Chapter 4

The State of Public Science in the SADC Region

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Contents

Executive summary

The de-institutionalisation of science in SADC

Africa's share of world science, as measured in papers published in the citation indexes of the Institute for Scientific Information (ISI), has been declining steadily over the past decade. Bibliometric studies show that Sub-Saharan Africa's share of world scientific papers declined from 1% in 1987 to 0,7% in 1996. These diminishing shares of African science overall do not reflect a decrease in absolute sense, but rather an increase in publication output less than the worldwide growth rate. Africa has lost 11% of its share in global science since its peak in 1987; Sub-Saharan science has lost almost a third (31%). The countries in Northern Africa – Egypt and the Maghreb countries (Algeria, Mauritania, Libya, Morocco and Tunisia) – accounted for the modest growth of the African share of the worldwide output during the years 1998 to 2002. The countries in the south, on the other hand, have generally done worse.

Bibliometric analysis of research output is only one measure of the relative decline of research and scholarship at many African universities. Numerous studies have been conducted over the past 10 to 15 years that demonstrate quite convincingly that research at former well-resourced and well-supported institutions in Sub-Saharan Africa (such as Makerere University in Uganda, Ibadan in Nigeria and the University of Dar es Salaam in Tanzania) has deteriorated. The research infrastructure and the general state of laboratories at many institutions have suffered from a lack of maintenance and timely replacement of old equipment. In addition, the generally poor quality of library resources has not improved significantly, with many university libraries not using automated management systems. The demand for sufficient research funding for ongoing research and scholarship continues, as does the need for proper research management and support at most of these institutions.

The cumulative effect of the funding policies of the last two decades of the previous millennium, the huge growth in student enrolments in higher education institutions, combined with continuing political instability in many African countries, have created a state of affairs which is best described as the 'de-institutionalisation' of science.

Science systems in developed and highly industrialised countries have a certain number of clear and evident features. Such systems are dense (well-populated) with highly articulated scientific institutions. A 'scientific institution' is defined as any formal organisation or entity that is dedicated to the pursuit of scientific knowledge production, dissemination and utilisation. This definition includes bodies that perform research and development (R&D) such as university centres, laboratories and institutes, as well as research and development performing entities outside the higher education sector. It also, however, includes scientific publishing houses, journals, conferences, workshops and seminars that are 'organisations' for the dissemination of scientific knowledge. Bodies that promote

the utilisation and commercialisation of scientific knowledge (e.g. technology incubators, technology transfer offices, patenting offices) are also included.

In a modern science system there are typically a multitude of these scientific institutions that perform clearly articulated functions and roles; together they constitute what could be termed the 'national mode of scientific production'. Unfortunately, few or none of the features of a modern science system apply to many countries in Sub-Saharan Africa. Many of the scientific institutions in these countries are fragile and susceptible to the vagaries of political and military events, are severely under-resourced and suffer because of a lack of clarity and articulation on science governance issues (demonstrated by constant shifts in ministerial responsibility for science). In fact, one could refer to some of these science systems and the associated institutions as operating in a 'subsistence mode' where they struggle to reproduce themselves. A subsistence mode refers to a system that produces knowledge for its own use only and does not export knowledge. In fact, it does not make a significant contribution to global knowledge production. It is debatable whether one can talk of a science 'system' in many of these countries, as they do not exhibit typical 'systemic' characteristics. Typically institutions are not aligned through input, process, output flows, and there is no typical systemic behaviour in response to external changes and demands. Rather, the image of an 'assemblage' of fragile, somewhat disconnected and under-resourced institutions is perhaps a more apt metaphor to describe the science arrangements in some of these countries.

One should, however, be cautious of over-generalisation and over-simplification, as there are also some instances of small, but robust, institutions (some universities and research centres) that have survived the ruptures of political changes and economic fluctuations, where pockets of significant science are still found. In these isolated cases science is publicly supported by the government and there is reasonable political stability and good governance of the science system. In many of these cases, there are also well-established links and collaborative networks with strong research establishments elsewhere in the world.

The governance of science

The governance of science refers to a set of appropriate policies that address science and technology priorities and their alignment with national socio-economic goals; a network of appropriate national structures to provide guidance and oversight to the science system (such as a ministry of science and technology); and appropriate science funding and monitoring agencies (such as a national agency for research funding).

As far as science policy development is concerned, our study suggests that it is possible to discern at least three very different trajectories:

- The first trajectory refers to those SADC countries that have gone through two waves of science policy development: during the first wave (not too long after acquiring independence) a first science and technology policy was developed, but during the subsequent years it was allowed to become dormant and ineffectual. A second wave of policy revision was instigated more recently (1990s and beyond) in order to recapture the essence of the science policy goals (as in the case of South Africa and possibly Zimbabwe).
- The second category consists of SADC countries that established their first science and technology policy documents in the 1990s and even more recently (since 2000): These include countries such as Botswana, Lesotho, Malawi, Mozambique, Namibia and Tanzania.
- A third and small category of countries in the region – viz. Angola, DRC, Madagascar, Mauritius and Swaziland – still has no science and technology policy.

Few of the countries in the region (notably Angola, Botswana, Malawi, Mozambique, Namibia, South Africa and Tanzania) have a dedicated ministry for science and technology. Fewer have a dedicated agency for managing research funding centrally, which is an indication of the lack of sufficient funds for research and development in most of the countries in the region.

Research and development intensity

The standard measure of the research and development intensity of a country is the ratio of gross expenditure on research and development (GERD) to gross domestic product (GDP). Most developing countries view 1% as the gold standard. The average of the EU member states in 2005 was around 1,9% and the countries with the highest research and development intensity in the world (Finland, Sweden and Singapore) exceed 2%.

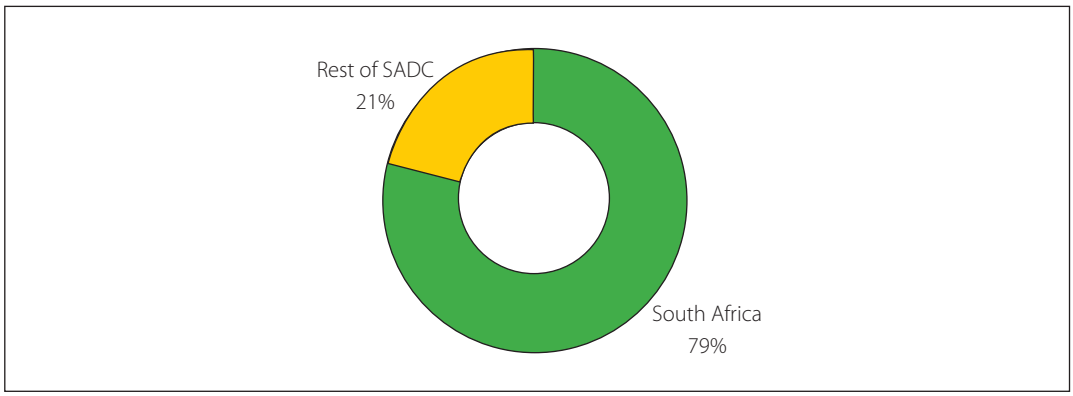
Of the SADC countries, South Africa is the only country that comes close to the ideal of 1% (the 2005/06 Research and Development Survey indicates that it stands at 0,93%). Mozambique has over the past decade made special efforts to invest more in research and development, with the result that its reported 0,6% in 2002 is laudable. Botswana, the DRC and Tanzania spend around 0,3 to 0,4% of GDP on research and development, while the remaining countries spend less than 0,2%. We have no information for Angola, Malawi, Namibia and Swaziland.

South Africa is the only country in the SADC region that regularly collects and makes available basic research and development statistics conforming to OECD Frascati standards. Zambia, Tanzania and Mozambique have in recent times undertaken some studies to establish GERD, but this remains a major challenge for science and technology authorities in the region. The standard research and

development surveys provide a wealth of information on research and development income and expenditure trends, the contributions to research and development by various sectors (higher education, government and private sector) as well as crucial human resources information. Despite recent efforts by the UNESCO Institute for Statistics to establish an indigenous capacity in basic scientometrics in Sub-Saharan Africa, very little has been achieved. This is an area that SARUA might wish to address in collaboration with such agencies.

