5	0.54%	10.50
South Africa	2010	4 021.3	0.76%	80.21
Uganda	2010	237.8	0.50%	7.11

† Data not disaggregated by sector

ǂ GERD does not include private non-profit R&D expenditure

Source: ASTII R&D surveys 2010 or latest year available

GDP, PPP and population data sourced from African Development Bank

Comparing the 2007/08 and 2010/11 R&D data of the countries that participated in both phases shows some degree of variation in R&D investments within and across countries. Ghana and Senegal increased their GERD from 120.1 PPP$ and 99.0 PPP$ to 150.2 PPP$ and 130.5 PPP$ respectively. Expressed as a percentage of GDP, Ghana's R&D intensity remained at 0.38% while Senegal's increased from 0.48% to 0.54%. GERD for South Africa and Uganda decreased from 4 976.6 PPP$ and 359.8 PPP$ in 2007/08 to 4 021.3 PPP$ and 237.8 PPP$ in 2010/11 respectively.

The decline in the South African 2010/11 GERD R&D survey was the second following the decrease in 2009/10. This was mainly due to the decline in business sector R&D spending; consequently GERD as a percentage of GDP fell to 0.76%.

The decrease in Uganda's R&D expenditure can, at face value, be explained by the declines in R&D expenditure in the public sector, from 345.0 PPP$ in 2007/08 to 152.1 PPP$ in 2010/11. The low number of researchers and students could have resulted in low R&D costs which would explain the decline. However, this is not sufficient to explain the decline in gross domestic R&D expenditure in the government sector (GOVERD).

Kenya, on the other hand, increased its GERD from 277.8 PPP$ in 2007/08 to 652.0 PPP$ in 2010/11, resulting in its GERD/GPD ratio doubling from 0.48% to 0.98%.

The large drop from 1.1% to 0.50% in Uganda and the large increase from 0.48 PPP$ to 0.98 PPP$ in Kenya cannot easily be explained on the basis of the available data and requires further investigation. Kenya attributed this increase (and in personnel numbers; see section on R&D personnel below) to improved survey coverage of the sectors.

Thirteen countries provided higher education and government R&D expenditure data from which public R&D expenditure could be calculated. R&D performed in the public sector varied from country to country. South Africa had the highest public sector R&D expenditure, followed by Kenya and Tanzania. The public sector R&D expenditures as % of GDP were above 50% in Kenya, Mali and Tanzania.

TABLE 3.3: GROSS DOMESTIC PUBLIC EXPENDITURE ON R&D (PUBLIC GERD), 2010

COUNTRIES	SURVEY YEAR	PUBLIC GERD (PPP$ M)	PUBLIC GERD % OF GDP	PUBLIC GERD PER CAPITA (PPP$)
Angola	2011	90.4	0.08%	4.61
Ethiopia	2010	176.3	0.21%	2.13
Ghana	2010	153.4	0.38%	6.29
Kenya	2010	519.6	0.78%	12.83
Malawi	2010	134.4	1.10%	9.02
Mali	2010	112.4	0.66%	7.32
Mozambique	2010	90.0	0.42%	3.85
Senegal	2010	108.9	0.45%	8.76
South Africa	2010	1 991.8	0.38%	39.73
Tanzania	2010	322.4	0.52%	7.19
Togo	2010	15.3	0.25%	2.50
Uganda	2010	152.1	0.32%	4.55
Zimbabwe[z]	2012	143.1[z]		

z Zimbabwe advised that the GDP figure is not reliable for use with the R&D data. Zimbabwe's R&D expenditure data is in national currency.

Source: ASTII R&D surveys 2010 or latest year available

GDP, PPP and population data sourced from African Development Bank

Table 3.4 shows the BERD/GDP percentages ranging from South Africa's 0.38% to Senegal's and Ghana's 0.002% to 0.001% respectively. Countries with BERD/GDP between these two values were Uganda (0.18%), Kenya (0.09%) and Ethiopia (0.04%). BERD per capita in US$ PPP follows a similar distribution to GERD/GDP, with South Africa (39.84 PPP$), Uganda (2.47 PPP$), Kenya (1.39 PPP$), Ethiopia (0.39 PPP$), Senegal (0.04 PPP$) and Ghana (0.01 PPP$) falling in the same order.

TABLE 3.4: GROSS DOMESTIC BUSINESS EXPENDITURE ON R&D (BERD), 2010

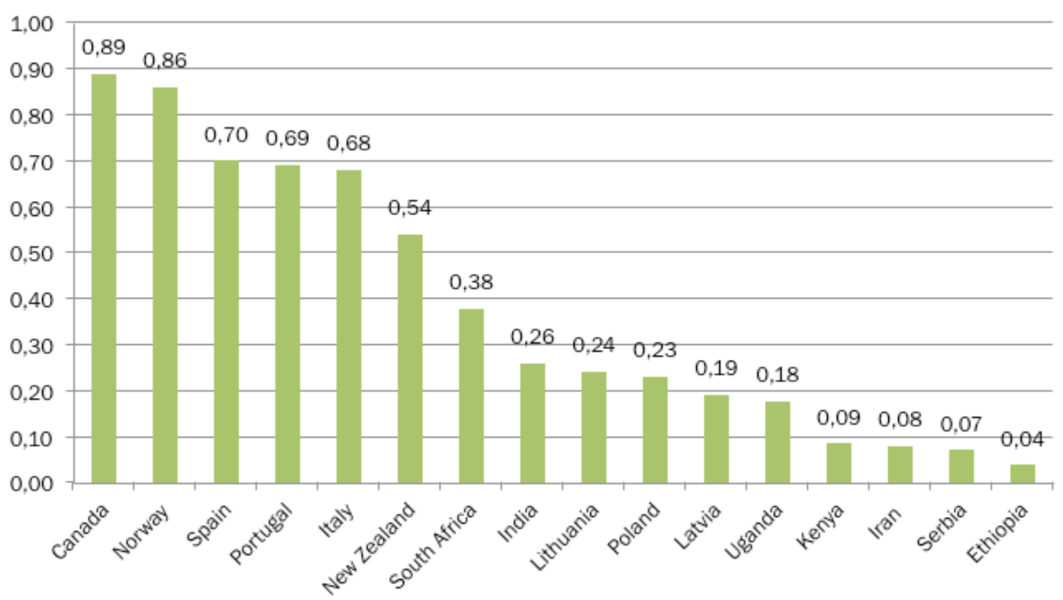
COUNTRIES	SURVEY YEAR	BERD (PPP$ M)	BERD % OF GDP	BERD PER CAPITA (PPP$)
Ethiopia	2010	32.4	0.04%	0.39
Ghana	2010	0.2	0.001%	0.01
Kenya	2010	56.4	0.09%	1.39
Senegal	2010	0.4	0.002%	0.04
South Africa	2010	1 997.2	0.38%	39.84
Uganda	2010	82.7	0.18%	2.47

Source: ASTII R&D surveys 2010 or latest year available

GDP, PPP and population data sourced from African Development Bank

Figure 3.1 provides data on GERD/GDP for selected countries, and shows the low investment in R&D by the business sector in most developing countries.

FIGURE 3.1: GLOBAL BERD/GDP (%), SELECTED COUNTRIES



Source: UNESCO-UIS (as of June 2013), ASTII R&D surveys 2010 or latest year available

Table 3.5 provides data on private non-profit R&D expenditure for the seven participating countries that provided this data. The R&D expenditure in the PNP sector is low in most of the countries that supplied this data.

TABLE 3.5: GROSS DOMESTIC PRIVATE NON-PROFIT (PNP) EXPENDITURE ON R&D, 2010

COUNTRIES	SURVEY YEAR	PRIVATE NON-PROFIT R&D EXPENDITURE (PPP$ M)	PRIVATE NON-PROFIT R&D EXPENDITURE % OF GDP	PRIVATE NON-PROFIT R&D EXPENDITURE PER CAPITA (PPP$)
Ghana	2010	0.0	0.00%	0.00
Kenya	2010	76.0	0.11%	1.87
Malawi	2010	2.2	0.02%	0.15
Mozambique	2010	9.0	0.04%	0.39
Senegal	2010	21.1	0.09%	1.70
South Africa	2010	32.3	0.01%	0.64
Uganda	2010	3.0	0.01%	0.09

Source: ASTII R&D surveys 2010 or latest year available

GDP, PPP and population data sourced from African Development Bank

Comparing 2007/08 and 2010/11 data, Malawi's PNP R&D expenditure dropped significantly from 46.3 PPP$ to 2.2 PPP$. This, according to officials within the country, could be attributed to the drastic cuts in foreign funding to Malawi.

Kenya's PNP sector R&D expenditure increased from 35.8 PPP$ to 76.0 PPP$; this could be attributed to better coverage of this sector. Uganda surveyed the PNP sector for the first time in 2010/11 while the survey of the PNP in Ghana yielded no results.

Table 3.6 provides data on government R&D expenditure for the countries that provided R&D data. The governments of Ghana, Kenya, and South Africa funded more R&D than those of the other countries listed in the table. Togo and Malawi spent the least, at 8.9 PPP$ and 21.3 PPP$ respectively.

TABLE 3.6: GROSS DOMESTIC GOVERNMENT EXPENDITURE ON R&D (GOVERD), 2010

COUNTRIES	SURVEY YEAR	GOVERD (PPP$ M)	GOVERD % OF GDP	GOVERD PER CAPITA (PPP$$)
Angola	2011	61.3	0.05%	3.12
Ethiopia	2010	88.0	0.10%	1.06
Ghana	2010	144.2	0.36%	5.91
Kenya	2010	265.0	0.40%	6.54
Malawi	2010	21.3	0.17%	1.43
Mali	2010	92.8	0.55%	6.04
Mozambique	2010	54.4	0.25%	2.32
Senegal	2010	67.9	0.28%	5.46
South Africa	2010	914.8	0.17%	18.25
Tanzania	2010	44.32	0.07%	0.99
Togo	2010	8.9	0.15%	1.48
Uganda	2010	91.7	0.19%	2.74
Zimbabwe	2012	24.3		

z Zimbabwe: Data is in national currency

Source: ASTII R&D surveys 2010 or latest year available

GDP, PPP and population data sourced from African Development Bank

Comparing the 2007/08 GOVERD with the latest data indicates that Ghana, Kenya, Mali, Mozambique and Senegal increased their expenditures from 111.4 PPP$ to 144.2 PPP$, 193.3 PPP$ to 265.0 PPP$, 0 to 92.8 PPP$, 36.5 PPP$ to 54.4 PPP$ and 33.2 PPP$ to 67.9 PPP$ respectively.

The following countries recorded declines in GOVERD between 2007/08 and 2010/11: Malawi declined from 33.3 PPP$ to 21.3 PPP$, South Africa from 1 079.9 PPP$ to 914.8 PPP$, Tanzania from 98.8 PPP$ to 44.32 PPP$ and Uganda from 165.5 PPP$ to 91.7 PPP$.

Table 3.7 provides data on higher education R&D expenditure (HERD) for the 16 countries that provided this data. All countries surveyed the higher education sector; however, Burkina Faso and Egypt did not disaggregate R&D expenditure data by sector of performance. Gabon did not submit expenditure data.

Lesotho and Cape Verde have the lowest HERD, at 0.5 PPP$ and 1.5 PPP$ respectively.

TABLE 3.7: GROSS DOMESTIC HIGHER EDUCATION EXPENDITURE ON R&D (HERD), 2010

COUNTRIES	SURVEY YEAR	HERD (PPP$ M)	HERD % OF GDP	HERD PER CAPITA (PPP$)
Angola	2011	24.3	0.02%	1.24
Cape Verde	2011	1.5	0.06%	2.92
Ethiopia	2010	88.3	0.10%	1.06
Ghana	2010	5.7	0.01%	0.23
Kenya	2010	254.6	0.38%	6.29
Lesotho	2011	0.5	0.02%	0.22
Malawi	2010	113.1	0.92%	7.59
Mali	2010	19.6	0.12%	1.27
Mozambique	2010	35.7	0.17%	1.52
Namibia	2010	18.6	0.13%	0.81
Senegal	2010	41.0	0.17%	3.30
South Africa	2010	1 077.0	0.20%	21.48
Tanzania	2010	278.05	0.45%	31.60
Togo	2010	6.4	0.10%	1.03
Uganda	2010	60.4	0.13%	1.81
Zimbabwe[z]	2012	118.0		

z Zimbabwe: Data is in national currency
Source: ASTII R&D surveys 2010 or latest year available
GDP, PPP and population data sourced from African Development Bank

Ghana's HERD increased from 2.8 PPP$ recorded in 2007/08 to 5.7% PPP$ in 2010/11, while Senegal's 2007/08 HERD (40.3 PPP$) is similar to that of 2010/11 (41.0 PPP$). South Africa increased its HERD from 965.5 PPP$ to 1 077.0 PPP$ between 2007/08 and 2010/11. Mozambique did not survey the higher education sector in 2007/08.

The large decrease in Uganda's HERD, from 179.5 PPP$ in 2007/08 to 60.4 PPP$ in 2010/11, could not be adequately explained and require further investigation by the Ugandan officials.

3.2.2 GERD BY SECTOR OF PERFORMANCE

GERD is a useful measure for analysing by sector of performance. R&D within a particular sector can illustrate a zone of activity in relation to general knowledge across a country's economy; and the Frascati guidelines recommend that GERD be disaggregated by sector of performance. The locus of R&D concentration within an economy speaks to international competitiveness and innovative capacity and is an indicator of maturity within a knowledge economy as knowledge diffuses across the system.

With the exception of South Africa, all of the countries surveyed showed a marked concentration of R&D within the public sector. This was particularly centered within the government and higher education sectors which in some countries (Egypt, Ethiopia, Ghana, Lesotho, Malawi, Mozambique and Senegal) accounted for the largest amount of GERD.

The business sector is a particularly significant role player in R&D in South Africa and Uganda. However, for many participating countries the data are not disaggregated by sector of performance or the private sector was not surveyed. This has implications for understanding the actual influence of private sector-driven R&D in Africa, most notably in the fast growing economies of northern and western Africa. The data below should therefore be interpreted with caution as the quantum of private sector influence in individual countries and across the continent as a whole is relatively unknown.

TABLE 3.8: GERD BY SECTOR OF PERFORMANCE (PERCENTAGE)

COUNTRIES	YEAR	TOTAL	GOVERNMENT	BUSINESS	HIGHER EDUCATION	PRIVATE NON-PROFIT
Angola	2011	100.0	71.6	*	28.4	*
Burkina Faso	2010	100.0	†	†	†	†
Cape Verde	2011	100.0	*	*	100.0	*
Egypt	2010	100.0	†	†	†	†
Ethiopia	2010	100.0	42.2	15.5	42.3	*
Ghana	2010	100.0	96.0	0.2	3.8	0.0 ^
Kenya	2010	100.0	40.6	8.7	39.1	11.6
Lesotho	2011	100.0	*	*	100.0	*
Malawi	2010	100.0	15.6	*	82.8	1.6
Mali	2010	100.0	82.6	*	17.4	*
Mozambique	2010	100.0	54.9	*	36.0	9.1
Senegal	2010	100.0	52.0	0.3	31.4	16.2
South Africa	2010	100.0	22.7	49.7	26.8	0.8
Tanzania	2010	100.0	13.7	*	86.3	*
Togo	2010	100.0	58.2	†	41.8	†
Uganda	2010	100.0	38.6	34.8	25.4	1.2
Zimbabwe	2012	100.0	17.1	*	82.9	*

* Sector not surveyed
† Data not disaggregated by sector
GDP, PPP and population data sourced from African Development Bank
Source: ASTII R&D surveys 2010 or latest year available

3.2.3 GERD BY SOURCES OF FUNDING

Flows of funding across sectors are an important metric to track over time as the source of funding for R&D is not always directly related to the sector of R&D performance. The observed trend is that R&D expenditure in the business enterprise sector is usually funded by that sector. The same is true for the government sector although in many developing countries a high proportion of funding may be from foreign donors. Government generally provides a large amount of funding for the higher education sector. Analysis of the above-mentioned countries with complete-sector coverage reveals that five of the six countries follow this trend, with the exception of Uganda which reported significant foreign investment in the higher education sector.

The government sector is the largest funder of R&D activities in some of the countries in this report. Except in South Africa where it finances 40% of R&D, the business sector plays a relatively minor role in financing R&D activity in the surveyed countries. In five of the six countries shown in Table 3.9, again with the exception of South Africa, foreign funders make significant contributions to R&D activity.

TABLE 3.9: GERD BY SOURCES OF FUNDING (PERCENTAGE)

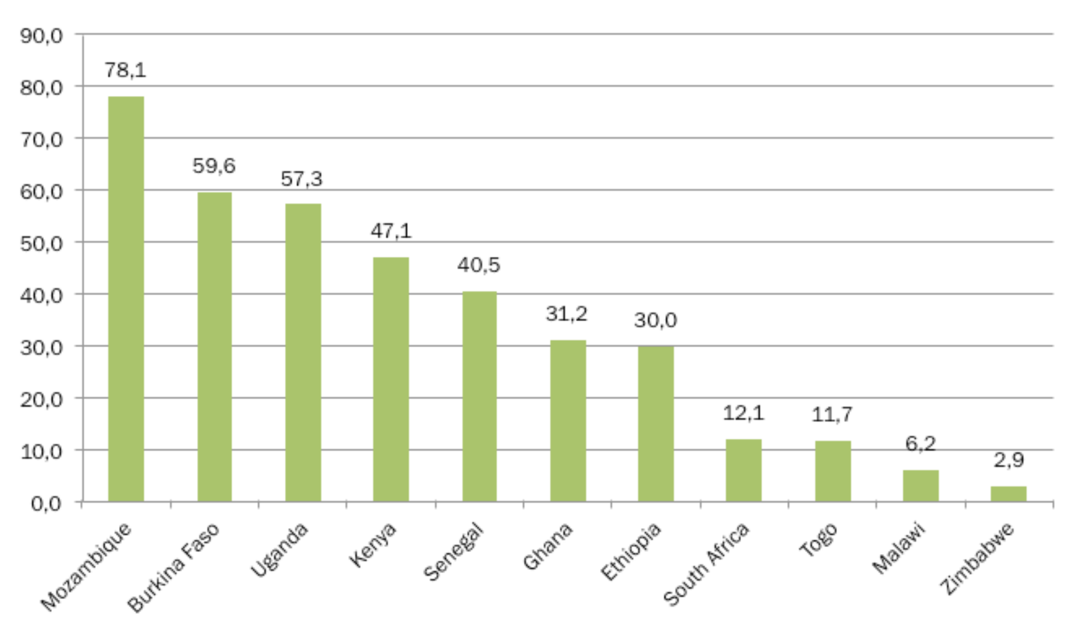
		BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT	ABROAD	OTHER	TOTAL
COUNTRIES	YEAR	%	%	%	%	%	%	%
Burkina Faso	2009	11.9	9.1	12.2	1.3	59.6	5.9	100
Ghana	2010	0.1	68.3	0.3	0.1	31.2	0.0	100
Kenya	2010	4.3	26.0	19.0	3.5	47.1	0.0	100
Senegal	2010	4.1	47.6	0.0	3.2	40.5	4.5	100
South Africa	2010	40.1	44.5	0.1	3.2	12.1	0.0	100
Uganda	2010	13.7	21.9	1.0	6.0	57.3	0.0	100

Source: ASTII R&D surveys 2010 or latest year available

Countries such as Mozambique, Burkina Faso and Uganda received more than 50% of their R&D funding from foreign sources (Figure 3.2). It must however be noted that not all of the countries represented in this category submitted complete survey coverage information and this may skew the representation. However, of the six countries that did submit complete information, all receive above 30% of R&D funding from abroad.

Overall, R&D dependence on foreign and donor funding is expected to decrease over time, although Mozambique, for example, remains highly dependent on this form of funding. By contrast, South Africa funds its R&D largely from domestic sources. The lower three countries, Malawi, Togo and Zimbabwe did not submit complete data. An improved survey coverage and data submission in the future may reveal their dependence on funding from non-domestic sources.

FIGURE 3.2: FOREIGN FUNDING OF COUNTRY'S R&D ACTIVITY (PERCENTAGE)



Source: ASTII R&D surveys 2010 or latest year available

3.2.4 GERD BY TYPE OF R&D

In addition to sectors of performance and sources of R&D funding, it is important to have information about R&D by type of research. The type of research within a country indicates the priorities of those who fund it and those who carry it out. Levels and types of R&D expenditure differ from sector to sector and from country to country. In providing information for the current AIO, ten countries reported on R&D expenditure by type of R&D performed. This is shown in Table 3.10.

Kenya and Zimbabwe assigned more than 50% of their R&D expenditure to basic research, followed by Togo at 37.6% and Uganda at 34.7%. On average, countries spent somewhat over 27% of their R&D funding on basic research activities, with none spending less than 15% on it. Lesotho has the highest expenditure on applied research at 70% followed by Malawi and Mozambique which spend more than 60% on it. Countries spending more than 15% of their R&D funds on experimental development research included Ghana, South Africa, Ethiopia, Uganda and Kenya. Experimental development is usually the business of firms, and these countries reported data on their business sectors. Not all countries adequately defined their R&D activity by type of research performed and some values were assigned to the 'not elsewhere classified' (NEC) category (Table 3.10).

TABLE 3.10: GERD BY TYPE OF R&D (PERCENTAGE)

COUNTRY	SURVEY YEAR	BASIC RESEARCH	APPLIED RESEARCH	EXPERIMENTAL DEVELOPMENT RESEARCH	NOT ELSEWHERE CLASSIFIED
Cape Verde	2011	23.6	3.3	0	73.1
Ethiopia	2010	19.8	43.5	21.2	15.5
Ghana	2010	16.8	33.8	49.4	0.0
Kenya	2010	57.5	24.6	17.9	0.0
Lesotho	2011	20.0	70.0	10.0	0.0
Malawi	2010	24.8	65.0	10.1	0.0
Mozambique	2010	27.4	61.9	10.7	0.0
South Africa	2010	23.9	39.8	36.3	0.0
Togo	2010	37.6	47.9	14.5	0.0
Uganda	2010	34.7	43.0	22.3	0.0
Zimbabwe	2012	54.1	34.3	11.6	0.0
Source: ASTII R&D surveys 2010 or latest year available					

3.3 R&D PERSONNEL

Another highly important subset of STI indicators measures the human resources devoted to research and experimental development. Information about the quality and availability of R&D personnel is crucial for understanding a country's S&T landscape. If there are human resource shortages or an insufficiently skilled labour force, it may be futile to increase R&D financing. Instead, steps should be taken to increase and strengthen the R&D workforce. Measures of internationally comparable R&D human resources are therefore important for detecting deficiencies in the system and for enabling policy makers, officials and donors to make informed decisions.

R&D personnel are defined as all persons employed in R&D activities and those providing related services, such as R&D managers, administrators and clerical staff. Statistics on these personnel provide information about their levels of formal qualification and occupation, gender, headcount, estimates of full-time equivalents (FTE) and fields of research.

3.3.1 R&D PERSONNEL BY OCCUPATION

One of the complexities of collecting data on R&D personnel resources is that of classifying who is a researcher and who is not. The Frascati Manual defines researchers as "professionals engaged in the conception or creation of new knowledge, products processes, methods and systems, and in the management of the projects concerned". This category of personnel usually holds a doctoral degree or equivalent although this is not always the case. The Frascati Manual recommends including in the researcher category PhD students and post-doctoral fellows.

Seventeen of the countries which provided information for the AIO-II reported on R&D human resources. Countries that indicated the largest numbers of R&D personnel included Egypt, Kenya and South Africa. Overall, ten of the countries reported that over 50% of their R&D personnel are researchers, with the percentages ranging from 55.6% in Ethiopia to 87.7.3% in Cape Verde. Of the countries that covered all the four main sectors, Kenya reported a large number of R&D personnel but a much lower percentage of researchers (21.0%). Egypt's results indicated that almost 65.4% of its R&D personnel are researchers, at 1 103 per million inhabitants. It is not clear if these ranges are real or simply reflect differences in measurement based on differing definitions of 'researchers'; this will require further investigation.

TABLE 3.11: R&D PERSONNEL AND RESEARCHERS (HEADCOUNT)

SECTORS SURVEYED	COUNTRY	R&D PERSONNEL	RESEARCHERS	RESEARCHERS AS % OF R&D PERSONNEL	POPULATION IN MILLION	R&D PERSONNEL PER MILLION INHABITANTS	RESEARCHERS PER MILLION INHABITANTS
Government, business, higher education, private non-profit	Burkina Faso	2 548	1 144	44.9	16.0	159	72
	Ghana	7 477	2 542	34.0	24.4	307	104
	Kenya	61 964	13 012	21.0	40.5	1 529	321
	Senegal	10 644	8 170	76.8	12.4	856	657
	South Africa	55 531	37 901	68.3	50.1	1 108	756
	Uganda	4 270	2 823	66.1	33.4	128	84
Government, business, higher education	Egypt[E]	139 223	90 990	65.4	82.5	1 688	1 103
	Ethiopia	13 095	7 283	55.6	82.9	158	88
	Mali	1 940	898	46.3	15.4	126	58
	Namibia[X]	949	748	78.8	2.3	416	328
Government, higher education, private non-profit	Malawi	3 809	1 843	48.4	14.9	256	124
	Mozambique	3 313	1 588	47.9	23.4	142	68
Government, higher education	Angola**	7 603	2 995	39.4	19.7	386.0	152
	Togo	923	568	61.5	6.0	153	94
	Zimbabwe	3 697	2 739	74.1	13.1	282	209
Higher education	Cape Verde	146	128	87.7	0.5	292	256
	Lesotho	53	42	79.2	2.2	24	19

The survey reference year is 2010 except for Angola (2011), Cape Verde (2011), Lesotho (2011) and Zimbabwe (2012)

[X] Namibia provided personnel data for the government sector; the expenditure data is incomplete.

[E] Egypt: do not correspond exactly to the Frascati Manual guidelines

Source: ASTII R&D surveys 2010 or latest year available

Population data sourced from African Development Bank

**In the case of Angola "R&D personnel" and "researchers" include university lectures who are not necessarily conducting research

3.3.2 PARTICIPATION OF WOMEN IN RESEARCH AND EXPERIMENTAL DEVELOPMENT

Historically, in much of Africa the R&D workforce was largely dominated by males. Many interventions have been put in place to increase the number of women in the STI field. The share of women researchers as a percentage of total researchers is an important indicator of progress in this respect.

Four of the seventeen countries (Namibia, Cape Verde, South Africa and Kenya) reported shares of above 40% for women in R&D personnel. In these countries, except Kenya, the shares of women researchers reached 40% and above.

No major differences were observed in the reported percentages of women in R&D personnel as a whole and the female share of researchers. This suggests that women are actively participating in research activities and not merely fulfilling the role of support staff. Countries such as Ethiopia, Ghana, Malawi, Mali and Togo reported less than 20% of women researchers. However, these figures call for further analysis and interpretation.

TABLE 3.12: FEMALE R&D PERSONNEL AND RESEARCHERS AND SHARES OF TOTAL (HEADCOUNT)

COUNTRIES	FEMALE R&D PERSONNEL	FEMALE RESEARCHERS	%FEMALE SHARE OF TOTAL R&D PERSONNEL	%FEMALE SHARE OF TOTAL RESEARCHERS
Angola**	2 630	756	34.6	25.2
Burkina Faso	637	232	25.0	20.3
Cape Verde	63	51	43.2	39.8
Egypt	38 510	38 510	27.7	42.3
Ethiopia	1 351	477	10.3	6.5
Ghana	1 641	465	21.9	18.3
Kenya	25 281	3 338	40.8	25.7
Lesotho	16	13	30.2	31.0
Malawi	751	360	19.7	19.5
Mali	404	144	20.8	16.0
Mozambique	1 110	512	33.5	32.2
Namibia	499	327	52.6	43.7
Senegal	2 885	2 031	27.1	24.9
South Africa	23 285	15 794	41.9	41.7
Togo	96	60	10.4	10.6
Uganda	1 096	687	25.7	24.3
Zimbabwe	1 044	692	28.2	25.3

Source: ASTII R&D surveys 2010 or latest year available

** In the case of Angola “R&D personnel” and “researchers” include university lectures who are not necessarily conducting research

3.3.3 RESEARCHERS BY SECTOR OF PERFORMANCE

Table 3.13 shows the distribution of researchers by sector of employment. The data indicate that in most of the countries that covered all four sectors, the majority of the researchers were employed in the public sector, mainly in higher education and government with the exception of Uganda. The high proportion of researchers in the public sector was also observed in the countries who surveyed only three of the main sectors. Uganda is an exception; it reported low numbers of researchers (including postgraduate students) in the higher education sector. One of the reasons provided for these low numbers is that Uganda has very few researchers in the higher education sector and that the low numbers are not as a result of undercounting. Countries where a significant percentage of researchers are employed in the business sector were Uganda (50.7%), Mali (27.7%) and South Africa (16.8%). Mali covered only three of the sectors and excluded the private non-profit sector. The deployment of researchers in private non-profit institutions was very modest in the countries which surveyed this sector.

TABLE 3.13: RESEARCHERS BY SECTOR OF EMPLOYMENT (HEADCOUNT): PERCENTAGE SHARES

SECTORS SURVEYED	COUNTRIES	TOTAL RESEARCHERS	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON- PROFIT
Government, business, higher education, private non-profit	Burkina Faso†	†	†	†	†	†
	Ghana	100	0.7	17.7	80.1	1.5
	Kenya	100	9.4	27.9	56.6	6.1
	Senegal	100	0	2.3	97.1	0.5
	South Africa	100	16.8	8.2	74.3	0.7
	Uganda	100	50.7	14.3	31.2	3.8
Government, business, higher education	Egypt	100	0.1	23.8	76.1	*
	Ethiopia	100	5.6	22	72.4	*
	Mali	100	27.7	37.8	34.5	*
	Namibia[x]	100	2.8	37.4	59.8	*
Government, higher education, private non-profit	Malawi	100	*	27.5	71.8	0.7
	Mozambique	100	*	35.5	61.0	3.5
Government, higher education	Angola	100	*	63.5	36.5	*
	Togo	100	*	12.3	87.7	*
	Zimbabwe	100	*	8.3	91.7	*
Higher education	Cape Verde	100	*	*	100	*

* Sector not surveyed

† Data not disaggregated by sector

[x] Namibia provided personnel data for the government sector, the expenditure data is incomplete

Source: ASTII R&D surveys 2010 or latest year available

** In the case of Angola "researchers" include university lectures who are not necessarily conducting research

3.3.4 QUALIFICATIONS OF R&D PERSONNEL

Conducting research requires adequately skilled human resources with appropriate educational qualifications. All of the participating countries provided information about the qualifications of their R&D personnel. Details of researchers' qualifications were available for 16 countries; and, from 14 countries, for R&D personnel. The findings are shown in Tables 3.14 and 3.15 and in Figure 3. 3.

There were evident differences in the qualifications of R&D personnel between countries. This again raises the question of how 'researcher' and other R&D personnel are defined and the reader is cautioned to keep this in mind.

TABLE 3.14: R&D PERSONNEL BY LEVEL OF EDUCATION (HEADCOUNT)

COUNTRIES	TOTAL R&D PERSONNEL	SECOND STAGE TERTIARY EDUCATION: DOCTORATE LEVEL (ISCED 6)	FIRST STAGE TERTIARY EDUCATION: THEORETICAL (ISCED 5A)	FIRST STAGE TERTIARY EDUCATION: PRACTICAL (ISCED 5B)	OTHER QUALIFICATIONS (ISCED 4 AND BELOW)
Cape Verde	146	71	65	10	0
Ghana	7 477	953	1 746	3 451	1 326
Kenya	61 964	826	9 708	48 415	3 015
Lesotho	53	23	24	0	6
Mali	1 940	419	601	467	453
Malawi	3 809	551	2 588	250	420
Mozambique	3 313	281	1 624	1 408	0
Namibia	949	175	606	147	21
Senegal	10 644	1 690	6 612	0	2 342
South Africa	55 531	20 482	18 715	16 334	0
Togo	923	446	122	100	255
Uganda	4 270	642	2 846	218	564
Zimbabwe	3 697	489	2 175	346	687

ISCED: International Standard Classification of Education

Source: ASTII R&D surveys 2010 or latest year available

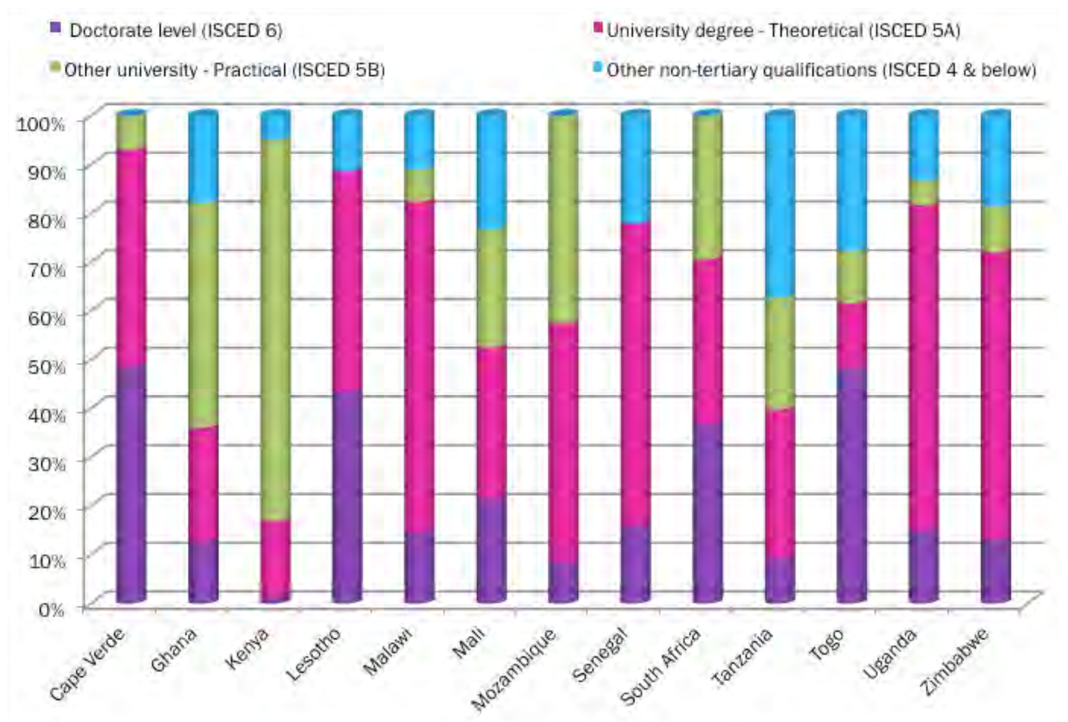
Countries with large percentages of R&D staff holding doctoral degrees include Cape Verde (48.6%), Togo (48.3%), Lesotho (43.4%) and South Africa (36.9%). Malawi (67.9%), Uganda (66.7%), Senegal (62.1%) and Zimbabwe (58.8%) had substantial percentages of R&D personnel with first stage tertiary education (ISCED5A), Table 2.15.

As was observed in the AIO 2010, in a number of countries including Ghana, Kenya and Mali a low percentage of R&D personnel have doctoral degrees and a high percentage have non-tertiary education. Although this requires attention, it does not necessarily mean that research projects in these countries are staffed by less than competent R&D personnel. Furthermore, this could be a methodological issue where countries differ in defining and counting R&D personnel and associated qualifications.

TABLE 3.15: R&D PERSONNEL BY LEVEL OF EDUCATION (HEADCOUNT): PERCENTAGE SHARES

COUNTRIES	TOTAL R&D PERSONNEL	SECOND STAGE TERTIARY EDUCATION: DOCTORATE LEVEL (ISCED 6)	FIRST STAGE TERTIARY EDUCATION: THEORETICAL (ISCED 5A)	FIRST STAGE TERTIARY EDUCATION: PRACTICAL (ISCED 5B)	OTHER QUALIFICATIONS (ISCED 4 AND BELOW)
Cape Verde	100.0	48.6	44.5	6.8	0.0
Ghana	100.0	12.7	23.4	46.2	17.7
Kenya	100.0	1.3	15.7	78.1	4.9
Lesotho	100.0	43.4	45.3	0.0	11.3
Mali	100.0	21.6	31.0	24.1	23.4
Malawi	100.0	14.5	67.9	6.6	11.0
Mozambique	100.0	8.5	49.0	42.5	0.0
Namibia	100.0	18.4	63.9	15.5	2.2
Senegal	100.0	15.9	62.1	0.0	22.0
South Africa	100.0	36.9	33.7	29.4	0.0
Togo	100.0	48.3	13.2	10.8	27.6
Uganda	100.0	15.0	66.7	5.1	13.2
Zimbabwe	100.0	13.2	58.8	9.4	18.6
Source: ASTII R&D surveys 2010 or latest year available					

FIGURE 3.3: QUALIFICATIONS OF R&D PERSONNEL (PERCENTAGES)



Source: ASTII R&D surveys

3.3.5 WHEN IS A RESEARCHER CATEGORISED AS DOING RESEARCH?

Analysing the human resource data from the participating countries highlighted the difficulty of defining who should be classified as a researcher. However, using the Frascati Manual's guidelines makes it possible to arrive at a reasonable estimate. The Manual recommends that, in addition to collecting headcount data, surveys should also estimate FTEs. This helps with estimating how much time researchers and support staff spend doing research or being involved with research projects. This is important as individuals do not necessarily work on research projects all the time and usually fulfil several other tasks. In this publication, time spent on research is expressed as FTE as a percentage of headcount. Sixteen countries provided estimates of full-time equivalents (FTE) and these are presented in Table 3.16. Eight countries indicated that 50% and above of their R&D personnel full-time equivalents are researchers. This is fewer countries in comparison to the eleven countries who reported researcher/personnel ratios of 50% and more for headcounts.

TABLE 3.16: R&D PERSONNEL AND RESEARCHERS (FTE)

COUNTRIES	TOTAL R&D PERSONNEL	TOTAL RESEARCHERS	RESEARCHERS AS A % OF R&D PERSONNEL	R&D PERSONNEL PER MILLION INHABITANTS	RESEARCHERS PER MILLION INHABITANTS
Angola**	6 408.0	2 245.0	35.0	327	114
Burkina Faso	2 049.4	742.4	36.2	128	46
Cape Verde	37.0	25.0	67.6	74	50
Egypt	89 764.4	41 568.4	46.3	1 088	504
Ethiopia	8 279.0	3 701.0	44.7	100	45
Ghana	3 004.4	940.6	31.3	123	39
Kenya	42 566.0	9 305.0	21.9	1 051	230
Lesotho	13.7	11.9	86.9	6	5
Malawi	1 720.6	732.1	42.6	115	49
Mali	856.0	442.5	51.7	56	29
Mozambique	2 164.5	912.4	42.2	93	39
Senegal	5 642.3	4 679.0	82.9	454	376
South Africa	29 486.4	18 719.0	63.5	588	373
Tanzania	2 928.6	1 599.6	54.6	65	36
Togo	443.7	220.3	49.7	74	37
Uganda	2 006.9	1 262.7	62.9	60	38
Zimbabwe	1 740.8	1 305.2	75.0	133	100

Source: ASTII R&D surveys 2010 or latest year available

** In the case of Angola “R&D personnel” and “researchers” include university lectures who are not necessarily conducting research

Table 3.17 shows the FTE data for total R&D personnel and researchers and Table 3.18 shows the FTEs as a percentage of headcount.

TABLE 3.17: R&D PERSONNEL AND RESEARCHERS (FTE), TOTAL AND FEMALES

	TOTAL R&D PERSONNEL	FEMALE R&D PERSONNEL	TOTAL RESEARCHERS	FEMALE RESEARCHERS
Angola**	6 408.0	2 223.0	2 245.0	543.0
Burkina Faso	2 049.4	538.0	742.4	160.4
Cape Verde	37.0	9.0	25.0	9.0
Egypt	89 764.4	17 405.1	41 568.4	17 405.1
Ethiopia	8 279.0	-	3 701.0	-
Ghana	3 004.4	636.2	940.6	162.7
Kenya	42 566.0	16 620.0	9 305.0	1 861.0
Lesotho	13.7	4.6	11.9	3.9
Malawi	1 720.6	1 304.9	732.1	135.8
Mali	856.0	139.7	442.5	62.2
Mozambique	2 164.5	728.6	912.4	294.2
Senegal	5 642.3	1 423.5	4 679.0	1 161.6
South Africa	29 486.4	14 777.0	18 719.0	9 642.1
Tanzania	2 928.6	816.1	1 599.6	393.4
Togo	443.7	45.6	220.3	21.2
Uganda	2 006.9	555.0	1 262.7	331.6
Zimbabwe	1 740.8	472.8	1 305.2	332.2

- Data not supplied

Source: ASTII R&D surveys 2010 or latest year available

** In the case of Angola “R&D personnel” and “researchers” include university lectures who are not necessarily conducting research

Senegal reported FTE as a percentage of headcount for total R&D personnel at 53.0% and South Africa 53.1% (Table 3.18). Senegal and South Africa are the only two countries that submitted FTE and headcount data four all sectors. Ghana, Mali, Malawi, Togo, Uganda and Zimbabwe reported ratios of between 40% and 50%. The countries reporting the highest ratios of FTE as a percentage of headcount were Burkina Faso, Angola, Kenya, Ethiopia and Mozambique. Closer examination of the data shows that countries with high FTE as percentage of headcounts reported very high FTE numbers; it should be pointed out that collecting FTE data can be a very difficult exercise.

Time allocated to research by female researchers for all countries averaged about 45.4%. Several countries indicated much higher ratios; however, caution should be used when interpreting the data because of the issues relating to the methodological differences, definition of ‘researcher’ and the complexity of calculating FTEs as well as sector coverage when conducting R&D surveys. All of these factors may be responsible for variances in some data points.

TABLE 3.18: RELATIONSHIP BETWEEN FULL-TIME EQUIVALENTS AND HEADCOUNTS: FTE AS A PERCENTAGE OF HC

	TOTAL R&D PERSONNEL	FEMALE R&D PERSONNEL	TOTAL RESEARCHERS	FEMALE RESEARCHERS
Angola**	84.3	84.5	75.0	71.8
Burkina Faso	80.4	84.5	64.9	69.1
Cape Verde	49.3	26.5	37.3	32.1
Ethiopia	63.2	-	50.8	-
Ghana	40.2	38.8	37.0	35.0
Kenya	68.7	65.7	71.5	55.8
Lesotho	25.8	28.8	28.3	24.0
Malawi	45.2	40.6	39.7	37.7
Mali	44.1	34.6	49.3	43.2
Mozambique	65.3	65.6	57.5	64.7
Senegal	53.0	49.3	57.3	57.2
South Africa	57.5	63.5	49.4	48.4
Tanzania	50.6	40.3	51.6	49.9
Togo	48.1	47.5	38.8	35.4
Uganda	47.0	50.6	44.7	48.3
Zimbabwe	47.1	45.3	47.7	48.0

- Data not supplied

Source: ASTII R&D surveys 2010 or latest year available

** In the case of Angola “R&D personnel” and “researchers” include university lectures who are not necessarily conducting research

3.3.6 RESEARCHERS BY FIELD OF SCIENCE

It is generally accepted that the higher are researchers’ qualification levels and education the better equipped they are to carry out good quality research in specific fields. Also important, particularly in the African context where solutions to economic and social issues are urgently needed, is the field of science in which the research is carried out. Table 3.19 and Figure 3.4 give information about researchers by field of science. It should be noted, however, that not all the countries surveyed collected this information.

Countries with relatively high percentages of researchers in the fields of engineering and of technology were Cape Verde (35.9%), Mozambique (22.0%) and Malawi (20.2%). Burkina Faso’s researchers were primarily involved in the medical and health science field (42.0%) and the largest percentages in Lesotho (54.8%) and Kenya (40.5%) were in agriculture. Just over fifty percent (50.7%) of Senegalese researchers were in the social sciences and 30.0% of Zimbabwe’s were in the natural sciences.

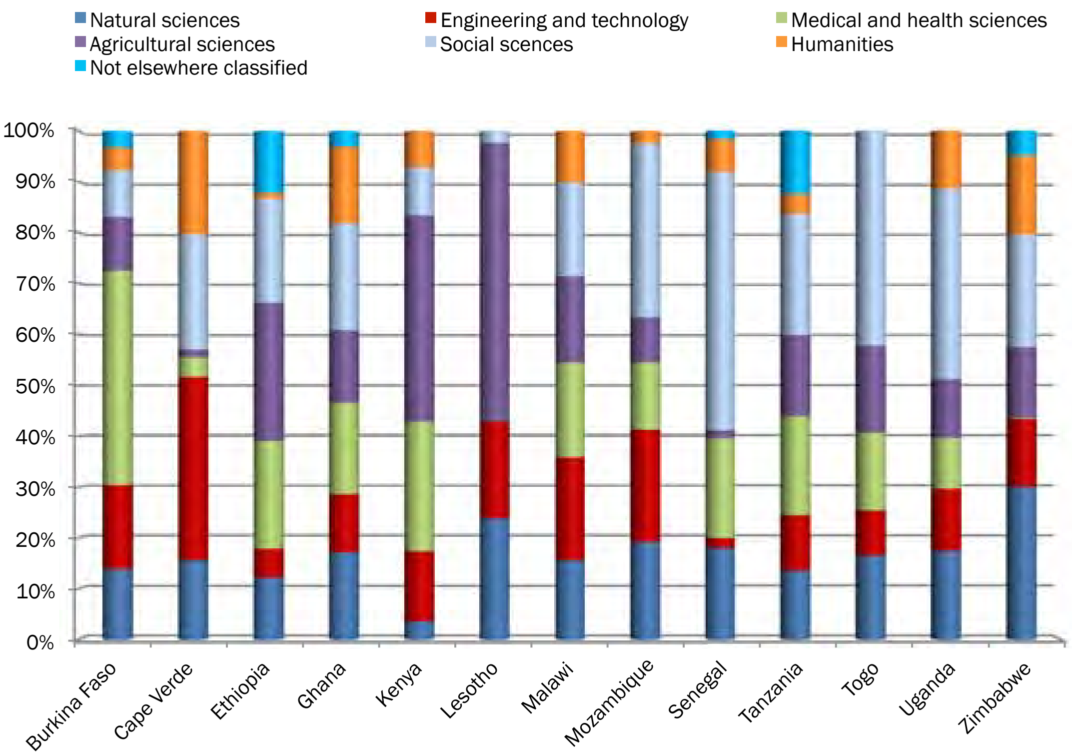
TABLE 3.19: RESEARCHERS BY FIELD OF SCIENCE (HEADCOUNT): PERCENTAGE SHARES

COUNTRIES	TOTAL	NATURAL SCIENCES	ENGINEERING AND TECHNOLOGY	MEDICAL AND HEALTH SCIENCES	AGRI-CULTURAL SCIENCES	SOCIAL SCIENCES	HUMANITIES	NEC
Burkina Faso	100.0	13.9	16.5	42.0	10.6	9.2	4.5	3.3
Cape Verde	100.0	15.6	35.9	3.9	1.6	22.7	20.3	0.0
Ethiopia	100.0	12.2	5.6	21.1	27.3	20.4	1.2	12.2
Ghana	100.0	17.2	11.4	18.0	14.2	21.0	15.1	3.1
Kenya	100.0	3.7	13.7	25.5	40.5	9.4	7.2	0.0
Lesotho	100.0	23.8	19.0	0.0	54.8	2.4	0.0	0.0
Malawi	100.0	15.6	20.2	18.6	16.9	18.4	10.2	0.0
Mozambique	100.0	19.3	22.0	13.2	8.9	34.1	2.5	0.0
Senegal	100.0	18.0	2.0	19.6	1.6	50.7	6.4	1.7
Togo	100.0	16.5	8.8	15.3	17.1	42.3	0.0	0.0
Uganda	100.0	17.4	12.2	10.1	11.5	37.4	11.4	0.0
Zimbabwe	100.0	30.0	13.3	0.2	13.9	22.2	15.5	4.9

NEC: Not elsewhere classified

Source: ASTII R&D surveys 2010 or latest year available

FIGURE 3.4: RESEARCHERS BY FIELD OF SCIENCE (PERCENTAGES)



Source: ASTII R&D surveys 2010 or latest year available

3.4 SUMMARY

This second AIO report is a milestone in R&D reporting in Africa, with nine more countries participating in collecting and sharing data than in the inaugural report. The additional country data have added diversity as well as some complexity in terms of the methodology used, definitions and understanding of concepts.

This chapter has presented information on gross domestic expenditure on research and experimental development and on the human resources devoted to R&D. Some countries submitted partial data which means that certain comparisons cannot be made; and the R&D indicators should be used with caution when making comparisons as some countries did not cover all of the sectors in their R&D surveys. There has been however significant improvement in Africa's ability to establish R&D indicators, as shown by the finance and human resource data provided by the participating countries. Baseline indicators are still being established in most countries but already they are deriving very significant value from the progress made in establishing datasets which make it possible for them to measure and evaluate their own R&D activities.

Major issues of concern are that R&D intensity remains very low in many countries; there is inadequate information about the role of the business sector; and R&D expenditure may be underreported in many of the participating countries. The lack of data about the business sector in most countries requires investigation and particularly in those countries that conducted the innovation survey. Basic research is crucial for increasing the stock of knowledge, training R&D personnel and stimulating collaboration (Salter and Martin, 2001).

Women's participation in research across the continent is very encouraging, with data indicating that they are active researchers and do not merely play supporting roles. The information presented in this chapter shows that the majority of researchers across the continent were employed in the higher education and government sectors. However, for the reasons outlined above, caution is advised when interpreting the data as not all countries may have used the definition of a researcher given in the Frascati Manual (2002). Continuous strategic training, capacity building and support across the entire production cycle of STI statistics should improve the quality of STI data on the African continent.

ANNEXURE 3A: COUNTRY TABLES

ANGOLA

TABLE 3A.1: ANGOLA: R&D PERSONNEL HC BY OCCUPATION (2011-2012)

R&D PERSONNEL BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**7 603**	*	**4 827**	**2 776**	*
Researchers	2 995	*	1 628	1 367	*
Technicians	684	*	568	116	*
Other supporting staff	3 924	*	2 631	1 293	*
FEMALE	**2 630**	*	**1 595**	**1 035**	*
Researchers	756	*	385	371	*
Technicians	246	*	195	51	*
Other supporting staff	1 628	*	1 015	613	*

* Sector not surveyed

** R&D Personnel and Researchers" include lecturers who are not necessarily conducting research

TABLE 3A.2: ANGOLA: R&D PERSONNEL FTE BY OCCUPATION (2011-2012)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**6 408.0**	*	**4 197.0**	**2 211.0**	*
Researchers	2 245.0	*	1 250.0	995	*
Technicians	636.0	*	528.0	108	*
Other supporting staff	3 527.0	*	2 419.0	1108	*
FEMALE	**2 223.0**	*	**1 407.0**	**816.0**	*
Researchers	543.0	*	303.0	240.0	*
Technicians	232.0	*	182.0	50.0	*
Other supporting staff	1 448.0	*	922.0	526.0	*

* Sector not surveyed

** R&D Personnel and Researchers" include lecturers who are not necessarily conducting research

TABLE 3A.3: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND TYPE OF COST IN MILLION ANGOLAN KWANZA (2011/12)

GERD BY SECTOR AND TYPE OF COST	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD by sector and type of cost	7 205.08	*	5 157.58	2 047.51	*
Labour cost	5 268.2	*	3 903.5	1 364.7	*
Other current cost	1 751.2	*	1 140.1	611.1	*
Land and buildings	41.3	*	38.7	2.6	*
Instruments and equipment	144.5	*	75.3	69.2	*

* Sector not surveyed

** R&D Personnel and Researchers” include lecturers who are not necessarily conducting research

BURKINA FASO

TABLE 3A.4: BURKINA FASO: R&D PERSONNEL HC BY OCCUPATION (2010)

R&D PERSONNEL BY OCCUPATION (HC)	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**2 548**	**†**	**†**	**†**	**†**
Researchers	1 144	†	†	†	†
Technicians	608	†	†	†	†
Other supporting staff	796	†	†	†	†
FEMALE	**637**	**†**	**†**	**†**	**†**
Researchers	232	†	†	†	†
Technicians	149	†	†	†	†
Other supporting staff	256	†	†	†	†

† Data not disaggregated by sector

TABLE 3A.5: BURKINA FASO: RESEARCHERS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 144**	†	†	†	†
ISCED 6	615	†	†	†	†
ISCED 5A	262	†	†	†	†
ISCED 5B	69	†	†	†	†
Other	198	†	†	†	†
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**1 144**	†	†	†	†
Natural sciences	159	†	†	†	†
Engineering and technology	189	†	†	†	†
Medical sciences	481	†	†	†	†
Agricultural sciences	121	†	†	†	†
Social sciences	105	†	†	†	†
Humanities	51	†	†	†	†
Not elsewhere classified	38	†	†	†	†
† Data not disaggregated by sector					

TABLE 3A.6: BURKINA FASO: R&D PERSONNEL FTE BY OCCUPATION (2010)

R&D PERSONNEL (FTE)	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION †	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**2 049.4**	†	†	†	†
Researchers	742.4	†	†	†	†
Technicians	579.4	†	†	†	†
Other supporting staff	727.6	†	†	†	†
FEMALE	**538.0**	†	†	†	†
Researchers	160.4	†	†	†	†
Technicians	140.7	†	†	†	†
Other supporting staff	236.9	†	†	†	†
† Data not disaggregated by sector					

TABLE 3A.7: BURKINA FASO: RESEARCHERS' FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**742.4**	†	†	†	†
ISCED 6	310.7	†	†	†	†
ISCED 5A	210.5	†	†	†	†
ISCED 5B	48.2	†	†	†	†
Other	173.0	†	†	†	†
FEMALE	**160.4**	†	†	†	†
ISCED 6	62.5	†	†	†	†
ISCED 5A	30.6	†	†	†	†
ISCED 5B	19.3	†	†	†	†
Other	48.0	†	†	†	†
RESEARCHERS FTE BY FIELD OF SCIENCE	**742.4**	†	†	†	†
Natural sciences	97.6	†	†	†	†
Engineering and technology	121.3	†	†	†	†
Medical sciences	344.3	†	†	†	†
Agricultural sciences	64.4	†	†	†	†
Social sciences	25.8	†	†	†	†
Humanities	48.7	†	†	†	†
Not elsewhere classified	40.4	†	†	†	†
FEMALE	**160.4**	†	†	†	†
Natural sciences	11.9	†	†	†	†
Engineering and technology	15.6	†	†	†	†
Medical sciences	94.4	†	†	†	†
Agricultural sciences	8.8	†	†	†	†
Social sciences	4.0	†	†	†	†
Humanities	14.8	†	†	†	†
Not elsewhere classified	11.0	†	†	†	†

† Data not disaggregated by sector

TABLE 3A.8: BURKINA FASO: GROSS DOMESTIC EXPENDITURES ON R&D IN MILLION CFA FRANC XOF (2009)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**7 905.8**	**†**	**†**	**†**	**†**
Business sector	943.3	†	†	†	†
Direct government	715.5	†	†	†	†
General university funds	0.0	†	†	†	†
Higher education	966.2	†	†	†	†
Private non profit	100.4	†	†	†	†
Funds from abroad	4 712.3	†	†	†	†
Other sources	468.0	†	†	†	†
† Data not disaggregated by sector					

CAPE VERDE

TABLE 3A.9: CAPE VERDE: R&D PERSONNEL HEADCOUNT BY OCCUPATION AND BY LEVEL OF EDUCATION (2011)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**146**	*	*	**146**	*
Researchers	128	*	*	128	*
Technicians	6	*	*	6	*
Other supporting staff	12	*	*	12	*
FEMALE	**63**	*	*	**63**	*
Researchers	51	*	*	51	*
Technicians	4	*	*	4	*
Other supporting staff	8	*	*	8	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**146**	*	*	**146**	*
ISCED 6	71	*	*	71	*
ISCED 5A	65	*	*	65	*
ISCED 5B	10	*	*	10	*
Other	0	*	*	0	*
FEMALE	**63**	*	*	**63**	*
ISCED 6	22	*	*	22	*
ISCED 5A	35	*	*	35	*
ISCED 5B	6	*	*	6	*
Other	0	*	*	0	*
* Sector not surveyed					