Scientific output in the SADC region

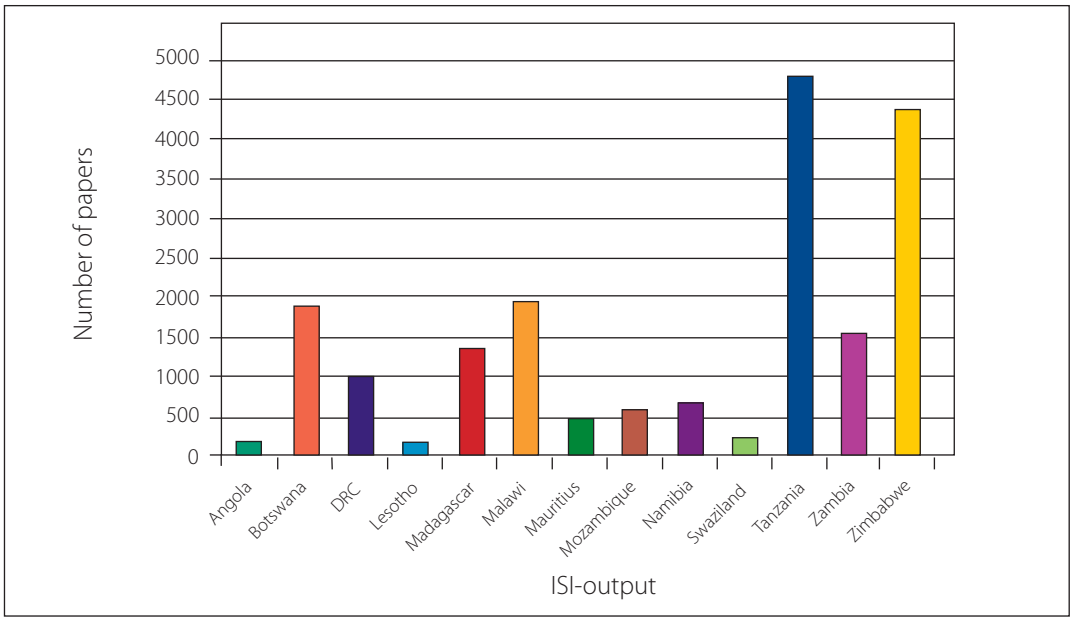
Figure 1 Scientific output in the SADC region



Our bibliometric analysis of absolute and comparative article output (as measured in terms of ISI-papers) has produced the following key findings:

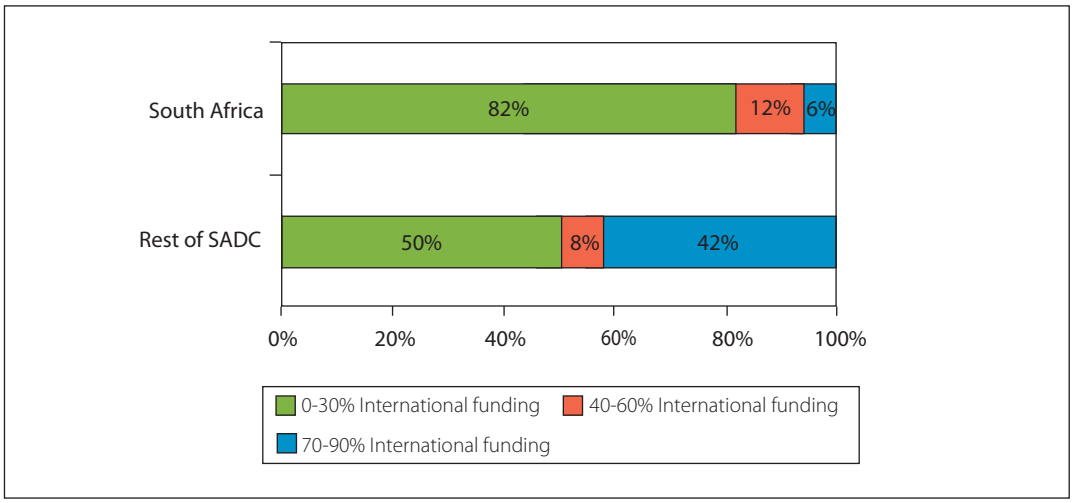
- South Africa is the most prolific and productive producer of scientific output in the region. In fact it dominates scientific production by producing on average 80% of all output for the period 1990 to 2007 and being about four times more productive than the average for the region (119 papers per million of the population compared to the average of 29 papers per million of the population).
- Tanzania is the second most prolific producer of output, having pushed Zimbabwe into the third position over the past five years.
- Botswana is the second most productive country with 96 papers per million of the population. The only other countries that have above-average productivity scores are Mauritius and Namibia.
- Scientific output in the region is dominated by the biodiversity of the eco-systems and the strategic demand for medical research in such fields as infectious and tropical diseases.

Figure 2 ISI-output per country (excluding South Africa) (1990 to 2007)



Funding of science

Figure 3 Proportion of total research funding sourced from international funding organisations



Funding of science in the majority of SADC countries remains a huge problem. This problem manifests itself in many ways:

- the lack of national government commitment to the stated ideals of expending 1% of GDP on research and development;

- the lack of a central infrastructure for co-ordinating and facilitating science funding (and its alignment with national research goals);
- the huge dependence on foreign funding for science and technology in the majority of countries and most of the universities in SADC (with the exception of South Africa) – 6% of survey respondents in South Africa said that more than 70% of their total research funding comes from international funding organisations. The comparative figure for the other SADC countries is 42%; and
- the relative lack of institutional research offices for co-ordinating and facilitating research funding within universities.

The lack of sufficient endogenous funding for research (and the converse dependence on international agencies for research support) has two significant consequences: firstly, governments in the region cannot steer the research efforts in their countries in any meaningful way. Any science policy and the formulation of science and technology priorities will be ineffectual unless the resources are available to give effect to such national agendas. Secondly, as a consequence, the research agendas and priorities in many SADC countries are therefore shaped and influenced by the research priorities of international funding agencies. Even if the priorities of such agencies are aligned with the needs of the countries in the region (and the emphasis on agricultural and health research would suggest that this is the case), it still means that the research conducted under these programmes remains reactive and often short-term. International funding is usually also project-driven with the result that researcher salaries, laboratory and equipment costs are not funded. Donor funding – even if it is well meant and properly used – does not help to build an indigenous scientific infrastructure and capacity. In the long term, governments in the region have to find the funds to build, sustain and grow their own scientific institutions and capacities if they wish to overcome existing dependencies and more directly steer their own scientific efforts.

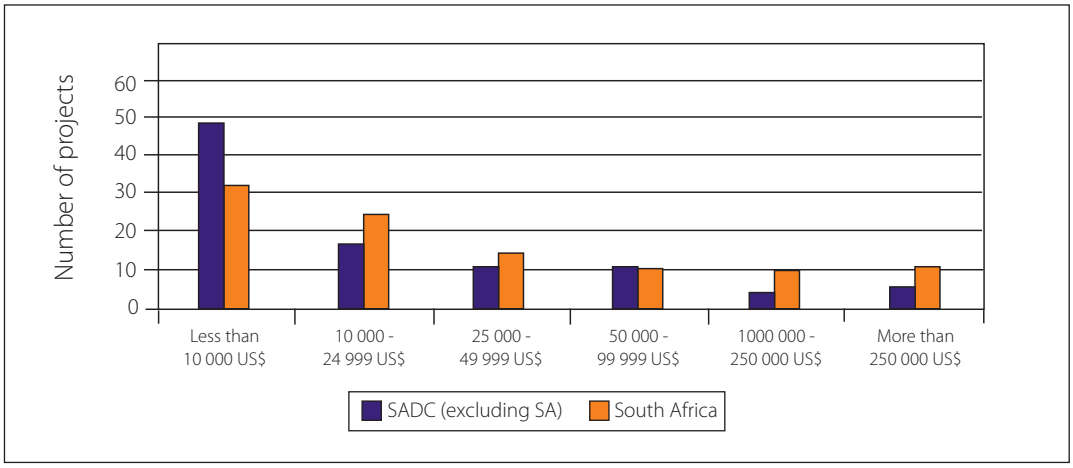
The robustness of the institutions of science

Research projects

The picture about involvement in research projects is a complex one. On the one hand, our respondents on average are involved in more than two projects at any given time and in many fields this increases to three or four. Significant percentages of our respondents indicated that they are involved in research that is jointly done with foreign collaborators, but it is also clear that South African

scientists overall have more money for projects, which is a likely explanation for the fact that they engage in more stand-alone projects. South African scientists also seem to access the big funding, as they are more likely to have projects with funding in excess of US$250 000.