TABLE 3A.10: CAPE VERDE: RESEARCHERS BY LEVEL OF EDUCATION AND BY FIELD OF SCIENCE (2011)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**128**	*	*	**128**	*
ISCED 6	71	*	*	71	*
ISCED 5A	57	*	*	57	*
ISCED 5B	0	*	*	0	*
Other	0	*	*	0	*
FEMALE	**51**	*	*	**51**	*
ISCED 6	22	*	*	22	*
ISCED 5A	29	*	*	29	*
ISCED 5B	0	*	*	0	*
Other	0	*	*	0	*
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**128**	*	*	**128**	*
Natural sciences	20	*	*	20	*
Engineering and technology	46	*	*	46	*
Medical sciences	5	*	*	5	*
Agricultural sciences	2	*	*	2	*
Social sciences	29	*	*	29	*
Humanities	26	*	*	26	*
Not elsewhere classified	0	*	*	0	*
FEMALE	**51**	*	*	**51**	*
Natural sciences	7	*	*	7	*
Engineering and technology	9	*	*	9	*
Medical sciences	3	*	*	3	*
Agricultural sciences	2	*	*	2	*
Social sciences	16	*	*	16	*
Humanities	14	*	*	14	*
Not elsewhere classified	0	*	*	0	*
* Sector not surveyed					

TABLE 3A.11: CAPE VERDE: R&D PERSONNEL FULL-TIME EQUIVALENTS BY OCCUPATION (2011)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**37.0**	*	*	**37.0**	*
Researchers	25.0	*	*	25.0	*
Technicians	4.0	*	*	4.0	*
Other supporting staff	8.0	*	*	8.0	*
FEMALE	**16**	*	*	**16.0**	*
Researchers	9.0	*	*	9.0	*
Technicians	2.0	*	*	2.0	*
Other supporting staff	5.0	*	*	5.0	*
* Sector not surveyed					

TABLE 3A.12: CAPE VERDE: R&D PERSONNEL FULL-TIME EQUIVALENTS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2011)

R&D PERSONNEL FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**37.0**	*	*	**37.0**	*
ISCED 6	18.0	*	*	18.0	*
ISCED 5A	9.0	*	*	9.0	*
ISCED 5B	10.0	*	*	10.0	*
Other	0.0	*	*	0.0	*
R&D PERSONNEL BY FIELD OF SCIENCE	**37.0**	*	*	**37.0**	*
Natural sciences	6.0	*	*	6.0	*
Engineering and technology	12.0	*	*	12.0	*
Medical sciences	0.0	*	*	0.0	*
Agricultural sciences	1.0	*	*	1.0	*
Social sciences	9.0	*	*	9.0	*
Humanities	9.0	*	*	9.0	*
Not elsewhere classified	0.0	*	*	0.0	*
* Sector not surveyed					

TABLE 3A.13: CAPE VERDE: R&D RESEARCHER FULL-TIME EQUIVALENTS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2011)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**25.0**	*	*	**25.0**	*
ISCED 6	18.0	*	*	18.0	*
ISCED 5A	7.0	*	*	7.0	*
ISCED 5B	0.0	*	*	0.0	*
Other	0.0	*	*	0.0	*
RESEARCHERS FTE BY FIELD OF SCIENCE	**25.0**	*	*	**25.0**	*
Natural sciences	5.0	*	*	5.0	*
Engineering and technology	8.0	*	*	8.0	*
Medical sciences	0.0	*	*	0.0	*
Agricultural sciences	0.0	*	*	0.0	*
Social sciences	6.0	*	*	6.0	*
Humanities	6.0	*	*	6.0	*
Not elsewhere classified	0.0	*	*	0.0	*
FEMALE	**9.0**	*	*	**9.0**	*
Natural sciences	3.0	*	*	3.0	*
Engineering and technology	1.0	*	*	1.0	*
Medical sciences	0.0	*	*	0.0	*
Agricultural sciences	0.0	*	*	0.0	*
Social sciences	3.0	*	*	3.0	*
Humanities	2.0	*	*	2.0	*
Not elsewhere classified	0.0	*	*	0.0	*
* Sector not surveyed					

TABLE 3A.14: CAPE VERDE: GROSS DOMESTIC EXPENDITURES ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION ESCUDO (2011)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**107.5**	*	*	**107.5**	*
Business sector	0.0	*	*	0.0	*
Direct government	0.0	*	*	0.0	*
General university funds	0.0	*	*	0.0	*
Higher education	107.5	*	*	107.5	*
Private non profit	0.0	*	*	0.0	*
Funds from abroad	0.0	*	*	0.0	*
GERD BY SECTOR AND TYPE OF COST	**107.5**	*	*	**107.5**	*
Labour cost	59.5	*	*	59.5	*
Other current cost	3.3	*	*	3.3	*
Land and buildings	15.6	*	*	15.6	*
Instruments and Equipment	29.1	*	*	29.1	*
CURRENT INTRAMURAL COSTS BY TYPE OF R&D	**62.8**	*	*	**62.8**	*
Basic research	24.8	*	*	24.8	*
Applied research	3.3	*	*	3.3	*
Experimental development research	0.0	*	*	0.0	*
Not elsewhere classified	34.7	*	*	34.7	*
TOTAL INTRAMURAL COSTS BY TYPE OF R&D	**107.5**	*	*	**107.5**	*
Basic research	25.4	*	*	25.4	*
Applied research	3.5	*	*	3.5	*
Experimental development research	0.0	*	*	0.0	*
Not elsewhere classified	78.6	*	*	78.6	*
* Sector not surveyed					

EGYPT

TABLE 3A.15: EGYPT: R&D PERSONNEL HEADCOUNT BY OCCUPATION (2011)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**139 223**	**246**	**69 740**	**69 237**	*
Researchers	90 990	123	21 630	69 237	*
Technicians	21 989	97	21 892	-	*
Other supporting staff	26 244	26	26 218	-	*
FEMALE	**-**	**-**	**-**	**-**	*
Researchers	38 510	16	8 222	30 272	*
Technicians	-	-	-	-	*
Other supporting staff	-	-	-	-	
*-data missing					

TABLE 3A.16: EGYPT: RESEARCHERS HEADCOUNT BY LEVEL OF EDUCATION (2011)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**90 990**	**123**	**21 630**	**69 237**	*
ISCED 6	57 695	3	17 181	40 511	*
ISCED 5A	33 295	120	4 449	28 726	*
ISCED 5B	0	0	0	0	*
Other	0	0	0	0	*
FEMALE	**38 510**	**0**	**0**	**0**	*
ISCED 6	21 200	0	0	0	*
ISCED 5A	17 310	0	0	0	*
ISCED 5B	0	0	0	0	*
Other	0	0	0	0	*

TABLE 3A.17: EGYPT: RESEARCHERS HEADCOUNT BY FIELD OF SCIENCE (2011)

TOTAL RESEARCHERS BY FIELD OF SCIENCE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**90 990**	**123**	**21 630**	**69 237**	*****
Natural sciences	-	-	-	7 455	*
Engineering and technology	-	-	-	6 944	*
Medical sciences	-	-	-	27 079	*
Agricultural sciences	-	-	-	6 016	*
Social sciences	-	-	-	14 399	*
Humanities	-	-	-	7 344	*
Not elsewhere classified	-	-	-	-	
*-Data missing					

TABLE 3A.18: EGYPT: R&D PERSONNEL FTES BY OCCUPATION (2011)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**89 764.4**	**171.0**	**69 740.0**	**19 853.4**	*****
Researchers	41 568.4	85.0	21 630.0	19 853.4	*
Technicians	21 958.0	66.0	21 892.0	-	*
Other supporting staff	26 238.0	20.0	26 218.0	-	*
FEMALE	**17 405.1**	**7**	**8 222**	**9 176.1**	*****
Researchers	17 405.1	7	8 222	9 176.1	*
Technicians	-	-	-	-	*
Other supporting staff	-	-	-	-	
*-Data missing					

TABLE 3A.19: EGYPT: RESEARCHERS FTES BY LEVEL OF EDUCATION (2011)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**41 568.4**	**85**	**21 630**	**19 853.4**	*
ISCED 6	27 098.5	1	17 181	9 916.5	*
ISCED 5A	14 469.9	84	4 449	9 936.9	*
ISCED 5B	-	-	-	-	*
Other	-	-	-	-	*
FEMALE	**17 405.1**	**-**	**-**	**-**	*
ISCED 6	10 198.9	-	-	-	*
ISCED 5A	7 206.2	-	-	-	*
ISCED 5B	-	-	-	-	*
Other	-	-	-	-	*

TABLE 3A.20: EGYPT: RESEARCHERS FTES BY FIELD OF SCIENCE (2011)

TOTAL RESEARCHERS BY FIELD OF SCIENCE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**41 568.4**	**85**	**21 630**	**19 853.4**	*
Natural sciences	-	-	-	2 158.4	*
Engineering and technology	-	-	-	2 068.4	*
Medical sciences	-	-	-	7 488.1	*
Agricultural sciences	-	-	-	1 644.2	*
Social sciences	-	-	-	4 304.4	*
Humanities	-	-	-	2 189.9	*
Not elsewhere classified	-	-	-	-	
*-data missing					

TABLE 3A.21: EGYPT: GROSS DOMESTIC EXPENDITURES ON R&D IN MILLION EGYPTIAN POUND (2011)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**5 877.0**	**†**	**†**	**†**	*****
Business sector	†	†	†	†	*
Direct government	†	†	†	†	*
General university funds	†	†	†	†	*
Higher education	†	†	†	†	*
Private non profit	†	†	†	†	*
Funds from abroad	†	†	†	†	*

† Data not disaggregated by sector

* Sector not surveyed

ETHIOPIA

TABLE 3A.22: ETHIOPIA: R&D PERSONNEL HEADCOUNT BY OCCUPATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**13 095**	**414**	**5 823**	**6 858**	*****
Researchers	7 283	411	1 602	5 270	*
Technicians	1 881	3	1 319	559	*
Other supporting staff	3 931	0	2 902	1 029	*
FEMALE R&D PERSONNEL	**1 351**	**81**	**1 011**	**259**	*****
Researchers	477	79	139	259	*
Technicians	52	2	50	0	*
Other supporting staff	822	0	822	0	*

* Sector not surveyed

TABLE 3A.23: ETHIOPIA: RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION AND BY FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**7 283**	**411**	**1 602**	**5 270**	*
ISCED 6	723	0	113	610	*
ISCED 5A	5 124	0	1 397	3 727	*
ISCED 5B	0	0	0	0	*
Other	1 436	411	92	933	*
FEMALE	**477**	**79**	**139**	**259**	*
ISCED 6	40	0	11	29	*
ISCED 5A	358	0	128	230	*
ISCED 5B	0	0	0	0	*
Other	79	79	0	0	*
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**7 283**	†	†	†	*
Natural sciences	892	†	†	†	*
Engineering and technology	409	†	†	†	*
Medical sciences	1 538	†	†	†	*
Agricultural sciences	1 986	†	†	†	*
Social sciences	1 487	†	†	†	*
Humanities	84	†	†	†	*
Not elsewhere classified	887	†	†	†	*
* Sector not surveyed					
† Data not disaggregated by sector					

TABLE 3A.24: ETHIOPIA: R&D PERSONNEL FULL-TIME EQUIVALENTS BY OCCUPATION AND FIELD OF SCIENCE (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**8 282**	**256**	**5 762**	**2 264**	*
Researchers	3 701.0	250.0	1 583.0	1 868.0	*
Technicians	1 441.0	6.0	1 295.0	140.0	*
Other supporting staff	3 140.0	0.0	2 884.0	256.0	*
TOTAL R&D PERSONNEL FTE BY FIELD OF SCIENCE	**8 282**	†	†	†	*
Natural sciences	521.0	†	†	†	*
Engineering and technology	291.0	†	†	†	*
Medical sciences	1 096.0	†	†	†	*
Agricultural sciences	1 946.0	†	†	†	*
Social sciences	1 839.0	†	†	†	*
Humanities	67.0	†	†	†	*
Not elsewhere classified	2 522.0	†	†	†	*
* Sector not surveyed					

TABLE 3A.25: ETHIOPIA: RESEARCHERS FULL-TIME EQUIVALENTS BY FIELD OF SCIENCE (2010)

RESEARCHERS FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**3 701**	†	†	†	*
Natural sciences	451	†	†	†	*
Engineering and technology	208	†	†	†	*
Medical sciences	780	†	†	†	*
Agricultural sciences	1 008	†	†	†	*
Social sciences	755	†	†	†	*
Humanities	42	†	†	†	*
Not elsewhere classified	457	†	†	†	*
§ Data included into the business sector					
* Sector not surveyed					

TABLE 3A.26: ETHIOPIA: GROSS DOMESTIC EXPENDITURES ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION BIRR (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**931.4**	**144.7**	**392.7**	**394.0**	*
Business sector	100.3	100.0	0.2	0.1	*
Direct government	521.4	44.7	266.5	210.2	*
General university funds	0.0	0.0	0.0	0.0	*
Higher education	10.1	0.0	0.0	10.1	*
Private non profit	0.4	0.0	0.3	0.1	*
Funds from abroad	279.0	0.0	110.4	168.6	*
Amounts not specified	20.2	0.0	15.3	4.9	*
GERD BY SECTOR AND TYPE OF COST	**931.4**	**144.7**	**392.7**	**394.0**	*
Labour cost	173.5	28.9	104.0	40.6	*
Other current cost	637.5	101.3	200.5	335.7	*
Land and buildings	120.4	14.5	88.2	17.7	*
Instruments and equipment	0.0	0.0	0.0	0.0	*
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**931.4**	**144.7**	**392.7**	**394.0**	*
Basic research	184.1	0.0	84.4	99.7	*
Applied research	404.8	0.0	211.8	193.1	*
Experimental development research	197.8	0.0	96.5	101.3	*
Not elsewhere classified	144.7	144.7	0.0	0.0	*
GERD BY FIELD OF SCIENCE	**931.4**	**144.7**	**392.7**	**394.0**	*
Natural sciences	60.6	0.0	0.4	60.2	*
Engineering and technology	43.5	0.0	5.5	37.9	*
Medical sciences	144.4	0.0	41.9	102.4	*
Agricultural sciences	441.6	0.0	344.8	96.8	*
Social sciences	66.6	0.0	0.0	66.6	*
Humanities	27.8	0.0	0.0	27.8	*
Not elsewhere classified	147.0	144.7	0.0	2.3	*
* Sector not surveyed					

GABON

TABLE 3A.27: GABON: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 604**	**1 474**	**40**	**52**	**38**
Researchers	34	0	2	21	11
Technicians	568	498	33	18	19
Other supporting staff	1 002	976	5	13	8
FEMALE	**488**	**382**	**36**	**22**	**48**
Researchers	17	0	1	9	7
Technicians	162	121	17	5	19
Other supporting staff	309	261	18	8	22

GHANA

TABLE 3A.28: GHANA: R&D PERSONNEL HEADCOUNT BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**7 477**	**38**	**1 795**	**5 581**	**63**
Researchers	2 542	17	450	2 037	38
Technicians	1 862	10	454	1 390	8
Other supporting staff	3 073	11	891	2 154	17
FEMALE	**1 641**	**8**	**406**	**1 197**	**30**
Researchers	465	0	80	369	16
Technicians	530	3	100	424	3
Other supporting staff	646	5	226	404	11
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**7 477**	**38**	**1 795**	**5 581**	**63**
ISCED 6	953	1	139	808	5
ISCED 5A	1 746	22	274	1 405	45
ISCED 5B	3 451	6	271	3 166	8
Other	1 327	9	1 111	202	5
FEMALE	**1 641**	**8**	**406**	**1 197**	**30**
ISCED 6	143	0	21	121	1
ISCED 5A	434	5	56	351	22
ISCED 5B	725	0	71	651	3
Other	339	3	258	74	4

TABLE 3A.29: GHANA: RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION AND BY FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION (HC)	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**2 542**	**17**	**450**	**2 037**	**38**
ISCED 6	930	1	125	802	2
ISCED 5A	1 442	14	206	1 218	4
ISCED 5B	146	2	95	17	32
Other	24	0	24	0	0
FEMALE	**465**	**0**	**80**	**369**	**16**
ISCED 6	137	0	16	120	1
ISCED 5A	302	0	39	248	15
ISCED 5B	23	0	22	1	0
Other	3	0	3	0	0
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**2 542**	**17**	**450**	**2 037**	**38**
Natural sciences	437	0	84	347	6
Engineering and technology	290	12	68	208	2
Medical sciences	457	0	17	440	0
Agricultural sciences	361	3	158	199	1
Social sciences	534	1	96	426	11
Humanities	384	1	27	338	18
Not elsewhere classified	79	0	0	79	0
FEMALE	**465**	**0**	**80**	**369**	**16**
Natural sciences	74	0	18	55	1
Engineering and technology	19	0	8	11	0
Medical sciences	95	0	3	92	0
Agricultural sciences	56	0	21	35	0
Social sciences	108	0	17	85	6
Humanities	97	0	13	75	9
Not elsewhere classified	16	0	0	16	0

TABLE 3A.30: GHANA: R&D PERSONNEL FTES BY OCCUPATION, LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**3 004.5**	**14.2**	**1 436.0**	**1 540.7**	**13.4**
Researchers	940.6	9.3	360.0	563.7	7.5
Technicians	731.4	3.3	363.2	363.1	1.8
Other supporting staff	1 332.5	1.6	712.8	613.9	4.1
FEMALE	**636.1**	**1.9**	**324.8**	**302.1**	**7.4**
Researchers	162.7	0.0	64.0	95.1	3.6
Technicians	185.5	1.0	80.0	103.1	1.5
Other supporting staff	287.9	0.9	180.8	103.9	2.3
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**3 004.5**	**14.3**	**1 436.0**	**1 540.8**	**13.4**
ISCED 6	346.7	0.7	111.2	233.2	1.6
ISCED 5A	928.4	8.9	219.2	690.5	9.8
ISCED 5B	821.6	3.6	216.8	600.3	0.9
Other	907.8	1.1	888.8	16.8	1.1
R&D PERSONNEL FTE BY FIELD OF SCIENCE	**3 004.5**	**14.3**	**1 436.0**	**1 540.8**	**13.4**
Natural sciences	347.9	1.0	127.4	216.1	3.4
Engineering and technology	455.2	7.8	332.8	113.0	1.6
Medical sciences	459.1	0.0	34.2	424.1	0.8
Agricultural sciences	881.3	3.5	645.5	230.1	2.2
Social sciences	507.2	1.2	231.5	271.4	3.1
Humanities	249.6	0.8	64.6	182.8	1.4
Not elsewhere classified	104.2	0	0	103.3	0.9

TABLE 3A.31: GHANA: RESEARCHERS FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**940.6**	**9.2**	**360.0**	**563.8**	**7.6**
ISCED 6	323.5	0.1	100.0	222.7	0.7
ISCED 5A	513.8	7.6	164.8	334.7	6.7
ISCED 5B	81.8	1.5	76.0	4.1	0.2
Other	21.5	0.0	19.2	2.3	0.0
RESEARCHERS FTE BY FIELD OF SCIENCE	**940.6**	**9.2**	**360.0**	**563.8**	**7.6**
Natural sciences	164.4	0.0	67.2	96.0	1.2
Engineering and technology	120.2	7.6	54.4	57.7	0.5
Medical sciences	135.4	0.0	13.6	121.8	0.0
Agricultural sciences	182.5	0.8	126.4	55.1	0.2
Social sciences	197.0	0.5	76.8	117.9	1.8
Humanities	117.6	0.3	21.6	93.5	2.2
Not elsewhere classified	23.6	0.0	0.0	21.8	1.8
FEMALE	**162.2**	**0.0**	**64.0**	**95.0**	**3.2**
Natural sciences	28.8	0.0	14.4	14.2	0.2
Engineering and technology	9.2	0.0	6.4	2.8	0.0
Medical sciences	26.1	0.0	2.4	23.7	0.0
Agricultural sciences	25.8	0.0	16.8	9.0	0.0
Social sciences	36.7	0.0	13.6	21.9	1.2
Humanities	31.5	0.0	10.4	19.3	1.8
Not elsewhere classified	4.1	0.0	0.0	4.1	0.0

TABLE 3A.32: GHANA: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION CEDI (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**173.4**	**0.3**	**166.5**	**6.6**	**0.0**
Business sector	0.2	0.2	0.0	0.0	0.0
Direct government	118.4	0.1	112.7	5.6	0.0
General university funds	0.1	0.0	0.0	0.1	0.0
Higher education	0.5	0.0	0.0	0.5	0.0
Private non profit	0.2	0.0	0.0	0.2	0.0
Funds from abroad	54.1	0.0	53.8	0.3	0.0
GERD BY SECTOR AND TYPE OF COST	**173.4**	**0.3**	**166.5**	**6.6**	**0.0**
Labour cost	97.4	0.1	93.4	3.8	0.0
Other current cost	32.6	0.0	31.6	1.0	0.0
Land and buildings	3.4	0.1	2.7	0.7	0.0
Instruments and equipment	39.9	0.0	38.8	1.1	0.0
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**173.4**	**0.3**	**166.5**	**6.6**	**0.0**
Basic research	29.1	0.0	25.3	3.8	0.0
Applied research	58.5	0.1	56.6	1.8	0.0
Experimental development research	85.7	0.1	84.6	1.0	0.0
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0

KENYA

TABLE 3A.33: KENYA: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**61 964**	**4 112**	**21 222**	**33 071**	**3 559**
Researchers	13012	1226	3624	7370	792
Technicians	38 370	1 870	15 560	18 939	2 001
Other supporting staff	10 582	1 016	2 038	6 762	766
FEMALE	**25 281**	**1 824**	**9 549**	**12 684**	**1 224**
Researchers	3 338	414	1 456	1 245	223
Technicians	17 673	656	7 269	8 892	856
Other supporting staff	4 270	754	824	2547	145
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**61 964**	**4 112**	**21 222**	**33 071**	**3 559**
ISCED 6	826	73	207	442	104
ISCED 5A	9 708	733	3 629	3 920	1 426
ISCED 5B	48 415	2 764	16 278	27 546	1 827
Other	3 015	542	1 108	1163	202
FEMALE	**25 281**	**1 824**	**9 549**	**12 684**	**1 224**
ISCED 6	307	14	89	162	42
ISCED 5A	3 359	282	1 759	904	414
ISCED 5B	20 382	1 299	7 245	11 151	687
Other	1 233	229	456	467	81

TABLE 3A.34: KENYA: RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION AND BY FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**13 012**	**1 226**	**3 624**	**7 370**	**792**
ISCED 6	667	64	105	474	24
ISCED 5A	3 475	327	904	2 039	205
ISCED 5B	8 160	768	2 417	4 412	563
Other	710	67	198	445	0
FEMALE	**3 338**	**414**	**1 456**	**1 245**	**223**
ISCED 6	87	18	21	42	6
ISCED 5A	799	115	310	310	64
ISCED 5B	2 198	260	1 005	780	153
Other	254	21	120	113	0
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**13 012**	**1 226**	**3 624**	**7 370**	**792**
Natural sciences	478	81	68	295	34
Engineering and technology	1 787	135	460	1 152	40
Medical sciences	3 312	529	1 045	1 422	316
Agricultural sciences	5 271	270	1 629	3 082	290
Social sciences	1 229	173	286	734	36
Humanities	935	38	136	685	76
FEMALE	**3 338**	**414**	**1 456**	**1 245**	**223**
Natural sciences	69	12	28	21	8
Engineering and technology	201	27	58	110	6
Medical sciences	661	114	424	21	102
Agricultural sciences	1 604	168	728	621	87
Social sciences	577	87	176	298	16
Humanities	226	6	42	174	4

TABLE 3A.35: KENYA: R&D PERSONNEL FTES BY OCCUPATION AND LEVEL OF EDUCATION (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**42 566**	**3 512**	**9 731**	**26 282**	**3 041**
Researchers	9 305	1 062	1 883	5647	713
Technicians	26 384	1 562	6 951	16 156	1 715
Other supporting staff	6 877	888	897	4 479	613
FEMALE	**16 620**	**1 600**	**4 629**	**9 389**	**1 002**
Researchers	1 861	331	582	747	201
Technicians	12 024	590	3 635	7 114	685
Other supporting staff	2 735	679	412	1 528	116
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**42 566.0**	**3 512.0**	**9 731.0**	**26 282.0**	**3 041.0**
ISCED 6	540.0	51.0	85.0	311.0	93.0
ISCED 5A	5 967.0	624.0	1 265.0	2 997.0	1 081.0
ISCED 5B	34 664.0	2 554.0	8 079.0	22 318.0	1 713.0
Other	1 395.0	283.0	302.0	656.0	154.0

TABLE 3A.36: KENYA: RESEARCHERS FTE BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**9 305.0**	**1 063.0**	**1 883.0**	**5 647.0**	**713.0**
ISCED 6	565.0	58.0	71.0	414.0	22.0
ISCED 5A	2 742.0	285.0	522.0	1 735.0	200.0
ISCED 5B	5 814.0	673.0	1 232.0	3 417.0	491.0
Other	184.0	47.0	58.0	81.0	0.0
RESEARCHERS FTE BY FIELD OF SCIENCE	**9 305.0**	**162.0**	**1 883.0**	**5 647.0**	**713.0**
Natural sciences	418.0	56.0	64.0	261.0	38.0
Engineering and technology	1 343.0	190.0	258.0	861.0	34.0
Medical sciences	2 325.0	414.0	585.0	1 073.0	252.0
Agricultural sciences	4 301.0	337.0	840.0	2 889.0	236.0
Social sciences	569.0	39.0	97.0	342.0	91.0
Humanities	349.0	26.0	39.0	221.0	62.0
FEMALE	**1 861.0**	**331.0**	**582.0**	**747.0**	**201.0**
Natural sciences	52.0	12.0	6.0	17.0	17.0
Engineering and technology	198.0	76.0	29.0	79.0	14.0
Medical sciences	422.0	113.0	212.0	13.0	84.0
Agricultural sciences	942.0	101.0	291.0	497.0	53.0
Social sciences	192.0	15.0	35.0	119.0	23.0
Humanities	55.0	14.0	9.0	22.0	10.0

TABLE 3A.37: KENYA: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION KENYAN SHILLINGS (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**24 903.6**	**2 156.0**	**10 120.6**	**9 726.0**	**2 901.0**
Business sector	1 081.0	618.0	123.0	326.0	14.0
Direct government	4 366.0	213.0	2 028.0	2 020.0	105.0
General university funds	2 100.0	-	-	2 100.0	-
Higher education	4 738.0	324.0	1 153.0	3 016.0	245.0
Private non profit	878.6	158.0	95.6	213.0	412.0
Funds from abroad	11 740.0	843.0	6 721.0	2 051.0	2 125.0
GERD BY SECTOR AND TYPE OF COST	**24 904.0**	**2 156.0**	**10 121.0**	**9 726.0**	**2 901.0**
Labour cost	6 170.0	601.0	3 012.0	2 145.0	412.0
Other current cost	2 150.0	321.0	765.0	920.0	144.0
Land and buildings	3 361.0	430.0	1 026.0	1 501.0	404.0
Instruments and equipment	13 223.0	804.0	5 318.0	5 160.0	1 941.0
TOTAL INTRAMURAL COSTS BY TYPE OF R&D	**24 904.0**	**2 156.0**	**10 121.0**	**9 726.0**	**2 901.0**
Basic research	14 318.0	1 034.0	5 668.0	5 933.0	1 683.0
Applied research	6 136.0	216.0	1 822.0	3 112.0	986.0
Experimental development research	4 450.0	906.0	2 631.0	681.0	232.0

LESOTHO

TABLE 3A.38: LESOTHO: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2011)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**53**	*	*	**53**	*
Researchers	42	*	*	42	*
Technicians	10	*	*	10	*
Other supporting staff	1	*	*	1	*
FEMALE	**16**	*	*	**16**	*
Researchers	13	*	*	13	*
Technicians	3	*	*	3	*
Other supporting staff	0	*	*	0	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**53**	*	*	**53**	*
ISCED 6	23	*	*	23	*
ISCED 5A	24	*	*	24	*
ISCED 5B	0	*	*	0	*
Other	6	*	*	6	*
FEMALE	**16**	*	*	**16**	*
ISCED 6	5	*	*	5	*
ISCED 5A	10	*	*	10	*
ISCED 5B	0	*	*	0	*
Other	1	*	*	1	*

* Sector not surveyed

TABLE 3A.39: LESOTHO: RESEARCHERS HC BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2011)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**42**	*	*	**42**	*
ISCED 6	22	*	*	22	*
ISCED 5A	20	*	*	20	*
ISCED 5B	0	*	*	0	*
Other	0	*	*	0	*
FEMALE	**13**	*	*	**13**	*
ISCED 6	5	*	*	5	*
ISCED 5A	8	*	*	8	*
ISCED 5B	0	*	*	0	*
Other	0	*	*	0	*
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**42**	*	*	**42**	*
Natural sciences	10	*	*	10	*
Engineering and technology	8	*	*	8	*
Medical sciences	0	*	*	0	*
Agricultural sciences	23	*	*	23	*
Social sciences	1	*	*	1	*
Humanities	0	*	*	0	*
Not elsewhere classified	0	*	*	0	*
* Sector not surveyed					

TABLE 3A.40: LESOTHO: R&D PERSONNEL FTES BY OCCUPATION, LEVEL OF EDUCATION AND FIELD OF SCIENCE (2011)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**13.7**	*	*	**13.7**	*
Researchers	11.9	*	*	11.9	*
Technicians	1.8	*	*	1.8	*
Other personnel	0.0	*	*	0.0	*
FEMALE	**4.6**	*	*	**4.6**	*
Researchers	3.9	*	*	3.9	*
Technicians	0.7	*	*	0.7	*
Other personnel	0.0	*	*	0.0	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**13.7**	*	*	**13.7**	*
ISCED 6	6.6	*	*	6.6	*
ISCED 5A	6.1	*	*	6.1	*
ISCED 5B	0.0	*	*	0.0	*
Other	1.0	*	*	1.0	*
FEMALE	**4.6**	*	*	**4.6**	*
ISCED 6	1.5	*	*	1.5	*
ISCED 5A	2.8	*	*	2.8	*
ISCED 5B	0.0	*	*	0.0	*
Other	0.3	*	*	0.3	*
TOTAL R&D PERSONNEL BY FIELD OF SCIENCE	**13.1**	*	*	**13.1**	*
Natural sciences	3.1	*	*	3.1	*
Engineering and technology	2.2	*	*	2.2	*
Medical sciences	0.0	*	*	0.0	*
Agricultural sciences	7.5	*	*	7.5	*
Social sciences	0.3	*	*	0.3	*
Humanities	0.0	*	*	0.0	*
Not elsewhere classified	0.0	*	*	0.0	*

* Sector not surveyed

TABLE 3A.41: LESOTHO: RESEARCHERS FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2011)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**11.9**	*	*	**11.9**	*
ISCED 6	6.6	*	*	6.6	*
ISCED 5A	5.3	*	*	5.3	*
ISCED 5B	0.0	*	*	0.0	*
Other	0.0	*	*	0.0	*
FEMALE	**3.9**	*	*	**3.9**	*
ISCED 6	1.5	*	*	1.5	*
ISCED 5A	2.4	*	*	2.4	*
ISCED 5B	0.0	*	*	0.0	*
Other	0.0	*	*	0.0	*
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**11.9**	*	*	**11.9**	*
Natural sciences	2.7	*	*	2.7	*
Engineering and technology	2.0	*	*	2.0	*
Medical sciences	0.0	*	*	0.0	*
Agricultural sciences	6.9	*	*	6.9	*
Social sciences	0.3	*	*	0.3	*
Humanities	0.0	*	*	0.0	*
Not elsewhere classified	0.0	*	*	0.0	*
* Sector not surveyed					

TABLE 3A.42: LESOTHO: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION MALOTI (2011)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**2.4**	*	*	**2.4**	*
Business sector	0.0	*	*	0.0	*
Direct government	1.2	*	*	1.2	*
General university funds	0.0	*	*	0.0	*
Higher education	0.0	*	*	0.0	*
Private non profit	0.0	*	*	0.0	*
Funds from abroad	0.1	*	*	0.1	*
Other sources of funds	1.1	*	*	1.1	*
GERD BY SECTOR AND TYPE OF COST	**2.4**	*	*	**2.4**	*
Labour cost	1.4	*	*	1.4	*
Other current cost	0.8	*	*	0.8	*
Capital expenditure	0.2	*	*	0.2	*
TOTAL CURRENT EXPENDITURE BY TYPE OF R&D	**2.4**	*	*	**2.4**	*
Basic research	0.9	*	*	0.9	*
Applied research	1.3	*	*	1.3	*
Experimental development research	0.1	*	*	0.1	*
Not elsewhere classified	0.0	*	*	0.0	*
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**2.4**	*	*	**2.4**	*
Basic research	0.5	*	*	0.5	*
Applied research	1.6	*	*	1.6	*
Experimental development research	0.2	*	*	0.2	*
Not elsewhere classified	0.0	*	*	0.0	*
* Sector not surveyed					

MALAWI

TABLE 3A.43: MALAWI: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**3 809**	*	**1 839**	**1 916**	**54**
Researchers	1 843	*	507	1 324	12
Technicians	1 548	*	1 193	324	31
Other supporting staff	418	*	139	268	11
FEMALE	**751**	*	**385**	**339**	**27**
Researchers	360	*	106	251	3
Technicians	352	*	270	68	14
Other supporting staff	39	*	9	20	10
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**3 809**	*	**1 839**	**1 916**	**54**
ISCED 6	551	*	239	310	2
ISCED 5A	2 588	*	1 085	1 494	9
ISCED 5B	250	*	147	96	7
Other	420	*	368	16	36
FEMALE	**751**	*	**385**	**339**	**27**
ISCED 6	128	*	49	77	2
ISCED 5A	350	*	104	240	6
ISCED 5B	53	*	34	17	2
Other	220	*	198	5	17

* Sector not surveyed

TABLE 3A.44: MALAWI: R&D RESEARCHERS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 843**	*****	**507**	**1 324**	**12**
ISCED 6	227	*	40	185	2
ISCED 5A	1 448	*	396	1 045	7
ISCED 5B	115	*	46	66	3
Other	53	*	25	28	0
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**1 843**	*****	**507**	**1 324**	**12**
Natural sciences	288	*	71	217	0
Engineering and technology	372	*	105	267	0
Medical sciences	343	*	93	242	8
Agricultural sciences	312	*	92	216	4
Social sciences	340	*	94	246	0
Humanities	188	*	52	136	0
Not elsewhere classified	0	0	0	0	0
FEMALE	**360**	*****	**106**	**251**	**3**
Natural sciences	64	*	15	49	0
Engineering and technology	24	*	12	12	0
Medical sciences	60	*	17	43	0
Agricultural sciences	39	*	19	17	3
Social sciences	94	*	27	67	0
Humanities	79	*	16	63	0
Not elsewhere classified	0	*	0	0	0
* Sector not surveyed					

TABLE 3A.45: MALAWI: R&D PERSONNEL FTES BY OCCUPATION AND LEVEL OF EDUCATION (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**1 720.6**	*	**1 422.3**	**267.8**	**30.5**
Researchers	732.1	*	496.9	225.1	10.2
Technicians	872.5	*	835.1	25.9	11.5
Other supporting staff	116.0	*	90.4	16.8	8.8
FEMALE	**304.9**	*	**244.5**	**51.7**	**8.7**
Researchers	135.8	*	90.1	42.7	3.0
Technicians	154.6	*	148.5	5.4	0.7
Other supporting staff	14.5	*	5.9	3.6	5.0
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**1 720.6**	*	**1 422.3**	**267.7**	**30.6**
ISCED 6	229.3	*	184.8	43.3	1.2
ISCED 5A	1 053.2	*	839.2	208.8	5.2
ISCED 5B	131.0	*	113.7	13.4	3.9
Other	307.1	*	284.6	2.2	20.3
* Sector not surveyed					

TABLE 3A.46: MALAWI: RESEARCHERS FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**732.4**	*****	**496.9**	**225.2**	**10.3**
ISCED 6	72.4	*	39.2	31.5	1.7
ISCED 5A	571.8	*	388.1	177.7	6.0
ISCED 5B	58.9	*	45.1	11.2	2.6
Other	29.3	*	24.5	4.8	0.0
RESEARCHERS FTE BY FIELD OF SCIENCE	**732.1**	*****	**496.9**	**225.0**	**10.2**
Natural sciences	106.5	*	69.6	36.9	0.0
Engineering and technology	148.3	*	102.9	45.4	0.0
Medical sciences	139.0	*	91.1	41.1	6.8
Agricultural sciences	130.3	*	90.2	36.7	3.4
Social sciences	133.9	*	92.1	41.8	0.0
Humanities	74.1	*	51.0	23.1	0.0
Not elsewhere classified	0.0	*	0.0	0.0	0.0
FEMALE	**135.8**	*****	**90.1**	**42.7**	**3.0**
Natural sciences	21.1	*	12.8	8.3	0.0
Engineering and technology	12.2	*	10.2	2.0	0.0
Medical sciences	21.8	*	14.5	7.3	0.0
Agricultural sciences	22.0	*	16.2	2.9	3.0
Social sciences	34.3	*	23.0	11.4	0.0
Humanities	24.3	*	13.6	10.7	0.0
Not elsewhere classified	0.0	*	0.0	0.0	0.0
* Sector not surveyed					

TABLE 3A.47: MALAWI: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION KWACHA (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**8 596.5**	*	**1 339.7**	**7 120.5**	**136.2**
Business sector	0.0	*	0.0	0.0	0.0
Direct government	7 925.4	*	804.8	7 120.5	0.0
General university funds	-	*	0.0	-	-
Higher education	0.0	*	0.0	0.0	0.0
Private non profit	136.2	*	0.0	0.0	136.2
Funds from abroad	534.9	*	534.9	0.0	0.0
GERD BY SECTOR AND TYPE OF COST	**8 596.4**	*	**1 339.7**	**7 120.5**	**136.2**
Labour cost	2 222.9	*	401.9	1 780.1	55.8
Other current cost	6 373.5	*	937.8	5 340.4	80.4
Land and buildings	0.0	*	0.0	0.0	0.0
Instruments and equipment	0.0	*	0.0	0.0	0.0
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**8 596.5**	*	**1 339.7**	**7 120.6**	**136.2**
Basic research	2136.2	*	0.0	2136.2	0.0
Applied research	5 588.4	*	535.9	4 984.4	68.1
Experimental development research	871.9	*	803.8	0.0	68.1
Not elsewhere classified	0.0	*	0.0	0.0	0.0
* Sector not surveyed					

MALI

TABLE 3A.48: MALI: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 940**	**502**	**997**	**441**	*
Researchers	898	249	339	310	*
Technicians	625	166	352	107	*
Other supporting staff	417	87	306	24	*
FEMALE	**404**	**143**	**156**	**105**	*
Researchers	144	29	48	67	*
Technicians	131	62	35	34	*
Other supporting staff	129	52	73	4	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**1 940**	**502**	**997**	**441**	*
ISCED 6	419	65	217	137	*
ISCED 5A	601	130	270	201	*
ISCED 5B	467	220	204	43	*
Other	453	87	306	60	*
FEMALE	**404**	**143**	**156**	**105**	*
ISCED 6	51	11	23	17	*
ISCED 5A	130	25	47	58	*
ISCED 5B	94	55	13	26	*
Other	129	52	73	4	*
* Sector not surveyed					

TABLE 3A.49: MALI: RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**898**	**249**	**339**	**310**	*
ISCED 6	346	56	161	129	*
ISCED 5A	408	103	133	172	*
ISCED 5B	144	90	45	9	*
Other	0	0	0	0	*
* Sector not surveyed					

TABLE 3A.50: MALI: R&D PERSONNEL FTES BY OCCUPATION (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**856.0**	**255.9**	**452.0**	**148.1**	*
Researchers	442.5	217.0	150.6	74.9	*
Technicians	342.4	31.2	240.2	71.0	*
Other supporting staff	71.1	7.7	61.2	2.2	*
FEMALE	**139.7**	**50.7**	**70.6**	**18.4**	*
Researchers	62.2	16.4	31.2	14.6	*
Technicians	43.7	14.5	25.8	3.4	*
Other supporting staff	33.8	19.8	13.6	0.4	*
* Sector not surveyed					

TABLE 3A.51: MALI: GROSS DOMESTIC EXPENDITURE ON R&D IN MILLION CFA FRANC XOF (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**30 866.0**	†	**25 489.0**	**5 377.0**	*
Business sector	-	†	-	-	*
Direct government	28 147.0	†	23 802.0	4 345.0	*
General university funds	-	†	-	-	*
Higher education	-	†	-	-	*
Private non profit	-	†	-	-	*
Funds from abroad	2 719.0	†	1 687.0	1 032.0	*

† Data not supplied

* Sector not surveyed

MOZAMBIQUE

TABLE 3A.52: MOZAMBIQUE: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**3 313**	*	**1 840**	**1 272**	**201**
Researchers	1 588	*	564	968	56
Technicians	1 390	*	1 103	175	112
Other supporting staff	335	*	173	129	33
FEMALE	**1 110**	*	**626**	**386**	**98**
Researchers	512	*	212	274	26
Technicians	447	*	342	52	53
Other supporting staff	151	*	72	60	19
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**3 313**	*	**1 840**	**1 272**	**201**
ISCED 6	281	*	50	216	15
ISCED 5A	1 624	*	679	858	87
ISCED 5B	1 408	*	1 111	198	99
Other	0	*	0	0	0
FEMALE	**1 110**	*	**626**	**386**	**98**
ISCED 6	65	*	11	50	4
ISCED 5A	546	*	280	224	42
ISCED 5B	499	*	335	112	52
Other	0	*	0	0	0

* Sector not surveyed

TABLE 3A.53: MOZAMBIQUE: R&D RESEARCHERS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 588**	*	**564**	**968**	**56**
ISCED 6	281	*	50	216	15
ISCED 5A	1 307	*	514	752	41
ISCED 5B	0	*	0	0	0
Other	0	*	0	0	0
FEMALE	**512**	*	**212**	**274**	**26**
ISCED 6	65	*	11	50	4
ISCED 5A	447	*	201	224	22
ISCED 5B	0	*	0	0	0
Other	0	*	0	0	0
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**1 588**	*	**564**	**968**	**56**
Natural sciences	306	*	80	226	0
Engineering and technology	350	*	233	117	0
Medical sciences	209	*	120	58	31
Agricultural sciences	142	*	48	94	0
Social sciences	542	*	83	434	25
Humanities	39	*	0	39	0
Not elsewhere classified	0	*	0	0	0
FEMALE	**512**	*	**212**	**274**	**26**
Natural sciences	85	*	29	56	0
Engineering and technology	101	*	82	19	0
Medical sciences	111	*	63	29	19
Agricultural sciences	29	*	8	21	0
Social sciences	162	*	30	125	7
Humanities	24	*	0	24	0
Not elsewhere classified	0	*	0	0	0
* Sector not surveyed					

TABLE 3A.54: MOZAMBIQUE: R&D PERSONNEL FTES BY OCCUPATION (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**2 164.4**	*	**1 273.5**	**755.0**	**135.9**
Researchers	912.3	*	324.0	556.1	32.2
Technicians	1 092.9	*	867.2	137.6	88.1
Other supporting staff	159.2	*	82.2	61.3	15.7
FEMALE	**728.6**	*	**433.3**	**229.1**	**66.3**
Researchers	294.2	*	121.8	157.4	14.9
Technicians	0.0	*	0.0	0.0	0.0
Other supporting staff	0.0	*	0.0	0.0	0.0
* Sector not surveyed					

TABLE 3A.55: MOZAMBIQUE: RESEARCHER FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**912.4**	*	**324.0**	**556.1**	**32.2**
ISCED 6	161.4	*	28.7	124.1	8.6
ISCED 5A	750.9	*	295.3	432.0	23.6
ISCED 5B	-	*	-	-	-
Other	-	*	-	-	-
RESEARCHERS FTE BY FIELD OF SCIENCE	**912.4**	*	**324.0**	**556.1**	**32.2**
Natural sciences	175.8	*	45.96	129.84	-
Engineering and technology	201.08	*	133.86	67.22	-
Medical sciences	120.07	*	68.94	33.32	17.81
Agricultural sciences	81.59	*	27.58	54.01	-
Social sciences	311.4	*	47.69	249.34	14.37
Humanities	22.41	*	0	22.41	0
Not elsewhere classified	-	*	0.0	-	0.0
FEMALE	**294.2**	*	**121.8**	**157.4**	**14.9**
Natural sciences	48.83	*	-	-	-
Engineering and technology	58.03	*	-	-	-
Medical sciences	63.77	*	-	-	-
Agricultural sciences	16.67	*	-	-	-
Social sciences	93.07	*	-	-	-
Humanities	13.79	*	-	-	-
Not elsewhere classified	-	*	-	-	-
* Sector not surveyed					

TABLE 3A.56: MOZAMBIQUE: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION METICAL (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**1 457.0**	*	**799.6**	**524.4**	**133.0**
Business sector	0.0	*	0.0	0.0	0.0
Direct government	200.1	*	100.5	99.6	0.0
General university funds	74.4	*	-	74.4	-
Higher education	0.0	*	0.0	0.0	0.0
Private non profit	44.0	*	0.0	0.0	44.0
Funds from abroad	1 138.5	*	699.1	350.5	89.0
GERD BY SECTOR AND TYPE OF COST	**1 457.0**	*	**799.6**	**524.4**	**133.0**
Labour cost	273.5	*	115.0	125.8	32.7
Other current cost	398.7	*	204.5	99.6	94.6
Land and buildings	192.7	*	192.1	0.0	0.6
Instruments and equipment	592.0	*	288.0	298.9	5.1
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**1 457.0**	*	**799.6**	**524.4**	**133.0**
Basic research	398.7	*	102.2	263.1	33.5
Applied research	902.3	*	626.2	200.0	76.1
Experimental development research	155.9	*	71.2	61.3	23.4
Not elsewhere classified	0.0	*	0.0	0.0	0.0
EXPENDITURE OF R&D BY FIELD OF SCIENCE	**1 457.0**	*	**799.6**	**524.4**	**133.0**
Natural sciences	108.1	*	55.5	52.6	0.0
Engineering and technology	215.0	*	179.1	35.9	0.0
Medical sciences	337.2	*	139.7	109.0	88.5
Agricultural sciences	419.4	*	268.7	150.7	0.0
Social sciences	280.7	*	117.9	118.3	44.5
Humanities	96.6	*	38.7	57.9	0.0
Not elsewhere classified	0.0	*	0.0	0.0	0.0
* Sector not surveyed					

NAMIBIA

TABLE 3A.57: NAMIBIA: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**949**	**21**	**403**	**525**	*
Researchers	748	21	280	447	*
Technicians	118	0	57	61	*
Other supporting staff	83	0	66	17	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**949**	**21**	**403**	**525**	*
ISCED 6	175	1	7	167	*
ISCED 5A	606	4	291	311	*
ISCED 5B	147	11	102	34	*
Other	21	5	3	13	*
* Sector not surveyed					

TABLE 3A.58: NAMIBIA: RESEARCHERS HEADCOUNTS BY FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION (HC)	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**748**	**21**	**280**	**447**	*
Natural sciences	82	0	6	76	*
Engineering and technology	18	0	2	16	*
Medical sciences	51	0	8	43	*
Agricultural sciences	321	0	254	67	*
Social sciences	119	10	5	104	*
Humanities	43	8	3	32	*
Not elsewhere classified	114	3	2	109	*
* Sector not surveyed					

TABLE 3A.59: NAMIBIA: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION NAMIBIAN DOLLARS (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**117.0**	**15.0**	**†**	**102.0**	*****
Business sector	23.2	15.0	†	8.2	*
Direct government	3.5	0.0	†	3.5	*
General university funds	88.5	0.0	†	88.5	*
Higher education	0.0	0.0	†	0.0	*
Private non profit	0.0	0.0	†	0.0	*
Funds from abroad	1.8	0.0	†	1.8	*
Amounts not specified	0.0	0.0	†	0.0	*

* Sector not surveyed

† Data not supplied

SENEGAL

TABLE 3A.60: SENEGAL: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**10 644**	**36**	**920**	**9 460**	**228**
Researchers	8 170	4	191	7 934	41
Technicians	605	12	388	166	39
Other supporting staff	1 869	20	341	1 360	148
FEMALE	**2 885**	**0**	**243**	**2 574**	**68**
Researchers	2 031	0	43	1 976	12
Technicians	163	0	91	63	9
Other supporting staff	691	0	109	535	47
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**10 644**	**36**	**920**	**9 460**	**228**
ISCED 6	1 690	0	118	1 546	26
ISCED 5A	6 612	1	134	6 448	29
ISCED 5B	0	0	0	0	0
Other	2 342	35	668	1 466	173
FEMALE	**2 885**	**0**	**243**	**2 574**	**68**
ISCED 6	258	0	25	228	5
ISCED 5A	1 883	0	29	1 844	10
ISCED 5B	0	0	0	0	0
Other	744	0	189	502	53

TABLE 3A.61: SENEGAL: R&D RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**8 170**	**4**	**191**	**7 934**	**41**
ISCED 6	1 647	0	110	1 518	19
ISCED 5A	6 511	1	76	6 416	18
ISCED 5B	0	0	0	0	0
Other	12	3	5	0	4
FEMALE	**2 031**	**0**	**43**	**1 976**	**12**
ISCED 6	257	0	28	223	6
ISCED 5A	1 766	0	9	1 753	4
ISCED 5B	0	0	0	0	0
Other	8	0	6	0	2
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**8 170**	**4**	**191**	**7 934**	**41**
Natural sciences	1 471	4	2	1 433	32
Engineering and technology	162	0	19	143	0
Medical sciences	1 601	0	0	1 597	4
Agricultural sciences	131	0	79	48	4
Social sciences	4 140	0	16	4 123	1
Humanities	523	0	8	515	0
Not elsewhere classified	142	0	67	75	0
FEMALE	**2 031**	**0**	**43**	**1976**	**12**
Natural sciences	245	0	2	234	9
Engineering and technology	21	0	5	16	0
Medical sciences	508	0	0	507	1
Agricultural sciences	32	0	29	3	0
Social sciences	1 129	0	2	1 126	1
Humanities	88	0	3	85	0
Not elsewhere classified	8	0	2	5	1

TABLE 3A.62: SENEGAL: R&D PERSONNEL FTES BY OCCUPATION, LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**5 642.3**	**36.0**	**920.0**	**4 458.3**	**228.0**
Researchers	4 679.0	4.0	191.0	4 443.0	41.0
Technicians	440.7	12.0	388.0	1.7	39.0
Other supporting staff	522.6	20.0	341.0	13.6	148.0
FEMALE	**1 423.5**	**0.0**	**243.0**	**1 112.5**	**68.0**
Researchers	1 161.6	0.0	43.0	1 106.6	12.0
Technicians	100.6	0.0	91.0	0.6	9.0
Other supporting staff	161.4	0.0	109.0	5.4	47.0
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**5 642.3**	**36.0**	**920.0**	**4 458.3**	**228.0**
ISCED 6	1 002.5	0.0	118.0	858.5	26.0
ISCED 5A	3 749.1	1.0	134.0	3 585.1	29.0
ISCED 5B	0.0	0.0	0.0	0.0	0.0
Other	890.7	35.0	668.0	14.7	173.0
R&D PERSONNEL FTE BY FIELD OF SCIENCE	**5642.3**	**36.0**	**920.0**	**4458.3**	**228.0**
Natural sciences	851.4	4.0	2.0	811.4	34.0
Engineering and technology	99.6	0.0	19.0	80.6	0.0
Medical sciences	908.4	0.0	0.0	904.4	4.0
Agricultural sciences	110.4	0.0	79.0	27.4	4.0
Social sciences	2 352.7	0.0	16.0	2 335.7	1.0
Humanities	301.8	0.0	8.0	291.8	2.0
Not elsewhere classified	1 018.0	32.0	796.0	7.0	183.0

TABLE 3A.63: SENEGAL: RESEARCHER FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**4 679.0**	**4.0**	**191.0**	**4 443.0**	**41.0**
ISCED 6	979.1	0.0	110.0	850.1	19.0
ISCED 5A	3 688.0	1.0	76.0	3 593.0	18.0
ISCED 5B	0.0	0.0	0.0	0.0	0.0
Other	12.0	3.0	5.0	0.0	4.0
RESEARCHERS FTE BY FIELD OF SCIENCE	**4 679.0**	**4.0**	**191.0**	**4 443.0**	**41.0**
Natural sciences	840.5	4.0	2.0	802.5	32.0
Engineering and technology	99.1	0.0	19.0	80.1	
Medical sciences	898.3	0.0	0.0	894.3	4.0
Agricultural sciences	109.9	0.0	79.0	26.9	4.0
Social sciences	2 325.9	0.0	16.0	2 308.9	1.0
Humanities	296.4	0.0	8.0	288.4	0.0
Not elsewhere classified	109.0	0.0	67.0	42.0	0.0
FEMALE	**1 161.6**	**0**	**43.0**	**1 106.6**	**12.0**
Natural sciences	142.0	0	2.0	131.0	9.0
Engineering and technology	14.0	0	5.0	9.0	0.0
Medical sciences	284.9	0	0.0	283.9	1.0
Agricultural sciences	30.7	0	29.0	1.7	0.0
Social sciences	633.6	0	2.0	630.6	1.0
Humanities	50.6	0	3.0	47.6	0.0
Not elsewhere classified	5.8	0	2.0	2.8	1.0

TABLE 3A.64: SENEGAL: GROSS DOMESTIC EXPENDITURE ON R&D IN MILLION CFA FRANC XOF (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**34 642.9**	**116.7**	**18 030.7**	**10 888.8**	**5 606.7**
Business sector	1 418.8	87.5	0.0	66.0	1 265.3
Direct government	16 490.2	29.2	5 828.1	10 397.8	235.2
General university funds	5.0	0.0	5.0	0.0	0.0
Higher education	11.5	0.0	0.0	0.0	11.5
Private non profit	1 118.6	0.0	0	0.0	1118.6
Funds from abroad	14 041.8	0.0	11 048.2	425.0	2 568.7
Other	1 556.9	0.0	1 149.5	0.0	407.5
GERD BY SECTOR AND TYPE OF COST	**34 642.9**	**116.7**	**18 030.7**	**10 888.8**	**5 606.7**
Labour cost	15 823.8	76.7	5 248.7	10 010.7	487.7
Other current cost	17 927.4	40.0	12 079.9	734.0	5 073.4
Land and buildings	115.6	0.0	19.5	93.4	2.7
Instruments and equipment	776.2	0.0	682.7	50.7	42.9

SOUTH AFRICA

TABLE 3A.65: SOUTH AFRICA: R&D PERSONNEL HEADCOUNTS BY OCCUPATION (2010/11)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**55 531**	**14 933**	**7 627**	**32 571**	**400**
Researchers	37 901	6 372	3 125	28 154	250
Technicians	8 559	630	1 757	2 123	49
Other supporting staff	9 071	3 931	2 745	2 294	101
FEMALE	**23 285**	**5 008**	**3 377**	**14 664**	**236**
Researchers	15 794	2 002	1 405	12 240	147
Technicians	3 140	1 395	845	890	10
Other supporting staff	4 351	1 611	1 127	1 534	79
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**55 531**	**14 933**	**7 627**	**32 571**	**400**
ISCED 6	20 482	896	1 116	18 414	56
ISCED 5A	18 715	6 418	3 394	8 697	206
ISCED 5B	16 334	7 619	3 117	5 460	138
Other	0	0	0	0	0
FEMALE	**23 285**	**5 008**	**3 377**	**14 664**	**236**
ISCED 6	8 145	231	427	7 458	29
ISCED 5A	8 332	2 259	1 712	4 241	120
ISCED 5B	6 808	2 518	1 238	2 965	87
Other	0	0	0	0	0

TABLE 3A.66: SOUTH AFRICA: RESEARCHERS HC BY LEVEL OF EDUCATION (2010/11)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**37 901**	**6 372**	**3 125**	**28 154**	**250**
ISCED 6	20 056	838	944	18 218	56
ISCED 5A	14 268	4 233	2 036	7 834	165
ISCED 5B	3 577	1 301	145	2 102	29
Other	0	0	0	0	0
FEMALE	**15 794**	**2 002**	**1 405**	**12 240**	**147**
ISCED 6	7 968	212	354	7 373	29
ISCED 5A	6 266	1 404	1 000	3 767	95
ISCED 5B	1 560	386	51	1 100	23
Other	0	0	0	0	0