Figure 4 Project funding – South Africa and the rest of SADC



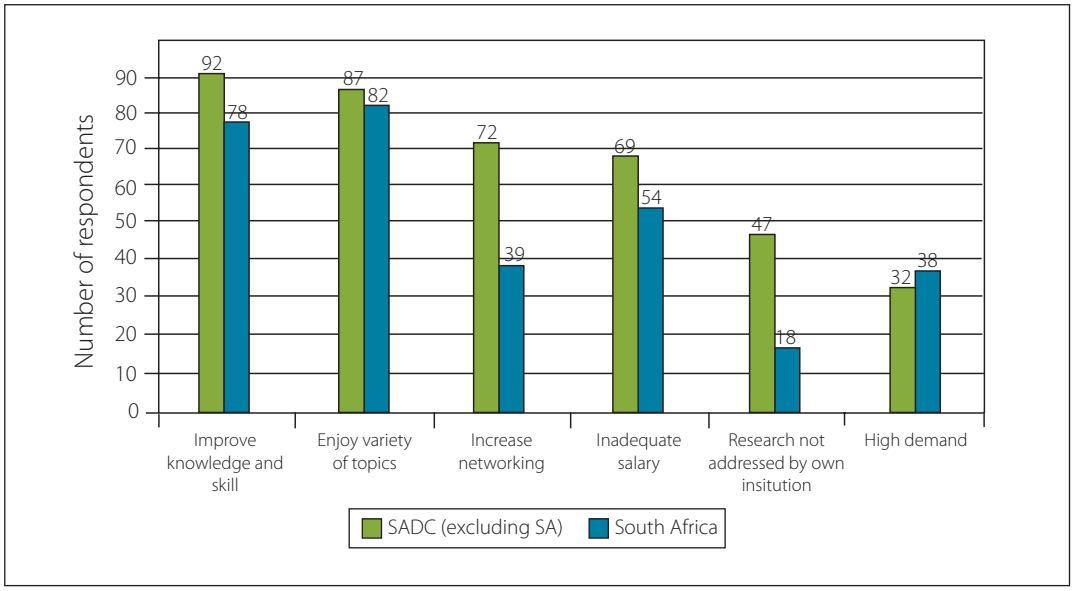
The interviews also paint a picture of huge teaching loads, lack of research interest in many institutions and a general lack of funding for the average scientist.

Human capital for science and technology

The development of human capital for science and technology in the region remains one of the biggest challenges. The fact that nearly a quarter of our respondents from SADC countries other than South Africa indicated that they are considering moving to another country is yet another indication of the pervasiveness of the brain drain in the region. The interviews furthermore attested to the devastating effects of such dispersion on many countries (Zimbabwe is a case in point), where the human capital base has been eroded to the point where effective research and teaching is barely possible.

Our findings also highlighted the mobility of high-level students in the region, where students in many countries do not study in their home country, but prefer (both because of lack of postgraduate teaching programmes and resources) to study elsewhere (and most notably in South Africa). There are, however, also positive signs emerging of a counter to this trend as an increasing number of the top universities in SADC countries (such as the University of Dar es Salaam, the University of Botswana and Agostinho Neto University in Angola) introduce master's and doctoral programmes and set up offices for postgraduate studies to stem the flight of students.

Figure 5 Reasons given for doing consultancy



Consultancy

Consultancy is widely prevalent across the region – whether people see it as a positive form of academic work (to enrich themselves, to increase their networks, to transfer knowledge to industry) or as a necessity born out of poor academic salaries and working conditions. The challenge for universities in the region is to ensure that such activities do not further undermine and weaken the already fragile base of many scientific institutions.

Scientific collaboration

Our study provides strong evidence for collaboration in most fields of science in the region. However, intra-regional collaboration amongst countries in the SADC region is evidently less than extra-regional collaboration. Collaboration is mostly with countries in the northern hemisphere; whether such collaboration is driven by well-established networks based on mutual interest or by the availability of funding from donor agencies in the north (which often make collaboration with scientists in the donor country easier), is not clear. Moreover, scientists and scholars from South Africa are involved in fewer joint activities across the whole spectrum of the research process (from conceptualisation and writing of proposals to execution and publication) than their counterparts in the other SADC countries. We would suggest that this collaboration is a correlation of the fact that scientists in the other SADC countries co-operate more internationally because of their greater reliance on overseas funding.

Table 1 Kinds of research activities that are performed jointly with other scientists/researchers

Research activity	South Africa (%)	Other SADC (%)
Joint writing of funding proposals	38,6	61,4
Joint conceptualisation/planning of research	43,3	56,7
Joint execution of research	39,6	60,4
Joint publication of research (e.g. writing reports, articles)	41,4	58,6

The qualitative comments suggest that collaboration is hampered by lack of funding for travel and the exchange of scholars in the region, as well as by the absence of regional organisations that could play a more facilitative role in bringing scientists in the region together.

Scientific networking: Societies, academies and conferencing

Scientific networking occurs in many forms. Scientific societies and scientific conferences are two of the normal forms of networking. The findings from our study again confirm that scientists in the region – and more so outside South Africa – are constrained by lack of funding in fully utilising the opportunities and value that such forms of networking offer. The fact that a third of respondents from SADC countries other than South Africa (and these are active scientists) are not members of a single scientific society or academy of science, and that 12% of this group indicated that they do not attend any conferences in an average year, is an indication that normal scientific practice is not the norm in many of these countries.

The visibility of science in the region

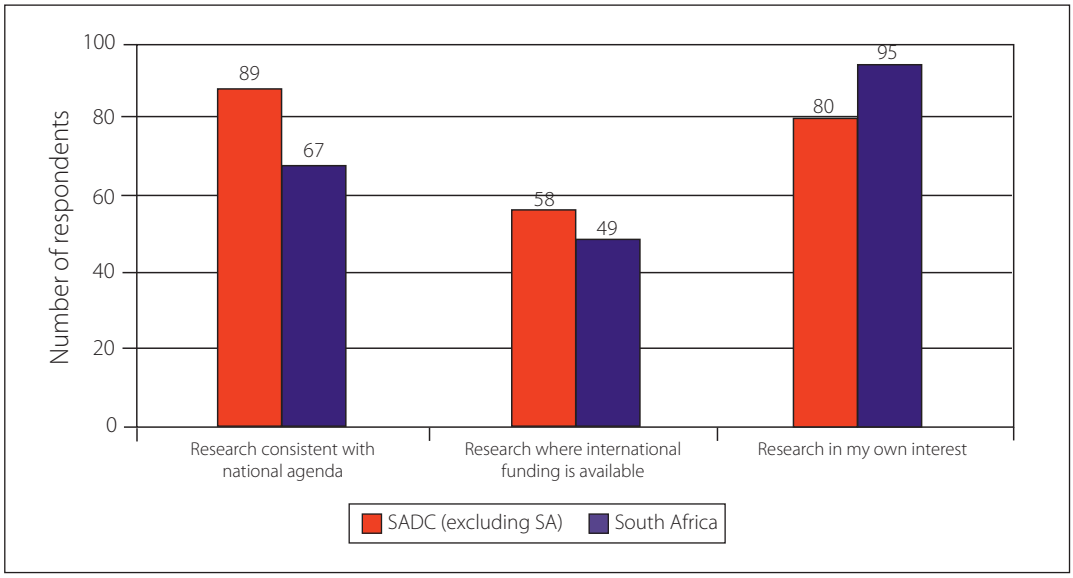
Our study demonstrates the complex patterns of scientific publishing in the region. Although scientists in all countries appreciate that publishing in foreign journals is preferable because of their high visibility and scholarly quality, the lack of opportunity to publish in such journals acts as a constraint. There are, however, many other constraints: lack of funding for proper equipment that impacts on experimental results, lack of scientific writing skills, perceived unfair competition even for local journals, and so on. These constraints force many scholars and scientists to publish in local journals even if they are not peer-reviewed, as the pressure to publish is a pervasive criterion in all performance-appraisal systems. The lack of a culture of publishing in certain highly applied environments (such as engineering) coupled with the need and practice of consultancy and technical service delivery also impact negatively on

scientific publication. Language is also an issue, as was evident from our interviews in francophone countries where the *de facto* dominance of English as the international publishing language is seen as a serious constraint and challenge.

National development goals and scientific research

Research agendas are driven by a complex set of interests as well as material conditions. Under conditions of proper resourcing and access to funds, equipment and other forms of academic capital, scientists would tend to prioritise their own interests. Where access to funding is limited and competition for scarce resources is intense, other interests (available funding and congruence with national goals, which in turn can lead to more funding) may become more prominent. Our findings show that the majority of scientists in the region pursue their own research interests. For South African scientists, alignment with national goals is a secondary interest, followed by access to funding. For scientists in the other SADC countries, alignment with national goals as well as access to funding is a more important consideration. These findings are moderated by field differences. The field visits confirmed the saliency of these issues and, in general, pointed to a need amongst scientists to do work that serves or supports national socio-economic priorities.

Figure 6 Reasons behind research



Recommendations

Reverse the decline in scientific research

The main finding of this study is that there is overwhelming empirical evidence that institutionalised scientific research in the region is on the decline. It is imperative that this trend has to be reversed. Our first (and overarching) recommendation, therefore, is that SARUA considers various practical ways to bring home to key stakeholders the absolute essential role and value of public science (and especially university research) in the region. We recommend that SARUA convenes a small group meeting with key stakeholders in the field to strategise ways in which the case for science could be made more strongly and effectively.

Strengthen intra-regional scientific collaboration

Scientific collaboration in the SADC region is mainly a function of traditional (in some cases colonial) linkages as well as available international funding support. This has led to a situation where south-north collaboration is the norm, rather than collaboration between countries in the region. Our recommendation is that SARUA considers various mechanisms to improve intra-regional scientific collaboration, especially amongst university researchers in the region. In addition to the strengthening of scientific journals and regional networking, the development of a regional knowledge base of scientific projects and scholars in the region could be utilised to support various regional collaborative ventures.

Stimulate increased funding for science from within SADC

The lack of sufficient funding for research is the reason cited most often for research constraints in the region. This is mainly because the majority of governments in the region do not allocate sufficient national funds for research and development, which results in the huge dependence on international funding sources. We recommend that SARUA considers the following three mechanisms to address this problem:

- embark on a deliberate advocacy and lobbying campaign to persuade national governments to make true on their commitments to allocate 1% of GDP to research and development;
- assist universities to gain access to international funding sources through services such as Research Africa; and
- conduct workshops with researchers on developing funding proposals so as to increase their success rate in the application for overseas funding.

Strengthen research management capacity

Field visits confirmed that most universities do not have adequate research management infrastructures and do not have well-developed and well-functioning research directorates in place. We recommend that SARUA considers collaborating with organisations such as the Southern African Research and Information Management Association (SARIMA), the Association for Commonwealth Universities (ACU) and the Society for Research Administrators (SRA) in strengthening the research management capacity of universities and other research organisations in the region.

Take steps to impact on student and staff mobility rates

Although our study did not aim to focus on brain drain in any detail, the findings from our survey show that this remains a major issue. The fact that academic salaries are poor and working conditions are not always conducive to research, forces many academics into consultancy and/or considering leaving their countries. Similarly, the lack of sufficient master's and doctoral programmes at many universities forces postgraduate students to consider studying elsewhere. Although SARUA cannot directly address the extent of the brain drain, it can make a positive impact on student and staff mobility rates by:

- using its own communication media to provide doctoral students in the region with information on available programmes;
- getting involved in regional initiatives that aim to prepare and train postgraduate students better for doctoral studies; and
- conducting workshops for academics in the design and implementation of new doctoral programmes.

Strengthen regional journals

African science in general and science in the SADC region suffers from a lack of international recognition. One of the reasons for this state of affairs relates to the lack of sufficient high-quality scientific journals in the region, as well as the lack of sufficient resources for efficient peer review and editorial practices. We recommend that SARUA considers initiatives that would strengthen regional journals with regard to quality and editorial management. We would also recommend that consideration be given to the establishment of one or two regional journals of high quality that would serve the needs of local researchers.

Produce a more comprehensive account of the state of scientific research in SADC

Various bodies and organisations (international and African) are involved in some way in promoting and supporting research in the SADC region. There are a few organisations that gather systematic information on scientific activities in the region. However, there is no central database or study of all

of these initiatives as they apply to SADC. Our survey has begun to identify the main role players and agencies, but further follow-up work is required. We recommend that SARUA considers commissioning a study that would map existing actors and initiatives (funding, training and information gathering) in SADC that would provide stakeholders with a more comprehensive picture of the state of scientific research in the region. Such a study would be a useful resource to support many of the actions proposed under the recommendations above.

Introduction

The Centre for Research on Science and Technology (CREST) at Stellenbosch University was awarded a contract under commission by the Southern African Regional Universities Association (SARUA) in April 2008 to undertake a study on "The state of public science in the SADC region". The overall goals of the study and research design and methodology of the research are outlined below.

Study goals

The main goals of the study were as follows:

- describe and understand the nature and state of scientific institutions in the region;
- describe in some detail the modes of knowledge production (basic research, contract research, consultancy research and so on) prevalent in the region;
- document the nature and extent of international funding agencies in their support of research in the region;
- analyse and describe the nature and extent of scientific collaboration within the region; and
- describe and understand the main forms of dissemination of scientific information in the region and specifically the role of local and indigenous journals in this regard.

The study would also attempt to assess the overall robustness of public science in SADC countries (with a specific focus on university research) with regard to the following issues:

- A qualitative assessment of the funding base of public science in the region.
  - How broad is the funding base?
  - How dependent are scientists on specific funding sources and specifically international donor and funding agencies?
- The robustness of research institutes in the region: This included a focus on their 'inscription' within the national science system, recognition and reward mechanisms, and the sustainability of institutes within regional and international networks. The specific objective was to establish whether academic and government-based researchers engage in building the institution of science in their universities and centres through long-term research programmes, addressing the challenge of the ageing of academics in many of these systems, as well as the levels of support for graduate students and postdoctoral fellows.
- The visibility of academic science in the region.
  - How do academic scientists disseminate their research findings and results?
  - Where do they publish?
  - What is the state of scientific journals in the respective countries?

- If they publish in international journals, with whom do they co-author?
- Do they have access to and utilise other modes of scientific communication?

- To what extent is science in the region addressing or attempting to address the most important development goals of the respective countries? This component would look more qualitatively at the kinds of topics that are receiving attention, the link between institutional research missions and national and regional goals, as well as the ways in which scientists are attempting to disseminate their research results into application and policy.

Research design and methodology

A mixed-methodological approach was followed, including a web-based survey of top scientists in the region, country visits, and a bibliometric study of scientific output from the region.

Web-based survey: In compiling a list of potential survey participants, a distinction was made between candidates from South Africa versus the other SADC countries. For South Africans the identification process targeted (1) university researchers rated by the National Research Foundation (NRF); (2) holders of NRF Research Chairs at universities; (3) holders of Technology and Human Resources for Industry Programme (THRIP) grants; and (4) directors of university health units funded by the Medical Research Council (MRC).

For the other SADC countries, a diverse approach was followed by (1) identifying the most productive SADC authors in the ISI *Web of Science* database; (2) identifying deans of faculties as well as scientists with at least a doctoral qualification from websites of public universities; and (3) extracting the names of SADC researchers from both online reports published by funding agencies (SIDA, IDRC, World Bank) and published conference papers on the internet.

Each scientist identified received an email, which formally introduced the survey and provided a hyperlink to access and complete the questionnaire online. During the country visits (see below) additional questionnaires (paper copies) were also distributed. A total of 634 completed questionnaires were received, of which the majority (244) were from South African researchers.

Interviews conducted during country visits: The country visits were largely devoted to conducting interviews with key informants in the science system (university research directors, deans of research, vice-chancellors responsible for research, directors of research centers/institutes, editors of journals, and government officials involved with research and science policy at a national level). During the country visits the fieldworkers also spent a portion of their time obtaining completed questionnaires from active researchers, especially in cases where the monitoring of the web-based survey responses revealed low participation. Field visits were conducted in all but three countries – South Africa, Angola and Tanzania.

Bibliometric analysis: The bibliometric analysis is based on data in *Africa Knowledgebase,* a database being developed by CREST. Data in this database are extracted from various sources – including

the Thomson Scientific *Web of Science* (ISI), Medline, African Journals Online (AJOL) – and contain information on articles produced by SADC researchers as from 1990. An integrated database structure was developed and significant value was added to the data in preparation for the regional and national bibliometric profiles.

Quality of survey data

The fact that some survey questionnaires were completed during field visits could introduce a bias in the data, especially in cases where the distribution of questionnaires was facilitated by a university representative and not by the researcher.