TABLE 3A.67: SOUTH AFRICA: R&D PERSONNEL FTES BY OCCUPATION (2010/11)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**29 486.4**	**10 205.1**	**6 491.0**	**12 477.3**	**313.1**
Researchers	18 719.6	4 804.0	2 651.4	11 067.9	196.2
Technicians	5 409.6	3 318.7	1 508.4	534.9	47.6
Other supporting staff	5 357.3	2 082.3	2 331.2	874.5	69.3
FEMALE	**14 777.0**	**3 473.7**	**2 928.4**	**8 179.4**	**195.6**
Researchers	9 642.1	1 554.3	1 190.4	6 770.0	127.4
Technicians	2 329.6	1014.7	770.5	534.9	9.5
Other supporting staff	2 805.3	904.6	967.4	874.5	58.8

TABLE 3A.68: SOUTH AFRICA: GERD AND SOURCES OF FUNDS IN MILLIONS OF RANDS (2010/11)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**20 253.8**	**10 059.0**	**4 607.4**	**5 424.6**	**162.8**
Business enterprise	8 128.2	7 528.7	200.6	367.3	31.6
Direct government	6 269.8	832.2	3 922.8	1 473.0	41.8
General university funds	2 749.1			2 749.1	
Higher education	10.9	2.5	1.6	4.8	2.0
Private non profit	650.7	253.4	5.5	357.2	34.6
Funds from abroad	2 445.0	1 442.3	476.8	473.1	52.7
GERD BY SECTOR AND TYPE OF COST	**20 253.8**	**10 059.0**	**4 607.4**	**5 424.6**	**162.8**
Labour cost	9 110.2	4 467.2	1 910.8	2 640.1	92.1
Other current cost	8 956.6	4 285.4	2 218.6	2 390.7	61.9
Land and buildings	572.8	202.8	118.3	247.2	4.4
Instruments and equipment	1 614.3	1 103.6	359.7	146.6	4.4
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**20 253.8**	**10 059.0**	**4 607.4**	**5 424.6**	**162.8**
Basic research	4 848.3	1 025.4	1 128.9	2 634.7	59.3
Applied research	8 058.8	3 949.4	2 131.8	1 890.2	87.4
Experimental development research	7 346.7	5 084.2	1 346.7	899.7	16.1
Not elsewhere classified	0	0	0	0	0
EXPENDITURE OF R&D BY FIELD OF SCIENCE	**20 253.8**	**10 059.0**	**4 607.4**	**5 424.6**	**162.8**
Natural sciences	8 905.8	4 850.7	2 377.1	1 664.8	13.2
Engineering and technology	3 600.2	2 768.0	370.1	462.0	-
Medical sciences	3 461.3	1 622.2	597.0	1 226.1	15.9
Agricultural sciences	1 307.2	371.3	704.9	205.3	25.7
Social sciences	2 512.7	446.8	528.0	1 433.6	104.3
Humanities	466.6	0	30.1	432.7	3.7
Not elsewhere classified	0	0	0	0	0

TANZANIA

TABLE 3A.69: TANZANIA: R&D PERSONNEL HEADCOUNT BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

RRD PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**5 788**	*	**2 358**	**3430**	*
Researchers	3 102	*	1 051	2 051	*
Technicians	711	*	425	286	*
Other supporting staff	1 975	*	882	1 093	*
FEMALE	**2 026**	*	**677**	**1 349**	*
Researchers	789	*	279	510	*
Technicians	350	*	109	241	*
Other supporting staff	887	*	289	598	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**5 788**	*	**2 358**	**3 430**	*
ISCED 6	531	*	135	396	*
ISCED 5A	1 772	*	615	1 157	*
ISCED 5B	1 333	*	502	831	*
Other	2 152	*	1 106	1 046	*
FEMALE	**2 026**	*	**677**	**1 349**	*
ISCED 6	122	*	31	91	*
ISCED 5A	540	*	165	375	*
ISCED 5B	428	*	123	305	*
Other	936	*	358	578	*
* Sector not surveyed					

TABLE 3A.70: TANZANIA: R&D RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**3 102**	*	**1 051**	**2 051**	*
ISCED 6	508	*	129	379	*
ISCED 5A	1 580	*	545	1 035	*
ISCED 5B	800	*	243	557	*
Other	214	*	134	80	*
FEMALE	**789**	*	**279**	**510**	*
ISCED 6	105	*	30	75	*
ISCED 5A	426	*	139	287	*
ISCED 5B	195	*	59	136	*
Other	63	*	51	12	*
* Sector not surveyed					

TABLE 3A.71: TANZANIA: R&D PERSONNEL FTES BY OCCUPATION (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**2 928.6**	*	**1 855.2**	**1 073.4**	*
Researchers	1 599.6	*	1 030.6	569.0	*
Technicians	472.2	*	347.5	124.7	*
Other supporting staff	856.8	*	477.1	379.7	*
FEMALE	**816.1**	*	**465.8**	**350.3**	*
Researchers	393.4	*	244.8	148.6	*
Technicians	112.2	*	90.2	22.0	*
Other supporting staff	310.4	*	130.8	179.6	*
* Sector not surveyed					

TABLE 3A.72: TANZANIA: GERD AND SOURCES OF FUNDS IN MILLIONS TANZANIAN SHILLINGS (2010/11)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**166 686.0**	*	**22 915.5**	**143 770.5**	*
Business sector	132.2	*	10.0	122.2	*
Direct government	31 711.4	*	13 850.9	17 860.5	*
General university funds	64 186.0	*	-	64 186.0	*
Higher education	553.4	*	148.4	404.9	*
Private non profit	87.0	*	68.7	18.3	*
Funds from abroad	70 015.9	*	8 837.4	61 178.5	*
* Sector not surveyed					

TOGO

TABLE 3A.73: TOGO: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010).

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**923**	*	**317**	**606**	*
Researchers	568	*	70	498	*
Technicians	125	*	42	83	*
Other supporting staff	230	*	205	25	*
FEMALE	**96**	*	**31**	**65**	*
Researchers	60	*	3	57	*
Technicians	18	*	10	8	*
Other supporting staff	18	*	18	0	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**923**	*	**317**	**606**	*
ISCED 6	446	*	13	433	*
ISCED 5A	122	*	57	65	*
ISCED 5B	100	*	17	83	*
Other	255	*	230	25	*
FEMALE	**96**	*	**31**	**65**	*
ISCED 6	44	*	0	44	*
ISCED 5A	16	*	3	13	*
ISCED 5B	14	*	6	8	*
Other	22	*	22	0	*
* Sector not surveyed					

TABLE 3A.74: TOGO: R&D RESEARCHERS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**568**	*	**70**	**498**	*
ISCED 6	446	*	13	433	*
ISCED 5A	122	*	57	65	*
ISCED 5B	0	*	0	0	*
Other	0	*	0	0	*
FEMALE	**60**	*	**3**	**57**	*
ISCED 6	44	*	0	44	*
ISCED 5A	16	*	3	13	*
ISCED 5B	0	*	0	0	*
Other	0	*	0	0	*
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**568**	*	**70**	**498**	*
Natural sciences	94	*	0	94	*
Engineering and technology	50	*	4	46	*
Medical sciences	87	*	0	87	*
Agricultural sciences	97	*	66	31	*
Social sciences	240	*	0	240	*
Humanities	0	*	0	0	*
Not elsewhere classified	0	*	0	0	*
FEMALE	**60**	*	**3**	**57**	*
Natural sciences	8	*	0	8	*
Engineering and technology	6	*	0	6	*
Medical sciences	7	*	0	7	*
Agricultural sciences	3	*	3	0	*
Social sciences	36	*	0	36	*
Humanities	0	*	0	0	*
Not elsewhere classified	0	*	0	0	*

* Sector not surveyed

TABLE 3A.75: TOGO: R&D PERSONNEL FTES BY OCCUPATION, LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**443.7**	*	**253.6**	**190.1**	*
Researchers	220.3	*	56.0	164.3	*
Technicians	54.4	*	33.6	20.8	*
Other supporting staff	169.0	*	164.0	5.0	*
FEMALE	**45.6**	*	**24.8**	**20.8**	*
Researchers	21.2	*	2.4	18.8	*
Technicians	10.0	*	8.0	2.0	*
Other supporting staff	14.4	*	14.4	0.0	*
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**443.7**	*	**253.6**	**190.1**	*
ISCED 6	153.3	*	10.4	142.9	*
ISCED 5A	67.1	*	45.6	21.5	*
ISCED 5B	34.4	*	13.6	20.8	*
Other	189.0	*	184.0	5.0	*
TOTAL R&D PERSONNEL BY FIELD OF SCIENCE	**443.7**	*	**253.6**	**190.1**	*
Natural sciences	46.8	*	0.0	46.8	*
Engineering and technology	32.2	*	10.4	21.8	*
Medical sciences	28.7	*	0.0	28.7	*
Agricultural sciences	255.4	*	243.2	12.2	*
Social sciences	80.6	*	0.0	80.6	*
Humanities	0.0	*	0.0	0.0	*
Not elsewhere classified	0.0	*	0.0	0.0	*
* Sector not surveyed					

TABLE 3A.76: TOGO: RESEARCHER FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**220.3**	*	**56.0**	**164.3**	*
ISCED 6	153.3	*	10.4	142.9	*
ISCED 5A	67.1	*	45.6	21.5	*
ISCED 5B	0.0	*	0.0	0.0	*
Other	0.0	*	0.0	0.0	*
RESEARCHERS FTE BY FIELD OF SCIENCE	**220.3**	*	**56.0**	**164.3**	*
Natural sciences	31.0	*	0.0	31.0	*
Engineering and technology	18.4	*	3.2	15.2	*
Medical sciences	28.7	*	0.0	28.7	*
Agricultural sciences	63.0	*	52.8	10.2	*
Social sciences	79.2	*	0.0	79.2	*
Humanities	0.0	*	0.0	0.0	*
Not elsewhere classified	0.0	*	0.0	0.0	*
FEMALE	**21.2**	*	**2.4**	**18.8**	*
Natural sciences	2.6	*	0.0	2.6	*
Engineering and technology	2.0	*	0.0	2.0	*
Medical sciences	2.3	*	0.0	2.3	*
Agricultural sciences	2.4	*	2.4	0.0	*
Social sciences	11.9	*	0.0	11.9	*
Humanities	0.0	*	0.0	0.0	*
Not elsewhere classified	0.0	*	0.0	0.0	*
* Sector not surveyed					

TABLE 3A.77: TOGO: GROSS DOMESTIC EXPENDITURES ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION CFA FRANC XOF (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**3 983.6**	*	**2 316.4**	**1 666.8**	*
Business sector	0.0	*	0.0	0.0	*
Direct government	3 518.3	*	1 904.1	1 613.9	*
General university funds	-	-	-	-	-
Higher education	0.0	*	0.0	0.0	*
Private non profit	0.0	*	0.0	0.0	*
Funds from abroad	465.3	*	412.3	53.0	*
GERD BY SECTOR AND TYPE OF COST	**3 983.3**	*	**2 316.4**	**1 666.8**	*
Labour cost	2 907.2	*	1 293.4	1 613.9	*
Other current cost	252.5	*	252.5	0.0	*
Land and buildings	3.0	*	3.0	0.0	*
Instruments and equipment	820.5	*	767.6	53.0	*
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**3 983.3**	*	**2 316.4**	**1 666.8**	*
Basic research	1 497.9	*	579.1	918.8	*
Applied research	1 906.3	*	1 158.2	748.1	*
Experimental development research	579.1	*	579.1	0.0	*
Not elsewhere classified	0.0	*	0.0	0.0	*
EXPENDITURE OF R&D BY FIELD OF SCIENCE	**3 983.3**	*	**2 316.4**	**1 666.8**	*
Natural sciences	437.3	*	0.0	437.3	*
Engineering and technology	281.8	*	81.0	200.8	*
Medical sciences	239.3	*	0.0	239.3	*
Agricultural sciences	2 345.4	*	2 235.4	110.0	*
Social sciences	679.4	*	0.0	679.4	*
Humanities	0.0	*	0.0	0.0	*
Not elsewhere classified	0.0	*	0.0	0.0	*
* Sector not surveyed					

UGANDA

TABLE 3A.78: UGANDA: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND BY LEVEL OF EDUCATION (2010)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**4 270**	**2 333**	**744**	**1 027**	**166**
Researchers	2 823	1 431.00	404	880	108
Technicians	922	579.00	206	108	29
Other supporting staff	525	323.00	134	39	29
FEMALE	**1 096**	**506**	**241**	**288**	**61**
Researchers	687	298.00	120	235	34.00
Technicians	254	128.00	76	37	13.00
Other supporting staff	155	80.00	45	16	14.00
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**4 270**	**2 333**	**744**	**1 027**	**166**
ISCED 6	642	194	91	353	4
ISCED 5A	2 846	1 655	467	610	114
ISCED 5B	218	142	34	26	16
Other	564	342	152	38	32
FEMALE	**1 096**	**506**	**241**	**288**	**61**
ISCED 6	167	64	17	85	1
ISCED 5A	792	398	168	181	45
ISCED 5B	49	26	8	10	5
Other	88	18	48	12	10

TABLE 3A.79: UGANDA: R&D RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS (HEADCOUNT) BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON-PROFIT
TOTAL	**2 823**	**1 431**	**404**	**880**	**108**
ISCED 6	616	194	88	331	3
ISCED 5A	1 926	1 038	285	522	81
ISCED 5B	24	0	12	7	5
Other	257	199	19	20	19
FEMALE	**687**	**298**	**120**	**235**	**34**
ISCED 6	158	64	15	78	1
ISCED 5A	494	225	95	147	27
ISCED 5B	6	0	1	4	1
Other	29	9	9	6	5
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**2 822**	**1 430**	**404**	**880**	**108**
Natural sciences	492	304	59	127	2
Engineering and technology	343	187	43	108	5
Medical sciences	284	0	46	230	8
Agricultural sciences	325	106	123	85	11
Social sciences	1 055	703	100	199	53
Humanities	323	130	33	131	29
Not elsewhere classified	0	0	0	0	0
FEMALE	**687**	**298**	**120**	**235**	**34**
Natural sciences	84	38	17	28	1
Engineering and technology	80	38	18	21	3
Medical sciences	87	0	13	72	2
Agricultural sciences	64	9	27	23	5
Social sciences	254	161	31	50	12
Humanities	118	52	14	41	11
Not elsewhere classified	0	0	0	0	0

TABLE 3A.80: UGANDA: R&D PERSONNEL FTES BY OCCUPATION, LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**2 006.6**	**1 055.6**	**545.9**	**358.0**	**47.4**
Researchers	1 262.7	639.0	264.6	325.0	34.4
Technicians	447.9	246.6	171.1	24.0	6.2
Other supporting staff	296.0	170.0	110.2	9.0	6.8
FEMALE	**555.0**	**264.0**	**174.5**	**95.0**	**21.5**
Researchers	331.6	161.1	75.3	81.0	14.2
Technicians	126.4	50.8	63.5	9.0	3.1
Other supporting staff	97.0	52.1	35.7	5.0	4.2
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**2 006.9**	**1 055.6**	**545.9**	**358.0**	**47.4**
ISCED 6	315.4	112.3	74.4	127.0	1.7
ISCED 5A	1 249.3	675.8	326.1	211.0	36.4
ISCED 5B	128.0	97.5	20.2	6.0	4.3
Other	314.5	170.0	125.2	14.0	5.0
TOTAL R&D PERSONNEL FTE BY FIELD OF SCIENCE	**2 006.9**	**1 055.7**	**545.8**	**358.0**	**47.4**
Natural sciences	249.6	85.7	95.9	66.0	2.0
Engineering and technology	248.2	149.7	57.3	40.0	1.2
Medical sciences	112.3	0	37.9	70.0	4.4
Agricultural sciences	337.7	28.8	275.1	29.0	4.7
Social sciences	948.3	767.9	69.4	86.0	25.0
Humanities	110.9	23.6	10.2	67.0	10.1
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0

TABLE 3A.81: UGANDA: RESEARCHER FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2010)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 263.2**	**639.2**	**264.7**	**325.0**	**34.3**
ISCED 6	307.6	112.3	72.4	122.0	0.9
ISCED 5A	826.0	427.8	176.2	192.0	30.0
ISCED 5B	8.8	0.0	5.3	3.0	0.5
Other	120.8	99.1	10.8	8.0	2.9
RESEARCHERS FTE BY FIELD OF SCIENCE	**1 263.0**	**639.0**	**264.6**	**325.0**	**34.4**
Natural sciences	189.7	85.3	42.5	61.0	0.9
Engineering and technology	120.7	55.4	32.3	32.0	1.0
Medical sciences	92.4	0.0	28.1	63.0	1.3
Agricultural sciences	164.6	26.2	107.1	28.0	3.3
Social sciences	596.4	450.7	48.2	79.0	18.5
Humanities	99.2	21.4	6.4	62.0	9.4
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0
FEMALE	**331.6**	**161.0**	**75.4**	**81.0**	**14.2**
Natural sciences	32.9	5.9	10.5	16.0	0.5
Engineering and technology	22.9	0.4	14.4	8.0	0.1
Medical sciences	20.2	0.0	7.2	13.0	0.0
Agricultural sciences	37.1	5.3	25.1	6.0	0.7
Social sciences	180.0	141.5	15.6	17.0	5.9
Humanities	38.5	7.9	2.6	21.0	7.0
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0

TABLE 3A.82: UGANDA: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION UGANDAN SHILLINGS (2010)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**194 769.3**	**67 722.0**	**75 138.9**	**49 482.0**	**2 426.4**
Business sector	26 632.8	25 652.0	5.4	818.4	157.0
Direct government	29 194.5	233.0	23 609.9	5 338.5	13.1
General university funds	13 530.4	-	-	13 530.4	-
Higher education	2 019.5	397.0	1 066.9	445.9	109.7
Private non profit	11 780.6	8 340.0	765.2	1 357.9	1 317.5
Funds from abroad	111 611.5	33 100.0	49 691.5	27 990.9	829.1
GERD BY SECTOR AND TYPE OF COST	**194 769.3**	**67 722.0**	**75 138.9**	**49 482.0**	**2 426.4**
Labour cost	45 996.9	19 600.0	16 526.0	8 593.4	1 277.5
Other current cost	89 344.0	29 200.0	36 940.9	22 529.6	673.5
Land and buildings	40 388.2	15 993.0	13 135.5	11 249.7	10.0
Instruments and equipment	19 040.2	2 929.0	8 536.5	7 109.3	465.4
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**194 769.3**	**67 722.0**	**75 138.9**	**49 482.0**	**2 426.4**
Basic research	67 586.9	29 254.2	20 931.6	16 469.4	931.7
Applied research	83 721.6	22 630.1	34 885.9	25 518.9	686.7
Experimental development research	43 460.8	15 837.7	19 321.4	7 493.7	808.0
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0
EXPENDITURE OF R&D BY FIELD OF SCIENCE	**194 769.3**	**67 722.0**	**75 138.9**	**49 482.0**	**2 426.4**
Natural sciences	17 518.5	11 614.9	177.3	5 707.9	18.4
Engineering and technology	23 733.3	16 220.8	1 286.7	6 225.6	0.2
Medical sciences	35 335.4	0.0	16 803.8	17 591.2	940.4
Agricultural sciences	32 619.7	1 221.6	26 089.8	5 298.4	9.9
Social sciences	58 067.9	38 048.9	13 440.2	5 600.1	978.7
Humanities	27 494.5	615.8	17 341.1	9 058.8	478.8
Not elsewhere classified	0.0	0.0	0.0	0.0	0.0

ZIMBABWE

TABLE 3A.83: ZIMBABWE: R&D PERSONNEL HEADCOUNTS BY OCCUPATION AND LEVEL OF EDUCATION (2012)

R&D PERSONNEL HC BY OCCUPATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**3 697**	*	**627**	**3 070**	*
Researchers	2 739	*	228	2 511	*
Technicians	430	*	129	301	*
Other supporting staff	528	*	270	258	*
FEMALE	**1 044**	*	**259**	**785**	*
Researchers	692	*	77	615	*
Technicians	140	*	50	90	*
Other supporting staff	212	*	132	80	*
TOTAL R&D PERSONNEL BY LEVEL OF EDUCATION	**3 697**	*	**627**	**3 070**	*
ISCED 6	489	*	11	478	*
ISCED 5A	2 175	*	189	1 986	*
ISCED 5B	346	*	187	159	*
Other	687	*	240	447	*
FEMALE	**1 044**	*	**259**	**785**	*
ISCED 6	131	*	3	128	*
ISCED 5A	546	*	69	477	*
ISCED 5B	116	*	82	34	*
Other	251	*	105	146	*

* Sector not surveyed

TABLE 3A.84: ZIMBABWE: R&D RESEARCHERS HEADCOUNTS BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2012)

RESEARCHERS BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**2 739**	*	**228**	**2 511**	*
ISCED 6	480	*	10	470	*
ISCED 5A	2 078	*	186	1 892	*
ISCED 5B	104	*	11	93	*
Other	77	*	21	56	*
FEMALE	**692**	*	**77**	**615**	*
ISCED 6	127	*	3	124	*
ISCED 5A	525	*	68	457	*
ISCED 5B	24	*	2	22	*
Other	16	*	4	12	*
TOTAL RESEARCHERS BY FIELD OF SCIENCE	**2 739**	*	**228**	**2 511**	*
Natural sciences	823	*	36	787	*
Engineering and technology	365	*	47	318	*
Medical sciences	5	*	5	0	*
Agricultural sciences	381	*	90	291	*
Social sciences	607	*	1	606	*
Humanities	424	*	0	424	*
Not elsewhere classified	134	*	49	85	*
FEMALE	**692**	*	**77**	**615**	*
Natural sciences	208	*	13	195	*
Engineering and technology	85	*	14	71	*
Medical sciences	2	*	2	0	*
Agricultural sciences	97	*	34	63	*
Social sciences	146	*	0	146	*
Humanities	118	*	0	118	*
Not elsewhere classified	36	*	14	22	*
* Sector not surveyed					

TABLE 3A.85: ZIMBABWE: R&D PERSONNEL FTES BY OCCUPATION, LEVEL OF EDUCATION AND FIELD OF SCIENCE (2012)

R&D PERSONNEL FTE	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL R&D PERSONNEL BY OCCUPATION	**1 740.8**	*	**267.5**	**1 473.3**	*
Researchers	1 305.2	*	135.3	1 170.0	*
Technicians	140.9	*	53.9	87.0	*
Other supporting staff	294.7	*	78.4	216.4	*
FEMALE	**472.8**	*	**107.5**	**365.3**	*
Researchers	332.2	*	51.3	281.0	*
Technicians	40.9	*	18.9	22.0	*
Other supporting staff	99.7	*	37.4	62.4	*
R&D PERSONNEL FTE BY LEVEL OF EDUCATION	**1 740.8**	*	**267.5**	**1473.3**	*
ISCED 6	175.6	*	6.9	168.7	*
ISCED 5A	1 111.1	*	119.3	991.9	*
ISCED 5B	153.8	*	73.5	80.3	*
Other	300.4	*	67.9	232.5	*
R&D PERSONNEL FTE BY FIELD OF SCIENCE	**1 740.7**	*	**267.4**	**1473.3**	*
Natural sciences	578	*	37.3	540.7	*
Engineering and technology	140.2	*	14.6	125.6	*
Medical sciences	51.7	*	1	50.7	*
Agricultural sciences	345.3	*	164.1	181.2	*
Social sciences	308.2	*	3.6	304.6	*
Humanities	220.5	*	2.8	217.7	*
Not elsewhere classified	96.8	*	44	52.8	*
* Sector not surveyed					

TABLE 3A.86: ZIMBABWE: RESEARCHER FTES BY LEVEL OF EDUCATION AND FIELD OF SCIENCE (2012)

RESEARCHERS FTE BY LEVEL OF EDUCATION	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
TOTAL	**1 305.2**	*	**135.3**	**1 170.0**	*
ISCED 6	175.6	*	6.9	168.7	*
ISCED 5A	1 050.1	*	113.3	936.8	*
ISCED 5B	36.7	*	6.2	30.5	*
Other	42.9	*	8.9	34.0	*
RESEARCHERS FTE BY FIELD OF SCIENCE	**1 305.3**	*	**135.3**	**1 170.0**	*
Natural sciences	388.1	*	21.4	366.7	*
Engineering and technology	176.1	*	27.9	148.2	*
Medical sciences	3.0	*	3.0	0.0	*
Agricultural sciences	189.0	*	53.4	135.6	*
Social sciences	283.0	*	0.6	282.4	*
Humanities	197.6	*	0.0	197.6	*
Not elsewhere classified	68.7	*	29.1	39.6	*
FEMALE	**332.3**	*	**51.3**	**281.0**	*
Natural sciences	111.2	*	11.0	100.2	*
Engineering and technology	19.2	*	3.3	15.9	*
Medical sciences	0.4	*	0.4	0.0	*
Agricultural sciences	56.7	*	29.5	27.2	*
Social sciences	60.0	*	0.2	59.8	*
Humanities	56.3	*	0.0	56.3	*
Not elsewhere classified	28.5	*	6.8	21.7	*
* Sector not surveyed					

TABLE 3A.87: ZIMBABWE: GROSS DOMESTIC EXPENDITURE ON R&D BY SECTOR AND SOURCE OF FUNDS IN MILLION US DOLLARS (2012)

GERD	TOTAL	BUSINESS	GOVERNMENT	HIGHER EDUCATION	PRIVATE NON PROFIT
GERD BY SECTOR AND SOURCES OF FUNDS	**142.3**	*****	**24.3**	**118.0**	*****
Business sector	1.9	*	1.8	0.1	*
Direct government	67.8	*	15.5	52.2	*
General university funds	11.3	*	-	11.3	*
Higher education	53.9	*	5.7	48.1	*
Private non profit	3.3	*	1.1	2.3	*
Funds from abroad	4.2	*	0.1	4.0	*
GERD BY SECTOR AND TYPE OF COST	**142.3**	*****	**24.3**	**118.0**	*****
Labour cost	53.4	*	5.4	48.0	*
Other current cost	10.7	*	1.3	9.4	*
Land and buildings	66.0	*	15.5	50.6	*
Instruments and equipment	12.3	*	2.2	10.1	*
TOTAL INTRAMURAL EXPENDITURE BY TYPE OF R&D	**142.3**	*****	**24.3**	**118.0**	*****
Basic research	77.0	*	7.6	69.4	*
Applied research	48.8	*	12.4	36.4	*
Experimental development research	16.5	*	4.3	12.2	*
Not elsewhere classified	0.0	*	0.0	0.0	*
EXPENDITURE OF R&D BY FIELD OF SCIENCE	**142.4**	*****	**24.3**	**118.0**	*****
Natural sciences	29.3	*	7.9	21.4	*
Engineering and technology	26.9	*	4.8	22.1	*
Medical sciences	2.0	*	0.0	2.0	*
Agricultural sciences	45.7	*	10.0	35.7	*
Social sciences	23.1	*	1.5	21.6	*
Humanities	15.3	*	0.0	15.3	*
Not elsewhere classified	0.0	*	0.0	0.0	*
* Sector not surveyed					

CHAPTER 4: INNOVATION

4.1 INTRODUCTION

The role of innovation as a driver of long-term economic growth, competitiveness and a better quality of life has gained acceptance amongst policy makers. In a developed economy, innovation is seen from the enterprise perspective as a way of increasing sales from the production of new products (goods and services) and of developing new industries. In a developing economy, it may be seen as a survival stratagem. The literature suggests a positive relationship between innovation and firm performance and growth in the services and manufacturing sectors, which may lead to increased competitiveness. Furthermore, innovative firms are likely to be more export-oriented than their non-innovative counterparts (Mohnen and Therrien, 2003; Mansury and Love, 2008).

Globally, the importance attached to innovation is articulated in, for example, the Innovation Strategy of the OECD and the focus of the European Commission on Innovation and the Innovation Union (OECD, 2012; European Commission, 2011). A number of African countries are taking part in building the human and institutional capacities needed to produce common internationally comparable indicators and conducting surveys of research and innovation at national levels to measure their innovation activities through ASTII (AU-NEPAD, 2010).

Africa is characterised by a very young population, with the proportion of youth among the region's total population the highest of any continent. Africa's governments are faced with a challenge of stimulating employment opportunities for this young populace, and innovation as a way of increasing economic growth is one option for tackling the question of employment. In general, governments are beginning to appreciate the benefits of innovation as shown by their commitment to understanding the dynamics of firms by promoting the measurement and study of innovation through surveys measuring R&D and innovation activities.