Another possible source of bias that we considered is the age of the respondent, as younger researchers could have been persuaded more easily by the university representatives to complete the paper copies of the questionnaire, especially in cases where the request was seen as an official university request. The electronic version of the questionnaire, on the other hand, targeted – as far as possible – only active and established researchers. Thus, the potential influence of age in the survey needed to be investigated. Table 2 shows the age distribution of the respondents per country. As can be seen, some countries have relatively high shares of young respondents, and in most cases these shares seem to correspond with a larger completion of paper copies of the questionnaire. Also, in any comparison of South African responses to those of the other SADC countries, the differences in age of respondents would need to be kept in mind (1% of South African respondents are 35 years or younger compared with 13% in the rest of SADC).

Table 2 Age of survey respondents, by country

Country	Age of survey respondents (%)					Number of survey respondents	% of respondents completing paper copies
	≤35 years	36-45 years	46-55 years	56+ years	No age specified		
Zimbabwe	35	42	6	13	4	52	63
Swaziland	25	38	13	19	6	16	44
Mauritius	23	38	31	8	0	13	31
Namibia	22	19	25	25	8	36	0
Malawi	18	43	20	12	6	49	47
Mozambique	10	25	45	10	10	20	65
Zambia	8	21	38	25	8	24	8
DRC	7	18	21	50	4	28	46
Tanzania	4	38	42	9	7	55	0
Madagascar	3	22	54	8	14	37	16
Botswana	2	30	38	20	10	50	2
South Africa	1	20	41	35	2	244	0
Lesotho	0	75	13	0	13	8	0
Angola	0	0	50	0	50	2	0
Total	**9**	**28**	**34**	**24**	**6**	**634**	**16**
Total (SA excluded)	**13**	**32**	**30**	**17**	**8**	**390**	-

It must be pointed out that country responses cover the university sector in each country to varying degrees. Table 3 shows, for example, that in Madagascar and Mauritius, the university sector is under-represented in the survey. Also, in a comparison between South Africa and the rest of SADC, the university sector is not equally represented: 98% university sector representation for South Africa versus 75% for the rest of SADC.

Table 3 Respondents employed at universities, by country

Country	Respondent employed at university (%)		Number of survey respondents
	Yes	No	
Madagascar	30	70	37
Mauritius	38	62	13
Tanzania	67	33	55
Zambia	67	33	24
DRC	75	25	28
Lesotho	75	25	8
Namibia	83	17	36
Malawi	84	16	49
Zimbabwe	85	15	52
Botswana	86	14	50
South Africa	98	2	244
Angola	100	0	2
Mozambique	100	0	20
Swaziland	100	0	16
Total	**84**	**16**	**634**
Total (SA excluded)	**75**	**25**	**390**

For the remainder, we will comment on possible bias at the level of specific questions that may be introduced, for example, by large numbers of non-responses.

Outline of the chapter

The main findings of the study are presented in Part 1 of this chapter. Our discussion is organised in the following sections:

1.1 General background on science and technology in the SADC region

1.2 The funding base of public science in the region

1.3 The robustness of the institutions of science

1.4 The visibility of academic science in the SADC region

1.5 National development goals and scientific research

The recommendations are presented in Part 2 as follows:

2.1 The case for science

2.2 Intra-regional research collaboration

2.3 Funding of research

2.4 Institutional research management

2.5 Human capital development

2.6 Scientific journals

2.7 Further research

Detailed country reports can be accessed on the SARUA website at www.sarua.org. These country reports focus on three areas:

- the governance of science in the country;
- science and technology priorities; and
- research and development performing institutions.

Part 1: Background and high-level findings

1.1 General background on science and technology in the SADC region

1.1.1 General trends in higher education and science and technology in Africa

The decline of university research in Africa

Various international forces associated with globalisation and internationalisation of trade in the 1980s and 1990s have had a devastating effect on the economies of many African countries: The decline in export volumes as well as the relative decline in the price of primary products in world trade in the 1980s and 1990s, combined with the mishandling of exchange rates and of external reserves, as well as the huge external debt overhang, created major resource gaps for the countries of Africa. This put serious pressure on their import capacity and the availability of resources for essential economic and social investment. The result was an increased dependence of the typical Sub-Saharan Africa country on aid from the developed countries.

At the same time, international agencies, most notably the World Bank, decided to privilege expenditure on basic education at the expense of support for higher education. This policy position was based on two premises: The first was the belief that the returns on investments in primary and secondary education are higher than those in higher education. The second reason related to concerns with equity and access to basic education, which would naturally lead to an emphasis on primary education. The result was quite predictable with many universities thrown into financial crisis, laboratories and libraries not receiving any funding for maintenance, overcrowded lecture rooms and high levels of flight of the top academics from these institutions.

Research and scholarship would be the main losers during these years. Africa's share of world science, as measured in papers published in the citation indexes of the Institute for Scientific Information has been declining steadily over the past decade. Bibliometric studies done at the University of Leiden's Centre for Science and Technology Studies show that Sub-Saharan Africa's share of world scientific papers declined from 1% in 1987 to 0,7% in 1996. These diminishing shares of African science overall do not reflect a decrease in absolute sense, but rather an increase in publication output less than the worldwide growth rate. Africa has lost 11% of its share in global science since its peak in 1987; Sub-Saharan science has lost almost a third (31%). The countries in Northern Africa, Egypt and the Maghreb countries (Algeria, Mauritania, Libya, Morocco and Tunisia) accounted for the modest growth of the African share of the worldwide output during the years 1998 to 2002.

Bibliometric analysis of research output is only one measure of the relative decline of research and scholarship at many African universities. Numerous studies have been conducted over the past 10 to 15 years that demonstrate quite convincingly that research at former well-resourced and supported

institutions such as Makerere University in Uganda, Ibadan in Nigeria and the University of Dar es Salaam in Tanzania have deteriorated. Research infrastructure and the general state of laboratories at many institutions have suffered from a lack of maintenance and timely replacement of old equipment. In addition, the generally poor quality of library resources has not improved significantly, with many university libraries not even using automated management systems. The demand for sufficient research funding for ongoing research and scholarship continues, as does the need for proper research management and support at most of these institutions.

The cumulative effect of the funding policies of the last two decades of the previous millennium, the huge growth in student enrolment in higher education institutions, combined with continuing political instability in many African countries, have created a state of affairs which is best described as the 'de-institutionalisation' of science.

The de-institutionalisation of research institutions in Africa

Science systems in developed and highly industrialised countries have a certain number of clear and evident features. Such systems are dense (well-populated) with highly articulated scientific institutions. 'Scientific institution' is defined as any formal organisation or entity that is dedicated to the pursuit of scientific knowledge production, dissemination and utilisation. This definition includes bodies that perform research and development such as university centres, laboratories and institutes, as well as research and development-performing entities outside the higher education sector. It also includes scientific publishing houses, journals, conferences, workshops and seminars which are 'organisations' for the dissemination of scientific knowledge. Bodies that promote the utilisation and commercialisation of scientific knowledge (e.g. technology incubators, technology transfer offices, patenting offices) are also included.

In a modern science system there are typically a multitude of these scientific institutions that perform clearly articulated functions and roles, and together constitute what could be termed the 'national mode of scientific production' (according to Roland Waast and Jacques Gaillard of the Institute for Development Research, Paris). The 'national mode' means that science is conducted for the public good and that the direction of science is shaped and steered by a nation's most pressing socio-economic needs. It also implies that the state assumes a major responsibility for financing research and development activities.

Unfortunately, few or none of the features of a modern science system apply to many countries in Sub-Saharan Africa. Many of the scientific institutions in these countries are fragile and susceptible to the vagaries of political and military events, and are severely under-resourced and suffer because of a lack of clarity and articulation of science governance issues (demonstrated by constant shifts in ministerial responsibility for science). In fact, one could even refer to some of these science systems and the associated institutions as operating in a 'subsistence mode' where they struggle to reproduce themselves. A subsistence mode refers to a system that produces knowledge for its own use only and does not export knowledge. In fact it does not make a significant contribution to global knowledge production. It is even debatable whether one can talk of a science 'system' in many of these countries,

as they do not exhibit typical 'systemic' characteristics. Institutions are not typically aligned through input, process and output flows, and there is no typical systemic behaviour in response to external changes and demands. Rather, the image of an 'assemblage' of fragile, somewhat disconnected and constantly under-resourced institutions is perhaps a more apt metaphor to describe the science arrangements in some of the SADC countries.

One should be cautious of over-generalisation and over-simplification, as there are also some instances of small, but robust institutions (some universities and research centres) that have survived the ruptures of political changes and economic fluctuations where pockets of significant science are still found. In these isolated cases (for example in Burkina Faso, Botswana, and more recently Rwanda), science is publicly supported by the government, there is reasonable political stability and good governance of the science system. In many of these cases, there are also well-established links and collaborative networks with strong research establishments elsewhere in the world.