4.2 WHAT IS INNOVATION AND HOW IS IT MEASURED?

According to the third edition of the Oslo Manual, innovation refers to the implementation of a new or significantly improved product (good or service), process, marketing method or organisational method in business practices, workplace organisation or external relations (OECD/Eurostat, 2005). Four types of innovations are identified in this definition, namely product, process, marketing and organisational innovations, with the last two included to expand the scope of what is considered to be innovation in recognition of the fact that innovation is more than just product and process innovation. This edition of the manual supports the inclusion of marketing and organisational innovations by pointing out that this 'creates a more complete framework, one that is better able to capture the changes that affect firm performance and contribute to the accumulation of knowledge' (Paragraph 10, OECD/Eurostat, 2005). It also 'allows for more extensive analysis of the interactions between different types of innovations, in particular the importance of implementing organisational changes in order to benefit from other types of innovations' (Paragraph 12, OECD/Eurostat, 2005).

Product innovation relates to significant changes in the capabilities of goods or services and includes the introduction of new goods and services and significant improvements to existing products that are brought to the market. Examples of product innovations are significant changes in technical specifications, components and materials; incorporated software; and increased user friendliness or other functional characteristics. Process innovation refers to the use of new or significantly improved methods for the production and supply of goods and services. Innovation must be new to the firm but to varying degrees it may also be new to the industry sector or market.

'Marketing innovations refer to the implementation of new marketing methods, including changes in product design and packaging in product promotion and placement, and in methods for pricing goods and services. Organisational innovations refer to the implementation of new organisational methods. These can be changes in business practices, in workplace organisation or in the firm's external relations' (Paragraph 23, OECD/Eurostat, 2005). Marketing and organisational innovations are, however, outside the scope of this publication.

Innovation takes place within and is supported by a country's national system of innovation (NSI) through its components including government, industry and finance, academic and research institutions, civil society and their environment. A framework for the NSI developed in the 1980s emphasizes the relationships between these components as the explanation of the performance of innovation systems. In other words, the process of innovation involves linkages and interactions between these players and stakeholders.

The third edition of the Oslo Manual recognizes the need for developing countries to measure their innovations using this manual to enable benchmarking and to develop a coherent set of international system of innovation indicators. However, it also recognizes the need for innovation surveys to acknowledge and be able to detect the characteristics of innovation in developing countries, such as the acquisition of embodied technology equipment for both product and process innovations, minor incremental changes being the most frequent types of innovation activity and organisational change being an extremely significant part of the innovation process (Paragraph 501, OECD/Eurostat, 2005). Although the Oslo Manual highlights its sensitivity to these issues and attempts to address them, it also indicates that some remain a challenge from the measurement point of view, mainly due to the difficulty in applying existing definitions (Paragraph 502, OECD/Eurostat, 2005). One such challenge is the requirement based on the Eurostat guidelines to include only firms with 10 or more employees in the innovation surveys. This needs to be reviewed for developing countries, as it may exclude many innovations taking place in SMEs. This chapter of the AIO-II describes how innovations were measured using a questionnaire derived from the EU Community Innovation Survey (CIS) in participating countries that contributed data. It then presents the findings resulting from these measurements and how this information can be used in determining policy directions.

4.3 METHODOLOGY

4.3.1 PARTICIPATING COUNTRIES

Of the thirty-five countries that participated in the NEPAD-ASTII project, only twelve undertook national innovation surveys as part of the project. These were Egypt, Gabon, Ghana, Kenya, Lesotho, Mali, Nigeria, Senegal, South Africa, Tanzania, Uganda and Zambia. All of these countries, except Mali and Ghana, submitted data about the indicators requested by ASTII in a standard template form. Ghana provided its data in the format of a country report; the data could be fitted into the ASTII standard template. To varying degrees, there were gaps in the data for some indicators for all countries. In the case of Mali, gaps in the data made it impossible to calculate the required indicators; Mali could therefore not be included in the report. This chapter reports on innovation activities of 11 countries covering the reference period 2008-2010, except for Gabon (2010-2012), Kenya (2008-2011), Lesotho (2010-2012), Senegal (2009-2011) and South Africa (2005-2007).

4.3.2 SAMPLING

Table 4.1 shows the headings under which data were collected through the innovation surveys in the participating countries. Most countries were unable to use representative samples which would have allowed population estimates to be generated for the variables being measured. South Africa and Uganda were able to produce population estimates. Small non-representative samples, however, serve to provide an indication of innovation in a given country.

When sampling firms, the participating countries were requested to use an employee size cut-off of firms with 10 or more employees. Ghana, Kenya, Lesotho, Senegal, and Uganda complied with this cut-off. Egypt and Tanzania used cut-offs of two and five employees respectively. When employee size cut-offs were not feasible, revenue was used as a cut-off for size class. This was done for South Africa, and both employee size and revenue were used for Uganda and Zambia. The revenue cut-offs for South Africa are presented in Annex 4B. There may, of course, be small firms with large revenue and vice versa. Because of the range of sampling cut-offs used, it is difficult if not impossible to make country comparisons. In addition, sector coverage differed between countries. All covered manufacturing, some covered mining and service industries while others included sectors such as higher education and research establishments.

The survey methodologies, including sampling fractions, were too dissimilar across countries to enable statistically sound country comparisons. Furthermore, some countries did not provide values for some of the indicators. This chapter, therefore, presents individual innovation profiles for each country based on the data submitted. The reader should avoid comparing the values of indicators between countries.

4.3.3 COMPUTATION OF THE INDICATORS

Standardised calculations were performed across countries using one of the following denominators: total number of firms for which there were survey responses (innovation-active plus non innovation-active firms), number of innovation-active firms and number of non-innovation-active firms with survey responses. In some cases, countries did not provide some of the data that they used to calculate the value of a given indicator. In such cases, the country-supplied value of the indicator was used.

The indicators presented in the chapter can be grouped as follows:

Innovation rate (number of innovation-active[4] firms as a percentage of the total number of firms with responses)

- Number of firms with abandoned or ongoing innovation activities as a percentage of the total number of firms
- Number of firms whose product innovations originated inside the country as a percentage of all product innovation-active firms versus the number of innovative firms whose product innovations originated outside the country
- Number of firms whose process innovations originated inside the country as a percentage of all process innovation-active firms versus the number of firms whose process innovations originated outside the country
- Proportion of total expenditure by type of innovation activity, where there are four types as follows: intramural R&D, extramural R&D, acquisition of machinery and acquisition of external knowledge
- Number of firms which rated each of the various types of information sources for innovation as highly important, expressed as percentage of all innovation-active firms. These include internal sources, suppliers of equipment, clients or customers, competitors, consultants and universities.
- Number of firms which collaborated on innovations with various types of collaborative partners, expressed as a percentage of all innovation-active firms. These include other enterprises within own enterprise group, suppliers of equipment, clients or customers, competitors, consultants and universities.
- Number firms which rated various outcomes of product and process innovation as highly important, expressed as a percentage of innovation-active firms
- Number of innovation-active and non innovation-active firms that rated various barriers of innovation as highly important, expressed as a percentage of all innovation-active and non innovation-active firms respectively
- Number of innovation-active firms which used the various methods of claiming their intellectual property (IP) rights for the innovations they developed, expressed as a percentage of all innovation-active firms.

The data give a picture of innovation in the participating countries including the type of innovations being implemented; the degree of novelty of product innovations; the activities in which firms engage in order to develop innovations; the factors contributing to and hindering innovation; and the realised outcomes of the innovation activity.

4 Only Gabon and South Africa submitted data that enabled the breakdown of the innovation rate into the components for innovative firms and firms with only abandoned and/or on-going innovation activities. The proportion of innovative firms that performed R&D could only be computed for South Africa, based on the availability of the required data.

TABLE 4.1: CHARACTERISTICS OF THE INNOVATION SURVEYS IN THE PARTICIPATING COUNTRIES

Country	Reference period	Targeted business sector population size	Random stratified sample used (Yes/No)	Original sample size	Realised sample size	Extrapolation techniques used (Yes/No)	Minimum employment or revenue cut-off for firms in survey	Number of completed innovation active returns obtained	Number of innovation active firms in completed returns	Number of innovative firms in extrapolated sample	Percentage of innovation-active firms in completed returns/ extrapolated sample
Egypt	2008-2010	2 022	Yes	2 022	2 941	No	2 employees	2941	1179	No extrapolation	40.1
Gabon	2010-2012	452	No	162	47	No	20 employees	26	16	No extrapolation	61.5
Ghana	2008-2010	1 200		500		No	10 employees	309	224	No extrapolation	72.5
Kenya	2008-2011	2 500	Yes	650	293	No	10 employees	158	117	No extrapolation	74.1
Lesotho	2010-2012	53	No	53	53	No	10 employees	41	24	No extrapolation	58.5
Nigeria	2008-2010	20000	Yes	2 500	1 569	No	10	631	410	No extrapolation	65.0
Senegal	2009-2011	205	Yes	65	65	No	10 employees	65	41	No extrapolation	63.1
South Africa	2005-2007	22 849	Yes	4 000	2 836	Yes	Revenue limits for different sub-sectors	757	420	14 934	65.4
Tanzania	2008-2010	5 000*	Yes	200	500	No	5	137	84	No extrapolation	61.3
Uganda	2008-2010	4912	Yes	582	582	Yes	10 employees /10 million Shillings	486	375	3783	77.0
Zambia	2008-2010	1 000	Yes	600	416	Yes	10 employees /100,000 Kwacha	416	212	No extrapolation	51.0

Source: ASTII innovation surveys

Notes:

Realised sample size is the original sample of firms after being cleaned, i.e. after the firms which did not meet the eligibility criteria were removed from the sample. In the case of Tanzania, the realised sample size was larger than the original sample size.

Egypt used a representative sample.

South Africa used the revenue cut-off points presented in Annexure 4B.

Uganda and Zambia used cut-off points based on both number of employees and revenue.

* The figure for target population for Tanzania is an approximation.

4.4 FINDINGS

4.4.1 EGYPT

The innovation rate among Egyptian firms, calculated as the number of innovation-active firms as a percentage of all firms, was 40.1%. About 8.1% and 28.1% of all innovation-active firms had abandoned and on-going innovation activities respectively. 89% of enterprises in Egypt reported that their product and process innovations originated from within the country.

All innovation surveys show 'own enterprise group' as a leading source of information. In part that is because the survey is being filled out by someone who belongs to this group. Therefore, from here on emphasis will simply be noted if this is not the case and emphasis will be on external sources.

Highly important external sources of information for innovation for Egyptian innovation-active firms included: suppliers of equipment, clients or customers, competitors, consultants, conferences and scientific journals (Table 4.2). Universities and technical colleges and government and public research institutions were less frequently considered as highly important sources of information for the development of innovation activities.

TABLE 4.2: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR EGYPTIAN FIRMS; NUMBER AND PERCENTAGE OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**295**	**25.0**
External Sources			
Market	Suppliers of equipment	204	17.3
	Clients or customers	236	20.0
	Competitors	142	12.0
	Consultants	105	8.9
Institutional	Universities or technical colleges	32	2.7
	Government or private research institutions	35	3.0
Other	Conferences	121	10.3
	Scientific journals	95	8.1
	Professional associations	56	4.8
Source: ASTII Innovation Survey, 2008-2010, Ministry of Scientific Research, Arab Republic of Egypt			

Product outcomes were more frequently rated as highly important by Egyptian firms than process outcomes (Table 4.3). Product innovation benefits included: increased range of goods or services, entering new markets; and improved quality of goods or services. The main process innovation outcomes improved flexibility of production and increased capacity of production. Among other outcomes of innovation, most firms reported improved ability to meet governmental regulatory requirements.

TABLE 4.3: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR EGYPTIAN FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	289	24.5
	Entered new market	278	23.6
	Increased market share		
	Improved quality of goods or services	383	32.5
Process	Improved flexibility of production	335	28.4
	Increased capacity of production	284	24.1
	Reduced labour costs per unit of labour	96	8.1
Other	Reduced environmental impacts	163	13.8
	Improved working conditions on health		
	Met governmental regulatory requirements	242	20.5
Source: ASTII Innovation Survey, 2008-2010, Ministry of Scientific Research, Arab Republic of Egypt			

The factors most frequently rated as highly important in terms of hampering innovation among innovation-active firms in Egypt were cost factors primarily relating to a lack of funds within the enterprise. Nevertheless, innovation was seen as necessary, with the number of firms reporting no need for innovation relatively low. Data relating to hampering factors for non-innovation-active firms was not provided by Egypt.

The most prevalent way of acquiring IP rights in Egypt was through registration of a trademark, with 16.0% of firms conducting innovation activities reporting having registered a trademark during the previous three years. 8.1% of firms with innovation activity reported having registered an industrial design.

4.4.2 GABON

The Gabonese innovation rate was estimated at 61.5%, (Table 4.1) with 43.8% of innovation-active firms having ongoing innovation activities.

Most Gabonese innovation-active firms rated the following as highly important external information sources for innovation: suppliers of equipment, clients or customers, competitors and consultants (Table 4.4).

TABLE 4.4: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR GABONESE FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**8**	**50.0**
External Sources			
Market	Suppliers of equipment	6	37.5
	Clients or customers	4	25.0
	Competitors	3	18.8
	Consultants	2	12.5
Institutional	Universities or technical colleges	1	6.3
	Government or private research institutions	1	6.3
Other	Conferences	1	6.3
	Scientific journals		
	Professional associations	1	6.3

Source: ASTII Innovation Survey, 2010-2012, Ministère de l'Education Nationale, de l'Enseignement Supérieur, de l'Enseignement Technique et de la Formation Professionnelle

Firms mainly collaborated within the country, with the rest of Africa and to some extent with Europe. Types of partners were: other enterprises within own enterprise group, suppliers of equipment, competitors, consultants, and universities and technical colleges. Firms also had some collaboration with clients or customers in Gabon and Europe and with universities and private research institutions within the country.

Table 4.5 shows that Gabonese firms with innovation activity tended to derive the following measured positive results from innovation: (1) Product outcomes: increased range of goods or services; new markets; increased market share and improved quality of goods or services; (2) Process outcomes: improved flexibility of production or service provision; increased capacity for production or service provision; and reduced labour costs per unit of labour; and (3) Other outcomes: reduced environmental impacts; healthier working conditions; and increased ability to meet government's regulatory requirements.

TABLE 4.5: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR GABONESE FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	9	56.3
	Entered new market	6	37.5
	Increased market share	8	50.0
	Improved quality of goods or services	8	50.0
Process	Improved flexibility of production	5	31.3
	Increased capacity of production	7	43.8
	Reduced labour costs per unit of labour	7	43.8
Other	Reduced environmental impacts	7	43.8
	Improved working conditions on health	7	43.8
	Met governmental regulatory requirements	8	50.0

Source: ASTII Innovation Survey, 2010-2012, Ministère de l'Education Nationale, de l'Enseignement Supérieur, de l'Enseignement Technique et de la Formation Professionnelle

More than half of the firms with innovation activity (56.3%) sold goods and services within Gabon, followed by 31.3% who sold to Europe, 12.5% to the rest of Africa, 12.5% to Asia and 6.3% to the United States.

The proportion of firms selling goods and services within Gabon and to other countries was higher for firms with rather than without innovation activity; and firms with innovation activity reported sales to Europe, Asia and the United States of America, whereas firms without innovation activity did not operate in these markets.

The factors reported most frequently as hampering innovation by the innovation-active firms were evenly distributed across all categories: cost, knowledge and market. Most firms reported no need to innovate due to existing innovations and no demand for innovations. Among non-innovation-active firms, the factors reported most frequently as hampering innovation were cost factors: lack of finance from sources and innovation costs being too high, as well as knowledge factors: lack of qualified personnel.

12.5% of the firms with innovation activity reported securing a patent within the country and 12.5% reported registering a trademark. No firms were engaged in any other methods of securing IP rights.

4.4.3 GHANA

The innovation rate for Ghana was estimated at 72.5%. (Table 4.1) 22.3% of innovation-active firms reported abandoned innovation activities and 27.7% had on-going innovation activities. The pattern of innovation expenditure was as follows: intramural (in-house) R&D (38.2%), extramural (outsourced) R&D (19.1%), acquisition of machinery

(18.6%) and acquisition of external knowledge (24.1%). In other words, internal R&D represented the highest share of the total expenditure, indicating emphasis on own R&D in order to innovate.

Firms tended to collaborate more with partners within rather than outside the country. This applied to all types of co-operation partners: other enterprise within own enterprise group, suppliers of equipment, competitors, consultants, universities and technical colleges and government and private research institutions.

66.5% of product innovations were developed within the country with 32.5% resulting from outside collaboration. Firms mostly collaborated with collaborative partners within the country as follows: other enterprises within same enterprise group (18.8%), suppliers of equipment (13.4%), clients or customers (26.8%), competitors (21.4%), consultants (16.5%), universities and technical colleges (17.9%), and government and private research institutions (20.1%). In this regard, clients or customers were the most prominent collaborative partners for firms in Ghana. Among collaborative partners outside the country, firms mostly collaborated with European suppliers of equipment (11.6%).

The main forms of acquisition of IP rights by innovation-active firms were registration of a trademark (23.7%) and registration of an industrial design (19.2%). 14.3% of the firms had secured a patent within the country and 7.6% from outside. 8.9% of innovation-active firms reported granting a licence on any IP rights resulting from innovation and 8.5% had claimed a copyright.

4.4.4 KENYA

Firms with innovation activity in Kenya were estimated to be 74% (Table 4.1). Among these firms with reported innovation activity, 48.7% still had on-going innovation activities and 25.3% had abandoned innovation activities.

Kenyan product innovations mainly originated from within the country (49.6%) compared to the rest of Africa (6.8%) and none originated elsewhere in the world.

The highest proportion of the total innovation expenditure was on the acquisition of machinery (39.5%), followed by intramural R&D (27.2%), acquisition of other external knowledge (20.7%) and extramural R&D (12.6%). Intramural R&D being the second highest indicates that it plays an important role in the development of innovations.

As shown in Table 4.6, most innovation-active firms (95.7%) reported enterprises in the same industry group as a highly important source of information. Suppliers of equipment, clients or customers, competitors, professional associations, conferences and scientific journals were also frequently rated as highly important external sources of information.

TABLE 4.6: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR KENYAN FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**112**	**95.7**
External Sources			
Market	Suppliers of equipment	103	88.0
	Clients or customers	105	89.7
	Competitors	94	80.3
	Consultants	62	53.0
Institutional	Universities or technical colleges	44	33.6
	Government or private research institutions	47	40.2
Other	Conferences	83	70.9
	Scientific journals	75	64.1
	Professional associations	84	71.8

Source: ASTII Innovation Survey, 2008-2011, Ministry of Higher Education, Science and Technology

Innovative firms collaborated mainly with enterprises within the country. An estimated 53% collaborated within the same enterprise group within the boundaries of Kenya. This was followed by the rest of Africa with an estimated 18% and Europe with 14.5%.

Table 4.7 shows the effects of the product and process innovations that were implemented by firms. An estimated 48.7% of innovative firms increased the range of their products, 35.9% entered a new market and 42.7 % and 69.2% respectively increased market share and improved the quality of goods or services. Roughly half of the innovative firms experienced improvement in processing their products. Approximately 48% of the firms reported an improvement in flexibility of production, 58.1% increased capacity of production and 35% a reduction in labour cost per unit of labour.

TABLE 4.7: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR KENYAN FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	57	48.7
	Entered new market	42	35.9
	Increased market share	50	42.7
	Improved quality of goods or services	81	69.2
Process	Improved flexibility of production	56	47.9
	Increased capacity of production	68	58.1
	Reduced labour costs per unit of labour	41	35.0
Other	Reduced environmental impacts	42	35.9
	Improved working conditions on health	61	52.1
	Met governmental regulatory requirements	73	62.4
Source: ASTII Innovation Survey, 2008-2010, Ministry of Higher Education, Science and Technology			

The main factors hampering innovation for innovation-active firms were cost factors such as lack of funds within the enterprise, lack of finance from sources, too high innovation costs and excessive perceived economic risks. Market factors also featured high on the list, followed by knowledge factors such as lack of qualified personnel and difficulty in finding co-operative partners.

Registering a trademark (36.8%) was the main form of securing IP rights, followed by applying for patent outside the country (29.1%), registering an industrial design (18.8%) and securing a patent within the country (17.1%).

4.4.5 LESOTHO

The estimated innovation rate among the responding firms in Lesotho was 58.5% (Table 4.1). Among innovation-active firms, 8.3% reported abandoned innovation activities and 70.8% on-going innovation.

A number of collaborations related to developing product innovations, with eight out of seventeen innovation-active firms carrying out their product innovations within the country. This was followed by product innovations resulting from collaborative efforts with the rest of Africa. Sales of products (goods and services) among innovation-active firms were evenly distributed across regions, with 20.8% reporting sales of goods and services within Lesotho, 20.8% to the United States of America, 16.7% to the rest of Africa, 16.7% to Europe and 8.3% to Asia. Their tendency to sell these products domestically was higher than that of non-innovation-active firms and the converse was true, with their tendency to sell products in markets outside the country observed to be slightly lower than that of non-innovation-active firms. Over 81.2% of innovation expenditure in the responding firms was on acquisition of machinery.

As indicated in Table 4.8, the highly important external sources of information on innovation for Lesotho firms were: clients or customers, suppliers of equipment, and competitors.

TABLE 4.8: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR LESOTHO FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**18**	75.0
External Sources			
Market	Suppliers of equipment	13	54.2
	Competitors	10	41.7
	Consultants	8	33.3
Institutional	Universities or technical colleges	4	16.7
	Government or private research institutions	8	33.3
Other	Conferences	10	41.7
	Scientific journals	8	33.3
	Professional associations	8	33.3
Source: ASTII Innovation Survey, 2010-2012, Ministry of Communications, Science and Technology			

The responding firms in Lesotho predominantly collaborated with the following partners within the country: other enterprise within own enterprise group, suppliers of equipment, competitors, universities and technical colleges and government and private research institutions. Most of their collaboration with Africa was with consultants.

Innovation-active firms in Lesotho reported experiencing all of the measured benefits of innovation and particularly those directly related to product and process innovations (Table 4.9).

TABLE 4.9: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR LESOTHO FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	20	83.3
	Entered new market	18	75.0
	Increased market share	17	70.8
	Improved quality of goods or services	21	87.5
Process	Improved flexibility of production	21	87.5
	Increased capacity of production	19	79.2
	Reduced labour costs per unit of labour	20	83.3
Other	Reduced environmental impacts	16	66.7
	Improved working conditions on health	14	58.3
	Met governmental regulatory requirements	17	70.8
Source: ASTII Innovation Survey 2010-2012, Ministry of Communications, Science and Technology			

The factors reported most frequently as hampering innovation among innovation-active firms were cost factors, primarily lack of funds within the enterprise. The number of firms reporting no need to innovate was relatively low, indicating the importance attached to being innovative.

A third (33.3%) of innovation-active firms in Lesotho reported having registered a trademark, 25.0% had granted a licence on any IP rights resulting from innovation, 20.8% had registered an industrial design, 16. 7% had secured a patent in the country, 8.3% had applied for a patent outside of the country and 8.3% had claimed a copyright.

4.4.6 NIGERIA

Nigeria's innovation rate was 65.0% (Table 4.1). Among the innovation-active firms, 7.5% reported abandoned innovation activities and 19.2% on-going innovation activities. The majority of process innovations were developed within the country (85.4%), indicative of Nigerian enterprises' capacity for process innovation.

Almost two thirds (62.1%) of innovation expenditure in Nigeria was used for acquisition of software. The second largest share of the expenditure was on extramural R&D (18.3%) and intramural R&D (14.8%).

Sources within their own enterprise group as well as clients or customers ranked highly as information sources for innovation-active firms in Nigeria (Table 4.10), followed by suppliers of equipment, competitors and professional associations.

TABLE 4.10: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR NIGERIAN FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**212**	**51.7**
External Sources			
Market	Suppliers of equipment	161	39.3
	Clients or customers	212	51.7
	Competitors	123	30.0
	Consultants	60	14.6
Institutional	Universities or technical colleges	28	6.8
	Government or private research institutions	17	4.2
Other	Conferences	47	11.5
	Scientific journals	29	7.1
	Professional associations	83	20.2
Source: ASTII Innovation Survey 2008-2010, National Centre for Technology Management (NACETEM)			

Innovation-active Nigerian firms mostly rated collaborative partners within the country as highly important compared to international partners. Collaboration with European partners was more prevalent than with partners from USA, Asia, the rest of Africa and other countries.

Regarding product outcomes, an increased range of goods and improved quality of goods or services ranked more highly with Nigerian innovation-active firms as innovation benefits than entering new markets or increasing market share (Table 4.11). The most highly ranked process innovation outcomes were improved flexibility and improved capacity of production. Other benefits reported were meeting governmental regulatory requirements.

TABLE 4.11: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR NIGERIAN FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	224	54.6
	Entered new market	157	38.3
	Increased market share	153	37.3
	Improved quality of goods or services	235	57.3
Process	Improved flexibility of production	172	42.0
	Increased capacity of production	166	40.5
	Reduced labour costs per unit of labour	106	25.9
Other	Reduced environmental impacts	n.a.	n.a.
	Improved working conditions on health	91	22.2
	Met governmental regulatory requirements	126	30.7

Source: ASTII Innovation Survey 2008-2010, National Centre for Technology Management (NACETEM)

48.8% of innovation-active Nigerian firms reported sales of goods and services within the country, 2.4% to the rest of Africa and less than 1% to each of Europe, the USA, Asia and other countries.

Cost factors, primarily a lack of internal financial resources for innovation and the costs of innovation being too high, were the main factors reported as hampering innovation among innovation-active firms. The number of innovation-active firms reporting no need to innovate because of existing innovations or lack of demand for innovation was low (2.1% and 1.8% respectively), while for non-innovation-active firms the proportions reporting no need to innovate was much higher (11.6% and 58.4%). This implies that more innovation-active firms consider innovation to be important. Higher proportions of non-innovation-active firms than innovation-active firms reported knowledge factors as highly important barriers to innovation.

Among the various forms of acquiring IP rights, the form that was reported by most Nigerian innovation-active firms was registration of a trademark (31.0%) followed by registering an industrial design (18.8%) and claiming a copyright (14.2%).

4.4.7 SENEGAL

The Senegalese innovation rate was estimated at 63.1% (Table 4.1). Among innovation-active firms, 12.2% reported abandoned innovation activities and 29.3% on-going innovation activity. Almost half (48.8%) of the innovations among innovation-active firms were developed in Senegal, 19.5% in Europe, and 7.3% in the rest of Africa, Asia and other countries.

12.2% of innovation-active firms in Senegal reported selling goods and services within the country, 19.5% reported sales to the rest of Africa, 12.2% to Europe, 9.8% to Asia, and 4.9% to the USA. The proportion of non-innovation-active firms selling products in Senegal, the United States, Asia and the rest of Africa was higher than the percentage of innovation-active firms that did so. 39.9% of innovation expenditure in Senegal was assigned to acquisition of other external knowledge and 39.0% to intramural R&D activities.

Sources within their own enterprise group and suppliers of equipment rank highly as information sources for innovation-active Senegalese firms clients, (Table 4.12), followed by clients or customers, competitors and consultants, with universities or technical colleges and government and private research institutions ranking least important.

TABLE 4.12: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR SENEGALESE FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**19**	**46.3**
External Sources			
Market	Suppliers of equipment	18	43.9
	Clients or customers	6	14.6
	Competitors	5	12.2
	Consultants	5	12.2
Institutional	Universities or technical colleges	1	2.4
	Government or private research institutions	1	2.4
Other	Conferences	3	7.3
	Scientific journals	2	4.9
	Professional associations	2	4.9

Source: ASTII Innovation Survey 2009-2011, Ministry of Higher Education and Research

Innovation-active firms in Senegal collaborated mostly with partners within the country (suppliers of equipment, other enterprises within their own enterprise group, clients or customers, competitors, consultants, universities and technical colleges, and government and private research institutions) compared to international partners. There was a small proportion of innovation-active firms that collaborated with partners in Europe, the rest of Africa and the United States.

Regarding product outcomes, improved quality of goods and services and an increased range of goods ranked higher with Senegalese firms as innovation benefits than entering new markets and increasing market share (Table 4.13). Other highly ranked innovation benefits were improved working conditions on health and meeting governmental regulatory requirements.