What are the factors that have in the past and still continue to shape and affect the (de-)institutionalisation of science in these countries? Four major historical influences on the nature of scientific institutions in Sub-Saharan Africa are subsequently discussed: (1) The continuing legacy of colonial science in many countries, (2) the destabilising influence of political events and civil wars, (3) the role of international agencies in shaping African sciences, and (4) the gradual erosion of human capital through the brain drain.

Colonial science legacy

Many of the research institutes established during colonial rule in Africa still exist in African countries. It is now well documented that the role of different colonial powers in the formation of scientific institutions varied greatly across continents. This is both a function of the nature of the institutions that were established as well as the 'model' of 'colonial' science pursued.

The **British model of colonial science** privileged the establishment of botanical gardens in many of the colonies as sites to conduct plant and other related research. This model was shaped by the influence exerted by the Royal Botanical Garden in Kew in London. At Lagos (Nigeria) a botanical garden was established in 1887; the Royal Niger Company also founded a garden for the distribution of plants at Asaba in 1888 and established four other agricultural stations in various locations between 1889 and 1890 for experiments with coffee, cocoa and other crops. Ghana (then the Gold Coast) also had a government botanical garden in 1890 at Aburi. Interestingly enough, over the years, the British attempted to give more responsibility to the colonies in steering their own research agendas. To accomplish this regional approach to colonial science and technology, research councils were created in British Africa (following the British model of a Council for Scientific and Industrial Research), which formulated regional research policies and priorities and then made recommendations on the allocation of research funds, as well as on projects assigned to institutes.

The **French approach** to colonial science was very different. Research done in the colonies had to be done through the mediation of institutions based in Paris such as the Musée National d'Histoire

Naturelle, which had a section devoted to tropical agriculture, and the École Supérieur d'Application d'Agriculture Tropicale, which provided the training for colonial agricultural officers. It was only the advent of the Pasteur Institute which pioneered the organisation of research activities in the region when it established local branches. The major translocation of French science in francophone Africa occurred from the late 19th century onwards until the 1950s with the establishment of six local Pasteur institutes in Saigon (1890), Algiers (1894), Nhatrang (1895), Madagascar (1902), Tunis (1903), Brazzaville (1910) and Dakar (1913). Unlike the British case, only modest effort was accorded by French colonial or metropolitan authorities to the development of research activities in African colonies. Hence, the science and technology activities of each institute or territory were explicitly and implicitly assimilated and undertaken by research institutions in metropolitan France that had African branches. Moreover, the regional centres so established were controlled by the French in terms of central management and staffing, as these centres were dominated by expatriates and no concrete efforts were made to develop the local capacity for independent research in the colonies.

It is perhaps fair to say – and somewhat ironically so – that the legacy of the French model has been more permanent and eventually more beneficial to the science system in those countries where it became embedded. Precisely because of the strong link to the centre in France (which is still today maintained in many cases), these institutions (such as the Pasteur institutes) perform a major role within the local science systems and are examples of pockets of research excellence in the midst of a generally fragile science landscape.

However, the fact of the matter is that this situation does not of course build local scientific institutions. In fact, too great a reliance on such foreign institutes may even be used as an excuse not to develop one's own institutions.

Political instability and civil wars

The destabilising influence of many regional and national political events have led to the closing of scientific institutions (universities) in many countries and effectively set science back many decades. Events such as the civil wars in Mozambique and Angola, and more recently the repressive regime in Zimbabwe, are examples. These events have had different negative impacts on institution-building in these countries. In many cases it led to the suspension of overseas research funding, the closing of institutions because of lack of government funding, and perhaps most notably the huge flight of top academics and scientists to other parts of the world.

International research and funding agencies

The role of international agencies in shaping and steering science on the African continent cannot be underestimated. In this regard, we include the role of international development and aid organisations such as the Swedish International Development Agency (SIDA), the Carnegie Corporation of New York, the Ford Foundation, the Rockefeller Foundation, the International Development Research Centre (Canada), and many others, as well as the presence of international research bodies such as the Consultative Group on International Agricultural Research (CGIAR) institutes, World Health Organisation research institutes, and so on. On the positive side, these institutions and agencies have,

to a large extent, managed to sustain minimal scientific production in many countries where the formal science and technology structures (universities and government research laboratories) have failed or declined. On the negative side, it could be argued that some organisations and agencies have been more interested in pursuing their own (international) research agendas and have not done enough to ensure the long-term sustainability of a local science base in Africa. In fact, some commentators may argue that international funding for doctoral students through sandwich programmes (which entail spending time at a northern university) has in fact been one of the contributing factors to the brain drain. Students on doctoral scholarships from developing countries who spend time at well-resourced northern universities are subsequently better qualified and certainly more networked, and hence able to leave their country of origin and seek employment elsewhere.

The gradual erosion of human capital through the brain drain

General concerns in the human resource area include poor pay and working conditions which have resulted in extensive and persistent brain drain. Studies sponsored by the Research and Development Forum for Science-Led Development in Africa (RANDFORUM) reveal that up to 30% of African scientists – i.e. excluding other professionals – are lost due to the brain drain. According to the Economic Commission for Africa and the International Organisation for Migration (IOM), an estimated 27 000 skilled Africans left the continent for industrialised countries between 1960 and 1975. Since 1990, at least 20 000 qualified people have left Africa every year. Accordingly, Alex Nunn of Leeds Metropolitan University notes that this situation leaves Africa with 20 000 fewer people who can deliver public services and articulate calls for greater democracy and development.

This concludes our introduction to the general state of science and scientific institutions for Sub-Saharan Africa. It is one of the key premises of this study that many of the issues discussed above are very relevant to the state of public science in the SADC region. Although the aim of the study is *not* to test (in any rigorous statistical sense) the plausibility of the de-institutionalisation thesis as outlined above, we do believe that there is overwhelming evidence from our research that many of the typical characteristics of de-institutionalisation are present in many SADC countries.

In the remainder of this section, we present more background information on the state of public science and higher education in the SADC region.

1.1.2 Statistical tables with key science and technology and higher education indicators

Research and development indicators

We present in Table 4 the most reliable and up to date statistics and data on key research and development indicators for the 14 SADC countries. Many studies have commented on the difficulties involved in gathering reliable data on research and development indicators in developing nations. Lack of standardised and frequent surveys, inadequate attention by many governments and statistical agencies to undertake data collection, and the differences in meaning of seemingly similar indicators are just some of the methodological challenges one faces in this regard. We elaborate on these indicators.

- **Research and development intensity** is measured as the ratio of Gross Expenditure on Research and Development (GERD) to Gross Domestic Product (GDP). Most developing countries view 1% as the gold standard. The average of the EU member states in 2005 was around 1,9% and the countries with the highest research and development intensity in the world (Finland, Sweden and Singapore) exceed 2%. Of the SADC countries, South Africa is the only country that comes close to the ideal of 1% (the 2005/06 Research and Development Survey indicates that it stands at 0,9%). Mozambique has, over the past decade, made special efforts to invest more in research and development, with the result that its reported spend of 0,6% of GDP in 2002 is laudable. Botswana, the DRC and Tanzania spend around 0,3 to 0,4% of GDP on research and development, while the remaining countries spend less than 0,2%. We have no information for Angola, Malawi, Namibia and Swaziland. South Africa is the only country in the SADC region that regularly collects and makes available basic research and development statistics conforming to OECD Frascati standards. Zambia, Tanzania and Mozambique have in recent times undertaken some studies to establish GERD, but this remains a major challenge for science and technology authorities in the region. The standard research and development surveys provide a wealth of information on research and development income and expenditure trends, the contributions to research and development by various sectors (higher education, government and private sector), as well as crucial human resources information. Despite recent efforts by the UNESCO Institute for Statistics to establish an indigenous capacity in basic scientometrics in Sub-Saharan Africa, very little has yet been achieved. This is an area that SARUA might wish to address in collaboration with such agencies.
- **Research and development workforce.** Another construct that is particularly difficult to measure is the size of the research workforce in a country. The OECD Manual stipulates that all full-time equivalent researchers in public and private sector research establishments be counted. Given the paucity of reliable research and development data for the SADC countries, we had to compile and calculate our own figures from various sources. Table 4, therefore, includes our best estimates for permanent academic staff in each country (we have taken 20% of these headcount figures as equivalent to a full-time equivalent researcher) and the headcounts of researchers in public sector establishments (which is taken as being equal to full-time equivalent research in this sector). The total number of full-time equivalent researchers for each country has thus been calculated. And finally, using a standard normalisation approach, this number was divided by every million of the population to arrive at a comparable figure across the countries. The results show huge variation with the majority of countries in the region, recording lower than 50 full-time equivalent researchers per million of the population. The results for the very small countries should be interpreted with caution (e.g. Swaziland and Mauritius) as the relatively high statistics do not necessarily mean that there is high science, engineering and technology human capital 'density' in the system overall. In these cases, the dominance of one university in an otherwise weakly populated science system tends to deliver misleading statistics. The main value of this indicator in this context is that it shows (1) the relatively well-resourced South African system and (2) the fact that most other countries in the region have a weak human resource base in science and technology. (Note: Our emphasis in this table is on researchers – those scientists and scholars who are directly involved in the production of (new) knowledge. In terms of the OECD Frascati Manual, our concern, therefore, is with researchers and not research and development workers. The latter category includes support and technical staff.)