TABLE 4.13: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR SENEGALESE FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	14	34.2
	Entered new market	9	22.0
	Increased market share	9	22.0
	Improved quality of goods or services	17	41.5
Process	Improved flexibility of production	7	17.1
	Increased capacity of production	7	17.1
	Reduced labour costs per unit of labour	5	12.2
Other	Reduced environmental impacts	5	12.2
	Improved working conditions on health	15	36.6
	Met governmental regulatory requirements	14	34.2
Source: ASTII Innovation Survey 2009-2011, Ministry of Higher Education and Research			

Cost (innovation costs being too high, excessive perceived economic risks and a lack of internal financial resources) was the main factor reported as hampering innovation among innovation-active firms.

Higher proportions of non-innovation-active firms than innovation-active firms reported knowledge factors as hampering innovation.

The number of innovation-active firms reporting no need to innovate because of existing innovations or lack of demand for innovation was lower for innovation-active firms than non-innovation-active firms, suggesting that innovation-active firms consider innovation to be important.

Among the various forms of acquiring IP rights, the form most frequently reported was registration of a trademark (34.2%) followed by securing a patent in the country (14.6%).

4.4.8 SOUTH AFRICA

South Africa's innovation rate was estimated at 65.4% (Table 4.1). Among the innovation-active, 6.8% reported abandoned innovation activities and 57.0% ongoing innovation activities. The proportion of firms that had either abandoned or ongoing innovation activities or both was 38.2%, giving an innovation rate of 27.2% for innovative firms. 24.1% of innovation-active firms also engaged in intramural R&D, while the rest (75.9%) did not. This indicates that more firms innovated than performed R&D.

76.0% of process innovations were developed within the country and 24% originated from abroad. This suggests a robust capacity in South African enterprises for developing their own process and product innovations.

59.6% of innovation expenditure in South Africa was assigned to acquiring machinery. The innovation activity that received the next highest expenditure was intramural R&D (21.2%) followed by extramural R&D (11.4%) and the acquisition of external knowledge (4.8%).

Apart from sources within their own enterprise group, clients or customers rank highly as information sources for innovation-active South African firms (Table 4.14), followed by suppliers of equipment, competitors, conferences and scientific journals. Universities or technical colleges and government and private research institutions rank less highly.

TABLE 4.14: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR SOUTH AFRICAN FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**6234**	**41.7**
External Sources			
Market	Suppliers of equipment	3180	21.3
	Clients or customers	6159	41.2
	Competitors	1704	11.4
	Consultants	687	4.6
Institutional	Universities or technical colleges	306	2.1
	Government or private research institutions	228	1.5
Other	Conferences	1993	13.3
	Scientific journals	1507	10.1
	Professional associations	841	5.6

Note: Numbers are based on population estimates

Source: National Innovation Survey, 2005-2007, Centre for Science, Technology and Innovation Indicators (CeSTII) on behalf of the Department of Science and Technology, South Africa

Innovation-active South African firms collaborated more with national than international partners. Collaboration within the country is mainly with other enterprises within their own enterprise group, suppliers of equipment, competitors, consultants, universities and technical colleges, and government and private research institutions. There was some collaboration with partners in Europe, USA and other countries (outside of Europe, USA and Asia) but little with Asian partners.

As important sources of information on innovation, South African firms highly rated information within their own enterprise group and from clients or customers with institutional sources of information, such as from universities or research institutions, less important. An increased range of goods and improved quality of goods or services ranked more highly with South African firms as innovation benefits than entering new markets (Table 4.15). The most highly ranked process innovation outcomes were improved capacity and improved flexibility of production. Other benefits reported were reduced environmental impact and meeting governmental regulatory requirements.

TABLE 4.15: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR SOUTH AFRICAN FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	4 664	31.2
	Entered new market	2 540	17.0
	Increased market share	n.a.	n.a.
	Improved quality of goods or services	4 579	30.7
Process	Improved flexibility of production	2 356	15.8
	Increased capacity of production	3 829	25.6
	Reduced labour costs per unit of labour	1 325	8.9
Other	Reduced environmental impacts	1 722	11.5
	Improved working conditions on health	938	6.3
	Met governmental regulatory requirements	2 348	15.7

Source: National Innovation Survey, 2005-2007, (CeSTII)
Note: Numbers are based on population estimates

56.7% of innovation-active South African firms reported sales of goods and services within the country, 28.8% to the rest of Africa, 20.4% to Europe, 13.2% to the USA, 13.7% to other countries and 12.8% to Asia.

A substantially higher proportion of firms with rather than without innovation activity reported sales of goods and services within the country and to other regions, which suggests potential market and profit benefits from innovative products.

Few abandoned innovation activities were reported, with cost (primarily a lack of internal financial resources for innovation) being the main factor reported as hampering innovation among innovation-active firms. The number of innovation-active firms reporting no need to innovate because of existing innovations or lack of demand for innovation was relatively low, while for non- innovation-active firms the proportions reporting no need to innovate was much higher. This implies that more innovation-active firms consider innovation to be important.

Higher proportions of innovation-active firms than non-innovation-active firms reported cost and knowledge factors as hampering innovation, while higher proportions of non-innovation-active firms than innovation-active firms reported market related factors as hampering innovation.

Among the various forms of acquiring IP rights, the form that was reported by most firms was registration of a trademark (11.3%) followed by claiming a copyright (5.1%).

4.4.9 TANZANIA

Tanzania's estimated innovation rate was 63.1% (Table 4.1). 23.8% of innovation-active firms reported abandoned innovation activities and 40.5% reported on-going innovation activities.

65.5% of innovation-active firms reported that their product innovations resulted from collaboration within the country, 14.3% with Europe, 13.1% with USA, 9.5% with Asia, 9.5% with the rest of Africa and 7.1% with other countries.

The external sources of information most frequently rated as highly important for innovation were clients or customers, followed by suppliers of equipment, competitors and consultants. Quite highly rated institutional and other sources were government or private institutions, conferences and professional associations (Table 4.16).

TABLE 4.16: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR TANZANIAN FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**52**	**61.9**
External Sources			
Market	Suppliers of equipment	27	32.1
	Clients or customers	56	66.7
	Competitors	23	27.4
	Consultants	14	16.7
Institutional	Universities or technical colleges	6	7.1
	Government or private research institutions	10	11.9
Other	Conferences	14	16.7
	Scientific journals	8	9.5
	Professional associations	17	20.2
Source: Tanzania Commission for Science and Technology (COSTECH)			

The most highly ranked benefit of innovation reported was improved quality of goods or services, followed by reduced environmental impacts, increased range of goods, improved working conditions on health and 'increased capacity of production' (Table 4.17).

TABLE 4.17: HIGHLY IMPORTANT EFFECTS OF INNOVATION FOR TANZANIAN FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	39	46.4
	Entered new market	31	36.9
	Increased market share	32	38.1
	Improved quality of goods or services	51	60.7
Process	Improved flexibility of production	31	36.9
	Increased capacity of production	38	45.2
	Reduced labour costs per unit of labour	31	36.9
Other	Reduced environmental impacts	40	47.6
	Improved working conditions on health	39	46.4
	Met governmental regulatory requirements	36	42.9

Source: ASTII Innovation Survey, 2008-2010, Tanzania Commission for Science and Technology (COSTECH)

40.5% of innovation-active firms in Tanzania reported sales of goods and services within the country, 17.9% to Europe, 10.7% to Asia, 9.5% to the rest of Africa, 6.0% to USA and 6.0% to other countries.

A slightly higher percentage of innovation-active than non-innovation-active firms reported selling goods and services within Tanzania, the rest of Africa, USA, Asia and other countries.

The factors most frequently reported as hampering innovation among innovation-active firms in Tanzania were cost factors and mostly lack of funds within the enterprise. However, the number of innovation-active firms reporting no need for innovation was relatively low, suggesting that being innovative was considered important. Higher proportions of innovation-active than non-innovation-active firms reported each of the cost, knowledge and market related factors as hampering innovation. Further, higher proportions of innovation-active than non-innovation-active firms reported no need to innovate.

65.5% of innovation-active firms reported having registered a trademark, 44.1% had registered an industrial design, 34.5% had secured a patent within the country, 25.0% had claimed a copyright, 20.2% had applied for a patent outside the country and 15.5% had granted a licence on any IP rights resulting from innovation. Almost a quarter of all innovation-active firms reported abandoned innovation activities. Most highly ranked by innovation-active firms as sources of information were information sources within the same enterprise group and information from clients or customers.

4.4.10 UGANDA

The innovation rate in Uganda was estimated at 77.0% (Table 4.1). 0.6% of innovation-active firms reported abandoned innovation activities and 5.7% on-going innovation activities. Approximately 82% of product innovations took place within the country as did 85% of process innovations.

52.3% of innovation expenditure was on external R&D, suggesting a low internal capacity for innovation. External sources of information for innovation that were rated as highly important by most firms were clients or customers, suppliers of equipment, competitors and consultants (Table 4.18). Other sources rated highly by a considerable percentage of firms were conferences and professional associations. Institutional sources such as universities or technical colleges and government or private research institutions were less highly rated.

TABLE 4.18: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR UGANDAN FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**2032**	**53.7**
External Sources			
Market	Suppliers of equipment	986	26.1
	Clients or customers	1855	49.0
	Competitors	869	23.0
	Consultants	461	12.2
Institutional	Universities or technical colleges	122	3.2
	Government or private research institutions	190	5.0
Other	Conferences	622	16.4
	Scientific journals	314	8.3
	Professional associations	428	11.3

Source: ASTII Innovation Survey, 2008-2010, Uganda National Council for Science and Technology (UNCST), Innovation Survey and year

Note: Numbers are based on population estimates

Innovation collaboration was with enterprises within their own enterprise group, suppliers of equipment, clients or customers, consultants, universities or technical colleges and government or private research institutions, followed by rest of Africa and, in most cases, Europe.

Innovation-active Ugandan firms reported experiencing all of the benefits of innovation; most frequently rated as highly important were improved quality of goods or services and increased range of goods (Table 4.19).

TABLE 4.19: EFFECTS OF INNOVATION ON UGANDAN FIRMS: NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	EFFECT OF INNOVATION	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Product	Increased range of goods	1632	43.1
	Entered new market	1147	30.3
	Increased market share	1217	32.2
	Improved quality of goods or services	1878	49.6
Process	Improved flexibility of production	1239	32.8
	Increased capacity of production	1144	30.2
	Reduced labour costs per unit of labour	840	22.2
Other	Reduced environmental impacts	746	19.7
	Improved working conditions on health	1172	31.0
	Met governmental regulatory requirements	1410	37.3

Note: Numbers are based on population estimates

Source: ASTII Innovation Survey, 2008-2010, Uganda National Council for Science and Technology (UNCST)

44.9% of innovation-active Ugandan firms sold goods and services to Europe, 46.1% to USA, 45.8% to Asia and 42.6% to other countries. 24.1% sold their products within the country. The percentages were similar for innovation-active and non-innovation-active firms.

Among innovation-active firms, the factors reported most frequently as hampering innovation related to costs and particularly to the high cost of innovation and to the lack of internal finance for innovation. The percentage of innovation-active firms reporting no need for innovation because of existing innovations or lack of demand for innovations was relatively small.

Higher proportions of innovation-active than non-innovation-active firms reported cost and knowledge factors as hampering innovation. Further, higher proportions of non-innovation-active than innovation-active firms reported no need to innovate.

The most prevalent method of acquiring IP was registration of a trade mark, with 20.4% of innovation-active Ugandan firms having done so. 10. 7% had registered an industrial design. A higher percentage (2.6%) of innovation-active firms reported applying for a patent outside than within the country (0.9%). 10.0% of firms had claimed a copyright and 9.7% had granted a license on any IP rights resulting from innovation.

4.4.11 ZAMBIA

Zambia's innovation rate was estimated at 51.0% (Table 4.1). 23.6% of innovation-active firms reported abandoned innovation activities and 64.6% on-going innovation activities. Approximately 95% of the product innovations were developed within the borders of Zambia. 73.9% of innovation expenditure was on intramural R&D.

External sources of information for innovation that were rated as highly important by most firms were clients or customers, sources within the same enterprise group, suppliers of equipment and competitors (Table 4.20). Other sources rated highly by a moderate percentage of firms included universities or technical colleges and government or private research institutions. No innovation-active firm considered consultants, scientific journals and professional associations to be highly important sources of information for the development of their innovations.

TABLE 4.20: HIGHLY IMPORTANT SOURCES OF INFORMATION FOR INNOVATION FOR ZAMBIAN FIRMS, NUMBER AND PERCENT OF INNOVATION-ACTIVE FIRMS

CATEGORY	INFORMATION SOURCE	INNOVATION-ACTIVE FIRMS	
		NUMBER	PERCENT
Internal sources	**Sources within same enterprise group**	**12**	5.7
External Sources			
Market	Suppliers of equipment	12	5.7
	Clients or customers	23	10.9
	Competitors	7	3.3
	Consultants	0	0.0
Institutional	Universities or technical colleges	2	2.0
	Government or private research institutions	1	0.5
Other	Conferences	0	0.0
	Scientific journals	0	0.0
	Professional associations	0	0.0
Source: ASTII Innovation Survey, 2008-2010, Zambia National Council for Science and Technology (UNCST)			

The majority of innovation-active Zambian firms (42.5%) sold goods and services within the country whereas 7.6% firms sold their goods and services to Asia, 7.1% to USA and Europe and 3.8% to other countries. 15.2% of non-innovation-active Zambian firms sold goods and services to United States and Asia, 14.7% to Europe, 12.8% to other countries. 11.3% of non-innovation-active firms sold their products within the country.

Zambian innovation-active firms reported that the most common method of acquiring IP was through securing patent in their own country (26.9%), followed by the registration of a trademark (19.3%). 10.9% of Zambian firms reported having registered an industrial design and 10.4% had been granted a license on any IP rights resulting from innovation. Amongst the companies who claimed IP rights, 9.0% and 4.3% had filed for copyright and applied for a patent outside of their own country respectively.

4.5 SUMMARY

4.5.1 INNOVATION IS PERVASIVE

As was the case with AIO 2010, this round of surveys found that innovation is present in all of the participating countries. An innovation is the implementation, by putting on the market, of a new or significantly improved product (good or service) or process and a new organisational or marketing method.[5] Selling these is thus a measure of the success of the innovation. In all countries, some of the goods and services resulting from innovations were sold both within and outside the country.

4.5.2 SOME INNOVATIONS DO NOT SUCCEED

Ranging between 40.1% and 77.0%, the innovation rate was generally high across all the reporting countries (Table 4.1). The proportion of firms with on-going innovation activities was even higher, at up to 70.8%. However, it should be noted that innovation activities may take considerable time to implement and some may have begun near the end of the reference period. The proportion of firms with abandoned innovation activities was generally low, ranging from very low (0.47%) to moderately low (25.3%), indicating that although the impact of factors hampering innovations varied across countries, it was generally on the lower end of the scale.

4.5.3 INNOVATIONS ORIGINATE WITHIN THE COUNTRY FOR MOST FIRMS

In all reporting countries, the majority of product and process innovations were developed within the country. There was also a relatively high frequency of firms collaborating with national partners. This is indicative of the enterprises' capacity for product and process innovation.

4.5.4 ACQUIRING MACHINERY AND INTRAMURAL R&D ACCOUNTED FOR THE LARGEST SHARE OF EXPENDITURE ON INNOVATIONS IN MOST COUNTRIES

In four of the nine countries providing data on expenditure on the various categories of innovation activities, acquisition of machinery had the largest share of the total expenditure, followed by intramural R&D (Table 4.21). These were Kenya, Lesotho, South Africa and Tanzania. In Ghana, intramural R&D had the largest share, followed by acquisition of external knowledge, extramural R&D and acquisition of machinery. Zambia also had the largest share of expenditure on intramural R&D but its second largest share was on the acquisition of machinery. Uganda, on the other hand, was the only country which reported extramural R&D as the activity with the largest share of expenditure, followed by intramural R&D and acquisition of machinery. Intramural R&D could be indicative of a commitment to innovation. Nigeria's largest share of expenditure was on the acquisition of software, while that of Senegal was on the acquisition of other external knowledge.

5 Organisational and marketing innovations were outside the scope of the analysis in this publication.

TABLE 4.21: SHARE OF EXPENDITURE FOR THE FOUR CATEGORIES OF INNOVATION ACTIVITIES FIRMS ENGAGED IN FOR REPORTING COUNTRIES

	INTRAMURAL (IN-HOUSE) R&D	EXTRAMURAL (OUT-SOURCED) R&D	ACQUISITION OF MACHINERY OR ACQUISITION OF SOFTWARE§	ACQUISITION OF OTHER EXTERNAL KNOWLEDGE	TOTAL
Ghana	38.2	19.1	18.6	24.1	100.0
Kenya	27.2	12.6	39.5	20.7	100.0
Lesotho	16.4	0.9	81.2	1.4	100.0
Nigeria	14.8	18.3	62.1	4.8	100.0
Senegal	39.0	15.6	5.5	39.9	100.0
South Africa	21.2	11.4	59.6	7.8	100.0
Tanzania	7.2	4.1	87.3	1.4	100.0
Uganda	27.4	52.3	15.6	4.7	100.0
Zambia	73.9	1.2	23.0	1.9	100.0

Source: ASTII innovation surveys, 2008-2010 for Ghana, Nigeria, Tanzania, Uganda and Zambia, and 2008-2011 for Kenya, 2010-2012 for Lesotho, 2009-2011 for Senegal and 2005-2007 for South Africa

§ For Nigeria, the data cover only acquisition of software

4.5.5 INNOVATION IS A CONNECTED ACTIVITY

In most countries, aside from within the firm or enterprise group itself, firms primarily sought ideas about innovation from clients or customers, followed by suppliers of equipment and competitors. Institutional sources such as universities and technical colleges and government and private research institutions ranked low. These findings corroborate those of the round of surveys reported in the AIO 2010 and other CIS-like surveys in other parts of the world (Eurostat, 2008: Tables 5.12 and 5.37; cited in AIO, 2010).

Firms collaborated with a range of partners but primarily with clients or customers within the country.

4.5.6 INNOVATION HAS IMPACT

In most countries, the principally perceived benefit of innovation is improved quality of goods or services. This was followed, in varying degrees across countries, by increased range of products, increased flexibility of production, increased capacity to produce, increased market share, the ability to meet government regulatory requirements, reduced labour costs per unit of labour, reduced environmental impacts and healthier working conditions. In all countries, innovation-active firms exported some of the goods and services resulting from their innovations.

4.5.7 THERE ARE BARRIERS TO INNOVATION

Lack of funds within the enterprise or group was the barrier to innovation most frequently reported by both innovation-active and non-innovation-active firms in the reporting countries. No need to innovate and lack of expertise were also cited by both types of firms as barriers of innovation.

4.5.8 ACQUIRING IP RIGHTS IS A FREQUENTLY-USED APPROACH TO INNOVATION

Registering a trademark was the approach to claiming IP rights most commonly reported. In addition, Tanzanian and Ugandan firms quite frequently registered industrial designs with Ugandan firms securing patents within the country and applying for patents outside the country.

4.5.9 INNOVATION AND R&D

In the AIO 2010, countries reported that more firms innovated than did R&D. In this report, the same result is confirmed by South Africa. There were some difficulties with other countries providing the number of innovative firms that did and did not report the performance of R&D. However the finding for South Africa is reported here as it is not contradicted by any of the country data and it is an important consideration for the development of innovation policy.

4.6 INTERPRETING THE FINDINGS

The AIO 2010 made clear why the results of the first round of surveys could not be compared across countries (AU-NEPAD, 2010). For reasons broadly similar to those mentioned in the AIO 2010, this remains the case with this second round of surveys:

- The reference periods are not perfectly comparable. For example, South Africa's data was based on the survey covering the reference period 2005 to 2007 and not to 2010 as with most of the other countries.
- In some countries, the methods and bases for determining the firm size cut-off points did not strictly follow the guidelines provided by Eurostat for the CIS and based on the Oslo Manual. For example, South Africa used firm revenue, Uganda and Zambia used both firm revenue and number of employees, while all other countries used number of employees.
- Most countries, except South Africa, Uganda and Zambia, did not use a stratified random sample or project the sample results to the population of firms. Egypt used a representative sample.
- Sector coverage and sample sizes differed across countries.

As in the AIO 2010, some of findings in the conclusions section can be considered robust. These include:

- the importance of clients and customers as sources of information on innovations, and as collaborators

- improved quality of products as the main benefit of innovation
- lack of internal funds as the main barrier to innovation
- registration of a trademark as the main method of acquiring IP rights.

However, in this second round of surveys as in the first, the propensity to innovate and the percentages of innovation-active firms with abandoned and on-going innovation activity are not highly comparable across countries and regions for the reasons highlighted at the beginning of this chapter.

The AIO 2010 gave a picture of the African innovation landscape but contained some gaps (AU-NEPAD, 2010). The present report shows that, despite the increase in the number of African countries carrying out national innovation surveys, comparing the results of these surveys remains as a challenge, to a great extent due to their different methodological procedures. Comparability can be achieved through the ongoing ASTII training workshops in participating countries, individualised training and expert monitoring at country level in the process of conducting the surveys. This is because this would promote adherence to the concepts and definitions in the Oslo Manual and the guidelines from Eurostat for conducting innovation surveys.

4.7 USING THE FINDINGS

The findings in the current report largely confirm those of the first round of surveys. The implications for action in that publication thus also still apply. For instance, the importance of the link between innovation-active firms and their clients or customers may suggest a policy or strategy to support collaboration. The finding that acquisition of machinery is one of the leading innovation activities may imply tax incentives to encourage investment in specific categories of machinery and equipment such as ICTs (AU-NEPAD, 2010). A related finding from the second round of surveys is that, in most countries, firms commonly invest in intramural R&D. Encouraging intramural R&D may require discussions and decisions about tax incentives and support for human capacity development.

As was observed from the first round of surveys, they continue to confirm the need for capacity building throughout the innovation system, including the capacity to conduct the surveys, process the results and use the findings for policy purposes (AU-NEPAD, 2010). The institutionalization of ASTII's work through the creation of AOSTI is a significant step towards building such capacity and strengthening national systems of innovation. ASTII should continue to provide a training forum and, at the appropriate time, evolve to an African equivalent of the OECD NESTI which would be attached to AMCOST and be represented at the OECD NESTI level. Such a forum would enable discussions among experts and would include non-experts who would learn from others and would take that knowledge back to their countries.

ANNEXURE 4B: SAMPLING INFORMATION FOR INNOVATION SURVEYS

TABLE 4B: TURNOVER CUT OFF POINTS FOR SOUTH AFRICA

SECTOR	SIC	TURNOVER (IN RANDS)§
Mining & quarrying	21-29	> 3,000,000
Manufacturing	30-39	> 4,000,000
Electricity, gas & water supply	41-42	> 4,000,000
Wholesale trade	61	> 5,000,000
Retail trade	62	> 3,000,000
Transport, storage & communication	71-75	> 2,000,000
Financial intermediation	81	> 2,000,000
Computer and related activities	86	> 2,000,000
Research & Development	87	> 2,000,000
Architectural & engineering activities	8821	> 2,000,000
Technical testing & analysis	8822	> 2,000,000 Source: Innovation Survey Sample Specification, Centre for Science, Technology and Innovation Indicators (CeSTII) and Statistics South Africa
§ Firms with this turnover value or above were included in the sample, otherwise they were excluded		

CHAPTER 5: ASSESSMENT OF SCIENTIFIC PRODUCTIVITY (2005 – 2010) OF AFRICAN COUNTRIES PARTICIPATING IN THE ASTII PROJECT

5.1 INTRODUCTION

"Bibliometric indicators provide information about the numbers, character and impacts of scientific output in a given country or region, or in a given discipline, the intensity and type of linkages between countries, research institutions or even individual researchers" (UIS, 2005).

Bibliometrics is a tool for evaluating and benchmarking research performance and has been defined as the application of mathematical and statistical methods to the entire scientific literature including books and documents (Pritchard, 1969). Its purpose is to measure the output of scientific and technological research through data derived from scientific literature and patents (OECD, 1997) and in this way to assist the diffusion and exploitation of knowledge.

Many governments globally use indicators to assess the impact of their science and technology policies on their science and innovation systems. Used in conjunction with other relevant indicators, bibliometrics helps governments and other stakeholders to decide what research or strategic projects to support.

The bibliometrics of the literature on science and technology in Africa is limited (AU-NEPAD, 2010) and in many cases relates to case studies of individual countries. Much of the literature is in English and this may result in undercounting or non-coverage of scientific research in other languages. Furthermore, bibliometrics tends to be reliable for the natural sciences but less so for the social sciences and humanities because of the types of outputs in each domain (books versus citation index journal publications). Despite these limitations, however, a number of studies have shed light on various aspects of Africa's scientific and technological production although there needs to be more awareness about how to use them (AOSTI, 2013).

This chapter is based on the bibliometric study[6] undertaken by AOSTI on the scientific and technological outputs of the AU's member countries. The study is first of a series on this topic and forms part of AOSTI's broader mandate to develop and manage science, technology and innovation indicators. The chapter summarises and highlights key findings from the study with the focus on countries that participated in the second phase of the ASTII project.

6 The full report can be requested from AOSTI.

5.2 METHODOLOGY

The bibliometric data and statistics were produced using Elsevier's Scopus bibliographic database as conditioned by Science-Metrix. Table 5.1 shows the indicators produced using this method.

TABLE 5.1: BIBLIOMETRIC INDICATORS PRODUCED USING ELSEVIER'S SCOPUS BIBLIOGRAPHIC DATABASE

BIBLIOMETRIC INDICATORS
Number of papers: This is a simple count of scientific papers that are normalised and the great majority of which have been peer-reviewed.
Growth Index (GI): the rate of growth of output compared to the growth observed at world level.
Average of Relative Impact Factor (ARIF): this refers to output quality based on the propensity to publish in highly cited journals. It is a measure of the number of citations within scientific journals. The impact factor is used to gauge the relative importance of a scientific journal within its field.
Average of Relative Citations (ARC): This is the number of times that papers were referenced and takes into account the difference in citation levels between scientific specialties. It provides a relatively direct assessment of paper quality and impact, since a great number of references is directly indicative of greater use of the published information by other researchers.
Specialisation Index (SI): This measure the relative emphasis on research areas within Africa compared with their prevalence in the world as a whole. The higher the SI, the more papers have been published in that particular area.
Collaboration Index (CI): This is a measure of the number of papers published with other authors in other AU member states and elsewhere.
National Collaboration Rate (NCR): This measures collaboration between institutions in a single country. The rate is calculated by dividing the number of papers with at least two institutional addresses within the country by that country's total number of papers.
Regional Collaboration Rate (RCR): This measures collaboration at the regional level and usually refers to intra- or inter-regional collaboration.
International Collaboration Rate (ICR): This measures international collaboration and is calculated by dividing the number of papers with at least one foreign country address by the entity's total number of papers.
Source: AOSTI 2013

5.3 SCIENTIFIC OUTPUT IN THE AFRICAN UNION

Between 2005 and 2010, the AU produced 1.8% of the world's total research output. This was far below the output of large economies such as the USA and China which produced 27.2% (2 737 080 units) and 16.7% (1 675 101 units) respectively. However, the AU's growth rate over this period was 43.8%, significantly higher than the world rate of 18%. Based on this rate of growth, if it were considered a country the AU would have ranked fourth behind India, China and Brazil in 2010. Within the AU, South Africa, Egypt, Nigeria, Tunisia, Algeria and Kenya have produced the largest number of scientific publications since 2005 (AOSTI, 2013). This trend is similar to the results shown in AIO 2010, with the same countries dominating production of scientific publications in terms of absolute outputs. However, this ranking varies when countries' outputs are normalised per capita or GDP.

142 569 papers were produced in the countries that submitted R&D and innovation survey indicators for the AIO-II, with the growth rates of South Africa (31%), Kenya (35%), Egypt 50%), Nigeria (54%), Ghana (54%) and Uganda (56%) much higher than the global average (Table 5.2). The growth rates of countries such as Cape Verde, Lesotho and Togo were too low to be meaningfully compared with others, while Namibia and Zimbabwe had negative growth rates.