A note on international comparative figures: In Table 4 below, we have only included full-time equivalent researchers in higher education institutions (excluding 20% of doctoral enrolments) and public sector institutions. The OECD requires that a country report on all full-time equivalent researchers across all sectors. For South Africa, the total number of full-time equivalent researchers across all sectors in 2004/05 came to 17 915 (which includes more than 5 300 full-time equivalent researchers in private sector firms and a proportion of time spent by postdoctoral fellows and postgraduate students). If these figures were to be taken into account, it would translate to approximately 380 full-time equivalent researchers per million of the SA population.

Table 4 Research and development indicators (SADC countries)

Country	GERD/ % GDP[1]	Headcount of academic staff	Full-time equivalent academic staff	Headcount of researchers in public sector [2]	Total number of full-time equivalent researchers	Number of full-time equivalent researchers per million of population
Angola	Not available	1 329 (2006)	147	Est. 20 (2002) (Khalil Timamy, 2002)	167*	8*
Botswana	0,4 (2005)	827 (2006)	165	Est. 100	265	139
DRC	0,4 (2004)	9 092	1 818	664 (2004)	2 500	38
Lesotho	0,1 (2004)	370 (2007)	45*	24 (Khalil Timamy, 2002)	69*	33*
Madagascar[3]	0,1 (2000)	900	180	260	440	23
Malawi	Not available	747 (2007)	149	Est. 240 (1999)	389	29
Mauritius	0,3 (1997)	Est. 500	100	Est. 80	180	150
Mozambique	0,6 (2005)	2 109 (2004)	421	468/FTE 374 (2002)	795	38
Namibia	Not available	86 (2006)	17	Est. 67 (1998)	84	42
South Africa	0,9 (2004/5)	18 270	3 506 (2004/5)	2 823 (2005)	6 329	135
Swaziland	Not available	328	60	Not available	60	55

1 UNESCO Science in Africa Report and CREST Country Reports.

2 It is assumed that researchers employed in government, parastatal bodies and other dedicated research institutions devote 100% of their time to research. The number of researchers in the public sector (excluding higher education) is therefore added to the full-time equivalent researchers in the higher education sector to produce the total estimate of full-time equivalent researchers in the country. Given the paucity of information on researchers in private sector firms, we have not included any estimate of these figures in the table.

3 Source: IRD Survey 1999.

Country	GERD/ % GDP[1]	Headcount of academic staff	Full-time equivalent academic staff	Headcount of researchers in public sector [2]	Total number of full-time equivalent researchers	Number of full-time equivalent researchers per million of popula-tion
Tanzania	0,4	2 735 (2005)	547	Est. 500[4]	1 047	27
Zambia	0,1 (2004)	815 (2004)	163	Est. 100	263	23
Zimbabwe	-	1 100	220	300	520	42

* The research team could not verify the accuracy of these figures

Higher education indicators

A primary interest in this study is the role and status of higher education institutions in the science systems of SADC countries. This is not surprising as in many of these countries, research and development efforts are in fact concentrated in one or a few universities – especially in the smaller countries. In addition, understanding more about the general status of higher education institutions and their capacity to produce highly skilled graduates for the economy and society is equally important. Table 5 captures different dimensions of the higher education landscape in the SADC countries.

- **Higher education enrolment figures:** Statistics on absolute enrolments are in themselves not that interesting or informative. However, it is worth pointing out that enrolments in South Africa (717 000) constitute nearly 75% of total higher education enrolments in the SADC region. Normalising these enrolment figures by 100 000 of the population provides us with a better measure for comparison. This normalisation shows that South Africa has the highest rate (1,64 enrolments per 100 000 of the population) followed by Mauritius (1,48). All the other countries are below 1 per 100 000 of the population with Angola, Mozambique and Tanzania recording the lowest enrolment rates.
- **Teaching staff:** The inclusion of the numbers of teaching staff in Table 5 has been done mainly to assist in the calculation of the size of the research work force in the country. One should, theoretically, also be able to calculate the student/teacher ratio from these figures. However, we are not convinced that the numbers in all cases reflect (permanent) academic staff only.

4 Based on figures in the IRD Report (2000) on Tanzania by Jacques Gaillard. This report provides good estimates of all degree holders in Agricultural Research Institutions.

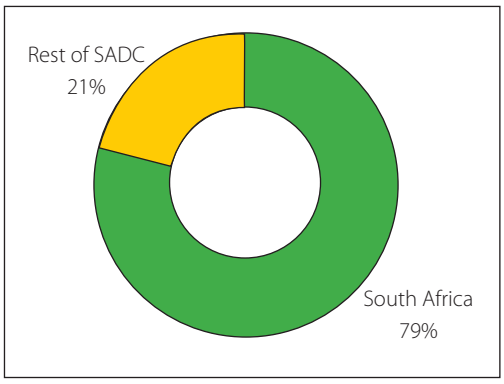
Table 5 Higher education statistics: enrolments and staff (2004)

Country	Enrolment (2004)			Teaching staff (2004)	
	Total higher education enrolment (2004)	% Female	Enrolments/ per capita population (%)	Total	% Female
Angola	12 982	40	0,10	1 285	20
Botswana	15 415	46	0,70	791	30
DRC	Not available	Not available	Not available	Not available	Not available
Lesotho	6 108	61	0,27	545	50
Madagascar	42 143	47	0,20	1 560	27
Malawi	5 089	35	0,04	418	32
Mauritius	17 781	58	1,48	Est. 500	Not available
Mozambique	22 256	32	0,11	2 516	22
Namibia	11 788	53	0,59	898	27
South Africa	717 793	54	1,64	43 023	50
Swaziland	6 594	52	0,60	328	24
Tanzania	42 948	29	0,11	2 516	16
Zambia	Not available	Not available	Not available	Not available	Not available
Zimbabwe	55 689	39	0,45	1 100	Not available
Total	**954 392**	**38**	**0,38**		

Sources: Global Education Digest 2006, UNESCO Institute for Statistics (www.uis.unesco.org/TEMPLATE/pdf/ged/2006/GED2006.pdf)
Additional information obtained from various CREST country reports and fieldwork

1.1.3 Bibliometric analysis of SADC scientific output

Figure 7 ISI-output (1990 to 2007)



Our bibliometric analysis was done on papers published in the 7 500+ journals of ISI Web of Science as well as journals published by Medline. Total output for the 14 SADC countries for the period 1990 to 2007 summed to 95 711 papers. The dominance of South Africa in the region is reflected in the fact that it has produced nearly 80% of this output (Figure 7). Table 6 lists the detailed output by country in alphabetical order.

The table shows that two other countries – Tanzania and Zimbabwe – produced the next biggest share of SADC's output over this period. At the other extreme, countries such as Angola, Lesotho, Mauritius, Mozambique, Namibia and Swaziland have produced very small numbers of papers, none of them contributing more than 1% to the overall scientific production.