TABLE 5.2: S&T OUTPUT OF AFRICAN COUNTRIES PARTICIPATING IN THE ASTII PROJECT AND THE WORLD TOTAL, 2005-2010

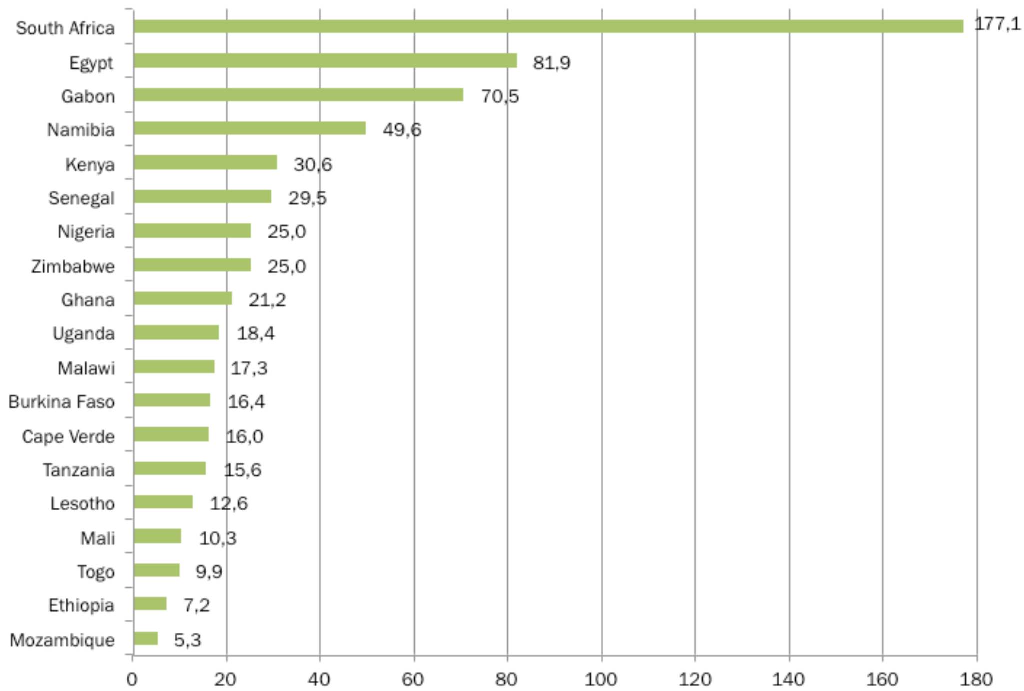
COUNTRY/ GROUP	2005	2006	2007	2008	2009	2010	2005-2007	2008-2010	% CHANGE 2008-2010/2005-2007	GROWTH INDEX
WORLD	**1,443,998**	**1,542,026**	**1,633,499**	**1,721,635**	**1,817,608**	**1,897,208**	**4,619,523**	**5,436,451**	**18%**	**100**
AFRICAN UNION	**21,237**	**25,175**	**28,217**	**31,165**	**36,270**	**39,390**	**74,629**	**106,825**	**43%**	**122**
South Africa	6,748	7,544	8,039	8,852	9,840	10,477	22,331	29,169	31%	111
Egypt	4,485	5,003	5,562	6,247	7,816	8,469	15,050	22,532	50%	127
Nigeria	2,090	2,971	3,487	3,714	4,498	4,977	8,548	13,189	54%	131
Kenya	848	961	1,122	1,190	1,326	1,430	2,931	3,946	35%	114
Tanzania	431	574	623	609	692	790	1,628	2,091	28%	109
Ethiopia	392	499	574	600	663	780	1,465	2,043	39%	118
Uganda	358	436	535	547	676	847	1,329	2,070	56%	132
Ghana	332	358	470	464	618	706	1,160	1,788	54%	131
Senegal	328	278	342	358	368	371	948	1,097	16%	098
Zimbabwe	245	291	335	287	264	301	871	852	-2%	083
Malawi	164	188	261	291	269	324	613	884	44%	123
Burkina Faso	160	243	233	267	288	290	636	845	33%	113
Zambia	123	157	185	202	192	241	465	635	37%	116
Mali	89	135	132	134	150	160	356	444	25%	106
Mozambique	69	101	104	122	137	136	274	395	44%	122
Gabon	100	110	87	102	114	109	297	325	9%	093
Namibia	114	112	101	92	100	100	327	292	-11%	076
Togo	44	47	60	68	68	78	151	214	42%	120
Angola	27	27	28	31	34	39	82	104	27%	108
Lesotho	14	19	25	29	31	27	58	87	50%	127
Cape Verde	1	10	4	8	10	14	15	32	113%	181

Source: AOSTI 2013

The number of scientific publications per capita can be used as a measure of scientific activity. Figure 5.1 shows the scientific publications of countries that participated in the second phase of the ASTII project, normalized per capita. The most productive countries in terms of scientific research articles published per capita between 2005 and 2010 were South Africa, Egypt and Gabon. At the AU level[7], Tunisia led with output per capita of 306.2, followed by the Seychelles with 296.1, South Africa with 177.1, Botswana with 132.1 and Egypt with 81.9 papers per capita (AOSTI, 2013).

7 See AOSTI report on "Scientific Productivity of the African Union Member States (2005 – 2010)

FIGURE 5.1: NUMBER OF PAPERS PER CAPITA (PER MILLION INHABITANTS) IN AFRICAN COUNTRIES PARTICIPATING IN THE ASTII PROJECT, 2005-2010



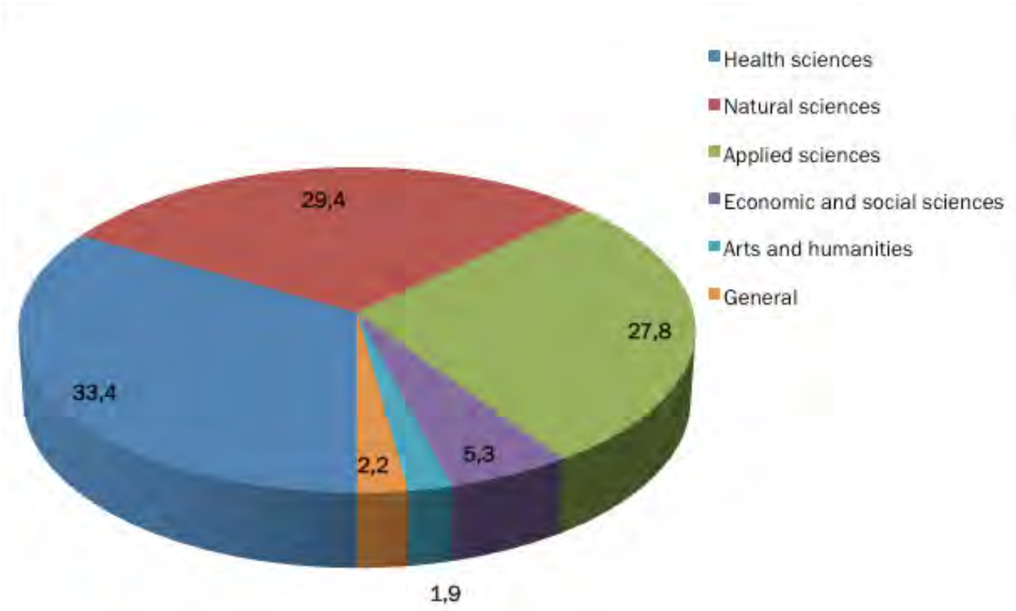
Source: AOSTI, 2013

The quality and impact of a unit of scientific output can be shown by its ability to be published in highly cited journals and by the number or level of citations that it receives. The value of being published in a highly cited journal is correlated with the impact factor of the journal; the indicator used is the average of relative impact factors (ARIF) which indicates the quality of the research output. The average of relative citations (ARC) indicates scientific impact. It measures the level of citations received and indicates how often a scientific publication is used in other scientific work. Zambia, Malawi, and Mozambique had the greatest propensity to publish in highly cited journals (ARIF>1) while Mozambique and Zambia had the greatest propensity to produce highly cited publications (ARC>1)

5.4 SCIENTIFIC PRODUCTION PER DOMAIN, FIELD AND SUBFIELD OF SCIENCE

Figure 5.2 shows the distribution of scientific outputs across scientific domain or major science field for all AU member countries from 2005 to 2010. The number of publications across all fields of science increased, although with differences in the level of growth across each field of science.

FIGURE 5.2: PERCENTAGE DISTRIBUTIONS OF SCIENTIFIC OUTPUTS IN THE AU BY MAIN SCIENTIFIC DOMAIN, 2005 – 2010



Source: AOSTI 2013

The largest numbers of publications were in health sciences at 59 528 (34.3%), followed by the natural sciences at 52 430 (29.4%) and applied sciences at 49 460 (27.8%). Within the main scientific domains, the AU's largest number of publications was produced in clinical medicine, biology, biomedical research, enabling and strategic technologies, chemistry, engineering, physics and astronomy, agriculture, fisheries and forestry, and information and communication technologies (Table 5.3).

TABLE 5.3: PUBLICATIONS BY FIELD OF SCIENCE IN THE AU, 2005-2007 AND 2008-2010

DOMAIN	FIELD	2005-2007	2008-2010	GROWTH INDEX 2008-2010/2005-200	SI	ARIF	ARC
Health sciences		**24 959**	**34 569**	**1,22**	**1,00**	**0,91**	**0,83**
	Biomedical research	6 153	8 632	1,30	1,22	0,95	0,90
	Clinical medicine	16 079	21 967	1,25	0,90	0,91	0,87
	Psychology and cognitive sciences	711	868	1,01	0,53	0,68	0,64
	Public health and health sciences	2 016	3 102	1,33	1,11	0,98	1,00

DOMAIN	FIELD	2005-2007	2008-2010	GROWTH INDEX 2008-2010/2005-200	SI	ARIF	ARC
Natural sciences		**22 601**	**29 829**	**1,20**	**1,13**	**0,84**	**0,76**
	Biology	6 888	9 578	1,18	2,54	0,83	0,78
	Chemistry	6 108	7 526	1,13	1,08	0,76	0,63
	Earth and environmental sciences	2 581	3 432	1,14	1,21	0,94	0,85
	Mathematics and statistics	1 929	2 756	1,19	1,20	0,83	0,79
	Physics and astronomy	5 095	6 537	1,23	0,63	0,90	0,83
Economic and social sciences		**20 211**	**29 249**	**1,20**	**0,89**	**1,01**	**0,86**
	Agriculture, fisheries and forestry	5 096	6 471	1,06	2,12	0,94	0,85
	Built environment and design	459	612	1,06	0,89	1,10	0,94
	Enabling and strategic technologies	5 403	8 400	1,34	0,84	1,07	0,92
	Engineering	5 633	7 294	1,09	0,79	1,08	1,00
	Information and communication technologies	3 620	6 472	1,40	0,63	0,79	0,61
Applied sciences		**3 552**	**5 917**	**1,26**	**1,08**	**0,85**	**0,68**
	Economic and business	1 561	2 665	1,26	1,10	0,67	0,60
	Social sciences	1 991	3 252	1,26	1,07	0,99	0,75
Arts and humanities		**1 406**	**1 999**	**1,10**	**1,06**	**0,95**	**0,97**
	Communication and textual studies	378	577	1,14	0,95	0,73	0,76
	Historical studies	583	792	1,08	0,98	1,20	1,42
	Philosophy and theology	427	604	1,10	1,55	0,69	0,60
	Visual and performing arts	18	26	1,08	0,30	0,80	0,38
General		**1 415**	**2 460**	**1,29**	**1,60**	**0,90**	**0,62**
	General science and technology	1 258	2 121	1,25	1,52	0,88	0,65
	General arts, humanities and social sciences	157	339	1,63	2,58	1,05	0,44
Source: AOSTI 2013							

The Specialisation Index (SI) indicates whether a country has a higher (SI>1) or lower (SI<1) share of world publications in particular fields of science than its overall share of the world total of publications. The SI indicates whether a country has higher or lower than average activity in a specific science field. It does not however reflect the importance of the scientific field or the quality of the publication. Figure 5.3 illustrates the impact and specialisation of publications produced in various fields of science by AU member states.

At the AU level, scientific papers are concentrated mainly in four subfields of science: general and internal medicine, tropical medicine, microbiology and virology. These have SI levels higher than the world average. The number of publications produced in these fields is not only high but they are also highly cited and have significant impact as shown by ARIF and ARC scores above the world average.

The AU is also highly specialized in biology and agriculture, forestry and fisheries. However, the most cited publications are in built environment and design, enabling and strategic technologies, biomedical research, clinical medicine, earth and environmental sciences and agriculture, fisheries and forestry.

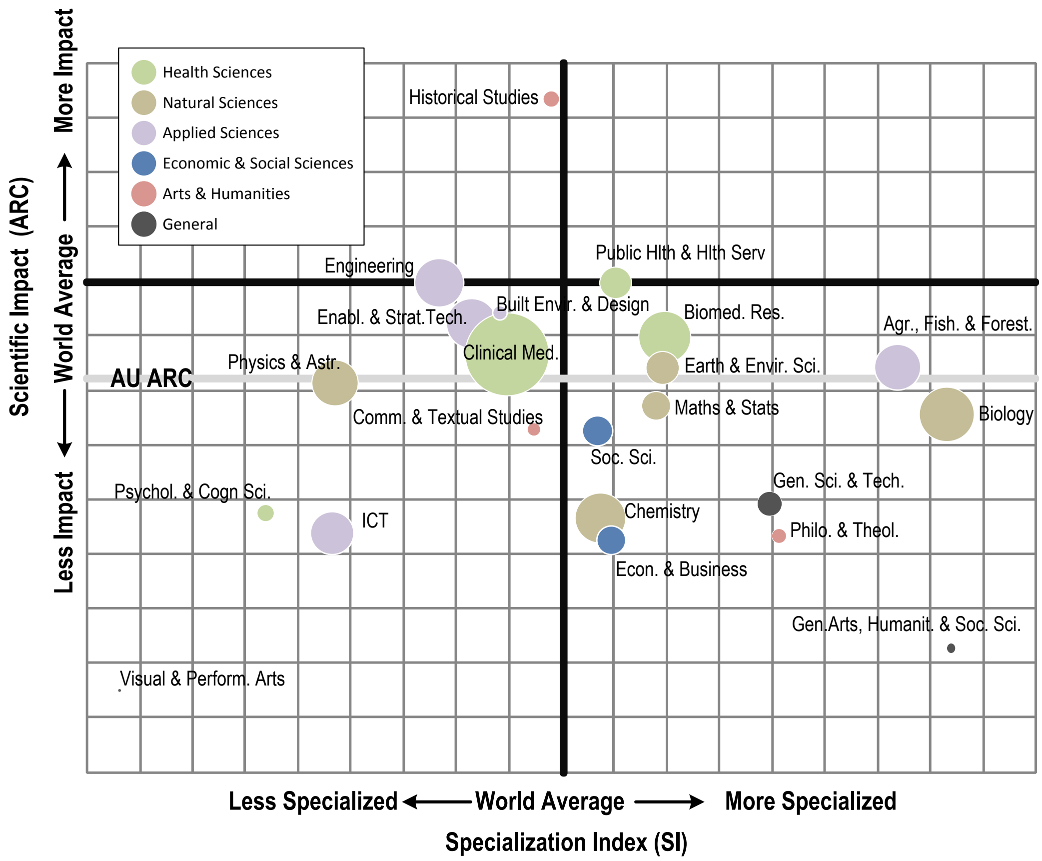
Research intensity within the health sciences domain is strong (SI>1) in health policy and services, sport sciences, and complementary and alternative medicine.

The AU is also strong in zoology and in mathematical physics within the natural sciences, forestry and horticulture and the applied sciences. The ARIF and ARC indexes greater than the world average are an indication of the quality of research produced in these fields.

There are some fields of science within the AU where the quality of research publications is above the world average but research efforts are minimal. These include engineering, energy, defence and security studies.

Within the EAC and the IAD, the GI, ARIF and ARC indices were above the world average in health research. At the country level, Egypt, Nigeria and South Africa produced the largest number of papers in health sciences. Kenya, Uganda, Tanzania, Ghana, Malawi, Burkina Faso and Mali scored highly for growth, specialisation and research impact.

FIGURE 5.3: POSITIONAL ANALYSIS OF THE AU MEMBER COUNTRIES BY SCIENTIFIC FIELD, 2005-2010



Source: AOSTI 2013

AU countries' output in the natural sciences has increased since 2005 but the publications were not in general published in highly rated journals nor did they have significant impact (ARC<1) in the scientific community. Egypt, Ghana and South Africa produced substantial numbers of publications in this field.

Within the applied sciences, research outputs in horticulture and forestry have ARIF and ARC indexes higher than the world average. Within the engineering sciences, the SI and ARC scores for chemical engineering and for mining and metallurgy are above the world average. The ARC and ARIF for aerospace and aeronautics are also above 1. Specialisation in this field is more pronounced in the Maghreb countries where the GI, SI and ARIF for Algeria and Tunisia were above world average scores. Senegal and South Africa also have high ARIF and ARC scores in the field.

The AU has a greater growth rate than the world average in the economic sciences and the social sciences. However, the number of publications remained low.

5.5 SCIENTIFIC COLLABORATION AT THE AU AND INTERNATIONAL LEVELS

This section deals with the extent of scientific collaboration within AU countries and Africa's regions and with scientists abroad. In general, collaboration among African countries is poor; however, there is regional collaboration among West African countries such as Cameroon, Burkina Faso, Niger, Togo, Mali, Congo, Benin, and Gabon.

To determine the effects of international collaboration, an analysis was carried out of the relationship between the number of national publications and the number of publications resulting from international collaborations. The results showed that publications with national authors only had ARC scores below the world average. However, 25 out of 36 AU countries with internationally authored papers had ARC scores above the world level. South Africa, Egypt and Ethiopia produced the largest number of papers with national authorship only.

Collaboration is widely regarded as beneficial to science in many ways (Katz and Martin, 1997; Glänzel and Schubert, 2007; Beaver 2001). Scientific publications resulting from international collaborative projects tend to be cited more frequently than those from national collaborative projects (Narin et al., 1991, Gaillard, 2003). However, collaboration can be viewed as indicating dependency particularly in countries that do not have sufficient resources to carry out their own research.

TABLE 5.4: COLLABORATION PATTERNS AMONG COUNTRIES PARTICIPATING IN THE ASTII PROJECT, 2005-2010

	NATIONAL PAPERS	ARC	INT'L COLL.	ARC	CI	TOTAL PAPERS	ARC	% INTERNATIONAL
South Africa	29 010	0,69	22 490	1,56	1,07	51 500	1,07	44%
Egypt	24 003	0,61	13 579	1,01	0,74	37 582	0,76	36%
Nigeria	17 728	0,32	4 009	0,91	0,27	21 737	0,43	18%
Kenya	1 825	0,47	5 052	1,50	1,80	6 877	1,23	73%
Ethiopia	1 272	0,55	2 236	1,08	1,04	3 508	0,89	64%
Ghana	1 084	0,40	1 864	1,23	0,97	2 948	0,93	63%
Tanzania	872	0,45	2 847	1,48	1,74	3 719	1,24	77%
Uganda	725	0,50	2 674	1,53	1,86	3 399	1,31	79%
Senegal	620	0,23	1 425	1,07	1,11	2 045	0,81	70%
Zimbabwe	462	0,50	1 261	1,23	1,22	1 723	1,03	73%
Malawi	298	0,56	1 199	1,47	1,60	1 497	1,29	80%
Burkina Faso	240	0,30	1 241	1,19	1,94	1 481	1,05	84%
Zambia	154	0,45	946	1,50	2,04	1 100	1,35	86%
Mali	142	0,34	658	1,34	1,50	800	1,16	82%
Togo	129	0,24	236	0,75	0,58	365	0,57	65%

	NATIONAL PAPERS	ARC	INT'L COLL.	ARC	CI	TOTAL PAPERS	ARC	% INTERNATIONAL
Namibia	108	0,42	511	1,29	1,43	619	1,14	83%
Gabon	79	0,19	543	1,15	1,90	622	1,03	87%
Mozambique	68	0,39	601	1,61	2,35	669	1,48	90%
Lesotho	33	0,23	112	1,02	0,74	145	0,84	77%
Angola	15	n.c.	171	0,78	2,01	186	0,73	92%
Cape Verde	1	n.c.	46	1,35	3,89	47	1,35	98%

Int'l Coll.: international collaboration

Source: AOSTI, 2013

Scientific papers published in national journals may have low impact factors and limited distribution but this does not necessarily imply that the quality of research is poor. Frequently, papers produced nationally address national issues and aim to propose solutions which affect national policy. The findings described in this chapter highlight the importance of collaboration, locally and internationally. However, as Tijssen (2007) writes, a "one size fit all" scientometrics assessment framework is bound to exclude or misrepresent essential scientific information.

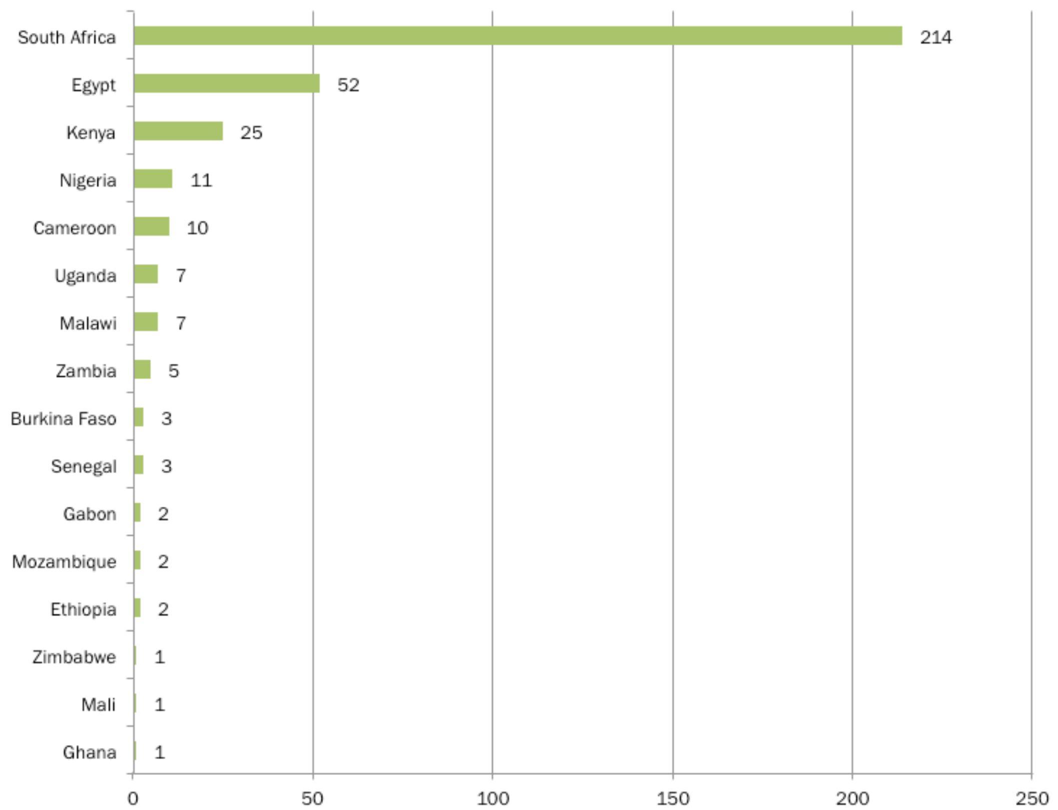
To take account of the fact that national publications reflect national research performance in Africa, a bibliometric system that includes international and local journals is required (Tijssen, 2007). However, for local journals not included in the citation index to be considered for meaningful bibliometric analyses, rigorous peer-reviewed processes of international standards would be required for both increased quality and international comparisons of scientific productivity.

5.6 LEADING SCIENTISTS IN THE PRODUCTION OF SCIENTIFIC PUBLICATIONS

"Leading scientists" used interchangeably with "top researchers" or "most active scientist" refers to scientists who have published the highest number of publications within a specific period. A highly active or top African researcher in this context would therefore be one who has published 40 or more papers indexed in the Scopus between 2005 and 2010. Between 2005 and 2010, 505 researchers from AU countries published 40 or more papers indexed in Scopus. About half (53.0%) were highly cited with ARC above 1.

About 52.0% of these scientists had an output growing faster than the world average. Almost half (49%) of the leading researchers have co-authored more than 50.0% of their publications with collaborators from other countries. Those researchers who collaborate internationally tend to have a greater than average scientific impact (ARC>1). South Africa has the largest number of leading scientists (214) followed by Egypt (52), Kenya (25), Nigeria (11), Cameroon (10), Uganda (7), Malawi (7) and Zambia (5) (Figure 5.4).

FIGURE 5.4: NUMBER OF TOP RESEARCHERS PER COUNTRY



Source: AOSTI 2013

Leading scientists are generally based at prominent institutions in the host country, and their research focus tends to be fields of science that produce high SI, ARC and ARIF publications. These scientists were located within the health sciences (35 in microbiology, 27 in virology, 24 in tropical medicine and 22 in general and internal medicine); in computer science (20 in networking and telecommunications and 13 in artificial intelligence and image processing); and in applied natural sciences (19 in applied physics, 19 in inorganic and nuclear chemistry, 14 in medicinal and biomolecular chemistry, 12 in materials, 10 in energy and 9 in biotechnology).

5.7 SUMMARY

Despite its limitations, bibliometrics provides a wealth of information that, when used with other indicators, reveals trends and developments in an area of academic knowledge. This chapter has focused mainly on the countries that participated in the ASTII programme. Indicators revealed that scientific publications from the AU member countries remained lower than those of the USA, China, and the world as a whole. However, the rate at which publications output grew was faster than the global average. From the countries analysed here, Egypt, Kenya Nigeria, and South Africa continued to produce the largest number of publications in the AU. There has been an overall increase in the number of publications across all fields of science between 2005 and 2010.

Output was particularly high in the health and applied sciences where research in fields such as medicine, tropical medicine, and microbiology, virology and horticulture and forestry, chemical engineering, and mining and metallurgy had significant impact as shown by SI, ARIF and ARC scores that are above the world average. This indicates that publications from these research fields are of high quality, are frequently cited by the scientific research community and that more research support is devoted to them by the AU member countries.

Among the AU countries, the level of output in the social and economic sciences and in the humanities was relatively low. This may be due to their low coverage in international databases and they may well be undercounted. The reasons for low coverage include the fact that most of the outputs are disseminated through local or domestic science journals, or other publication outlets with a geographically or linguistically restricted range of dissemination (Tijssen, 2006, 2007). The low output rate may also be related to the mode of publication in the social sciences and humanities where books are more common than journal articles. However, despite limited international recognition, such publications may be important if they relate to research that addresses local issues and assists with meeting national policy objectives.

The chapter has shown that scientists within AU member countries tend not to collaborate with one another and instead seek partnerships outside the continent. The reasons for this differ from country to country and include funding, visibility, infrastructure and size of the science system. Most of the scientists who collaborate internationally have ARC scores higher than the world average and are based in top performing institutions within the AU. This is an indication of the importance of collaboration and networking in a globalised world.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

AIO-II draws on the results of R&D surveys, innovation surveys and bibliometrics to describe the status of the science systems of a number of AU member countries.

6.1 SCIENCE, TECHNOLOGY AND INNOVATION POLICY

African countries have ST&I policies or are in the process of developing or reviewing them. However, few mention innovation policy and, in most cases, a distinction is not made between science policy and innovation policy. A science system is different from an innovation system and science policy is therefore different from innovation policy; it is linkages that make the innovation system function.

The results of the innovations surveys also indicate that more firms innovate than do R&D, reinforcing the argument for separating ST and innovation policies.

Recommendation:

- Governments may want to consider separating S&T from innovation policies and create dedicated institutions to deal with innovation matters.

6.2 IMPROVING THE QUALITY OF DATA

The processes leading to the production of this publication indicate that there is more work to be done in order to have comparable statistics of good quality across the continent.

Recommendations:

- Train more officials per country and create a critical mass of experts to undertake surveys. The training should be both short and long term.
- Institutionalise R&D surveys and innovation surveys, creating a culture of collecting and archiving statistics, and especially STI statistics, at national level.
- Encourage dialogue among countries to share best practices.

6.3 USE OF THE DATA FROM THE SURVEYS

One of ASTII's objectives is to provide AU member states with reliable and accurate information to inform policy processes.

Recommendations:

- Data and information from the surveys form part of policy-making processes,
- The data should be disseminated through popularisation of country reports, policy briefs and use of the Outlook series.

6.4 THE IMPORTANCE OF PARTICIPATION BY ALL AU MEMBER STATES

The success of the ASTII initiative is dependent on the active participation of countries through ownership of the programme as well as the provision of data on a regular, consistent and timely basis. This will make it possible to monitor the impact of STI on the continent on a long term basis.

Recommendations:

- Countries are encouraged to join the initiative and those that are already part of it should continue to participate on a consistent basis.
- AU members should continue to mobilise stakeholders to ensure ownership of the ASTII project within their countries.

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