Table 6 SADC ISI-output by country (1990 to 2007)

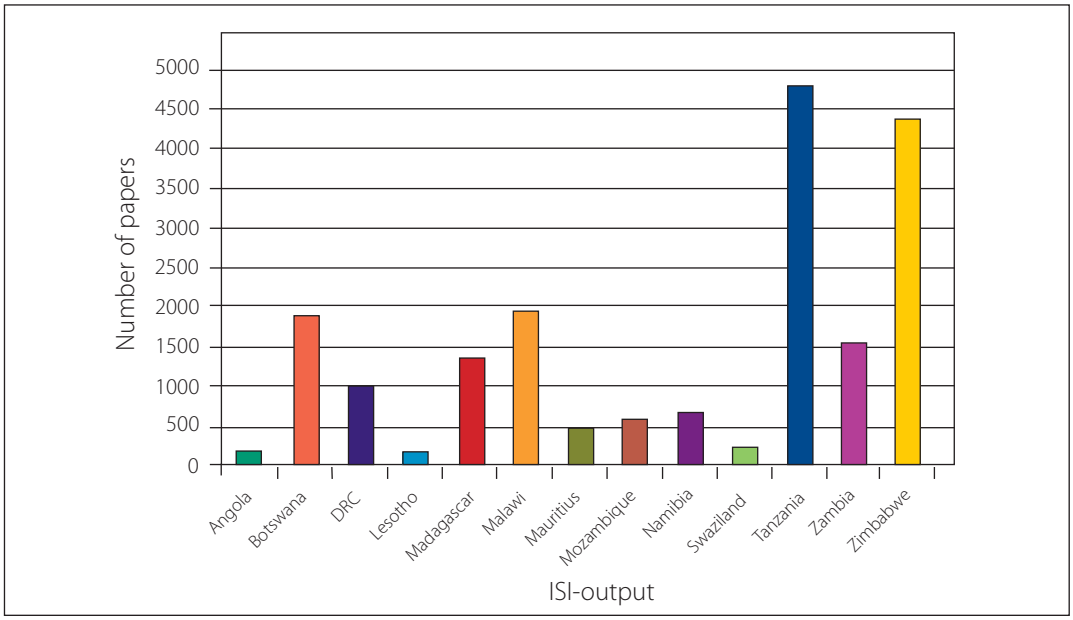
Country	ISI papers	Column %
Angola	182	0,2
Botswana	1 876	2,0
DRC	1 118	1,2
Lesotho	192	0,2
Madagascar	1 315	1,4
Malawi	2 001	2,1
Mauritius	621	0,7
Mozambique	713	0,7
Namibia	895	0,9
South Africa	75 544	78,9
Swaziland	249	0,3
Tanzania	4 815	5,0
Zambia	1 724	1,8
Zimbabwe	4 466	4,7
Total	**95 711**	**100,0**

Note: Percentages have been rounded off and may not total 100 exactly

In order to get a better impression of the distribution of the individual SADC countries, we have filtered South Africa out in Figure 8 below. This figure shows that one could distinguish between three clusters of SADC countries outside South Africa in terms of scientific output (share of total output in brackets):

- high output: Tanzania (24%) and Zimbabwe (22%);
- medium output (>1 000 papers): Malawi (10%), Botswana (9%), Zambia (8%), Madagascar (7%) and the DRC (6%); and
- low output (<1 000 papers): Angola (0,9%), Lesotho (1%), Mauritius (3%), Mozambique (3,5%), Namibia (4%) and Swaziland (1%).

Figure 8 ISI-output by country (excluding South Africa) (1990 to 2007)



Note: The language factor should be taken into account as it is not impossible that the article count of the lusophone (Angola and Mozambique) and francophone countries (DRC, Madagascar and Mauritius) in the region may be underestimated due to the predominance of English-language journals in the ISI Web of Science

Trends in ISI-output

The statistics provided in Table 6 refer to the total output over the period 1990 to 2007. Some interesting trends are evident when we disaggregate the dataset by three equal periods of six years: 1990 to 1995, 1996 to 2001 and 2002 to 2007. We first present a detailed breakdown for the individual countries for these three time windows (Table 7), followed by the share of South Africa and the other SADC countries for this period (Figure 9).

Table 7 SADC ISI-output by country by six-year window (1990 to 2007)

Country	1990-1995	Column %	1996-2001	Column %	2002-2007	Column %
Angola	44	0,2	57	0,2	81	0,2
Botswana	280	0,1	648	2,2	948	2,5
DRC	264	1,0	173	0,6	242	0,6
Lesotho	79	0,3	59	0,2	68	0,2
Madagascar	235	0,9	405	1,4	675	1,8
Malawi	424	1,6	655	2,2	922	2,4
Mauritius	96	0,4	212	0,7	313	0,8
Mozambique	134	0,5	213	0,7	366	1,0
Namibia	197	0,7	275	0,9	423	1,1
South Africa	22 515	82,1	23 804	79,1	29 225	77,4
Swaziland	71	0,3	85	0,3	93	0,3
Tanzania	1 132	4,1	1435	4,8	2 248	6,0
Zambia	510	1,9	518	1,7	696	1,8
Zimbabwe	1 458	5,3	1 548	5,2	1 460	3,9
Total	**27 439**		**30 087**		**37 760**	

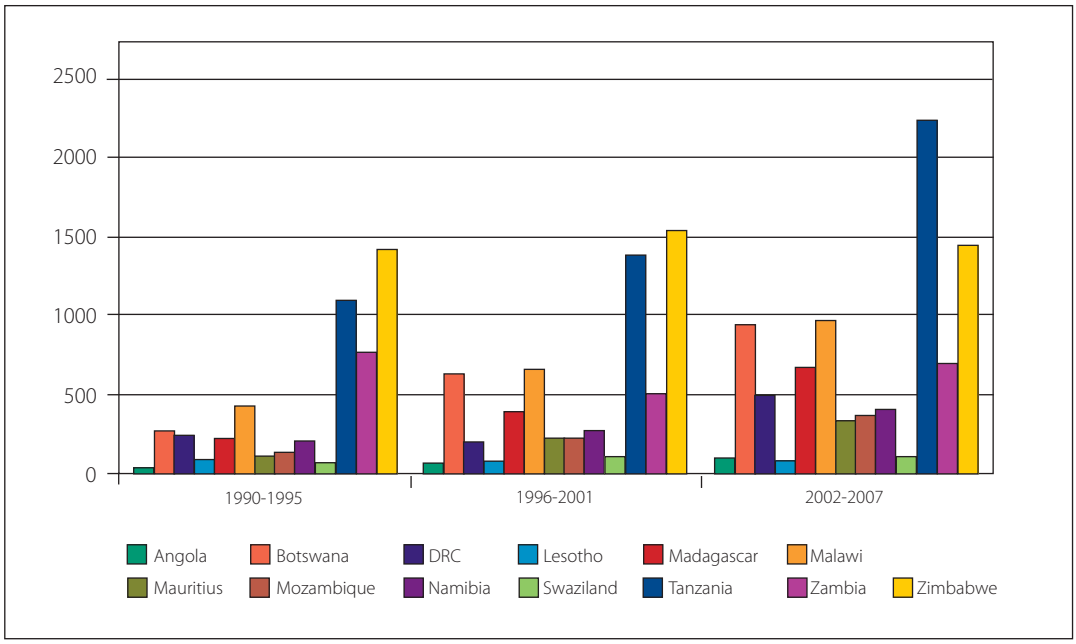
Note: Percentages have been rounded off and may not total 100 exactly

The presentation of the statistics over time allows us to see which countries have increased (more than doubled their output) their share of SADC's article output, which countries have done worse (more than halved their output), and which countries have remained pretty much the same:

- countries doing better: Botswana, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Tanzania; and
- countries doing the same or slightly worse: Angola, the DRC, Lesotho, South Africa, Swaziland and Zimbabwe.

The good performance of countries such as Botswana, Malawi and Tanzania over time is clearly illustrated in Figure 9 which excludes the South Africa output data. Conversely, it is also clear that Zimbabwe's output is on a downward trend: having been the second most productive SADC country behind South Africa in the early nineties, it has since been surpassed by Tanzania. Botswana's good performance – mainly through the University of Botswana – is also worth highlighting as it has more than tripled its output over this 18-year period.

Figure 9 SADC ISI-output by six-year window (1990 to 2007) (excluding South Africa)



The comparative rankings as well as gains of the SADC countries for the first and last periods are presented in Table 8 below. In order to take into account the differences in country size, we have normalised the output data by dividing the ISI-output for 2007 for country population (Table 9). This shows that Botswana is now the second most productive country in the region, followed by Mauritius and Namibia.

Table 8 Rankings of SADC countries by ISI-output (1990 to 1995 vs 2002 to 2007)

Country	1990-1995	Rank	2002-2007	Rank	Gain
South Africa	22 515	1	29 225	1	■
Zimbabwe	1 458	2	1 460	3	▼
Tanzania	1 132	3	2 248	2	▲
Zambia	510	4	696	6	▼
Malawi	424	5	922	5	■
Botswana	280	6	948	4	▲
DRC	264	7	242	11	▼
Madagascar	235	8	675	7	▲
Namibia	197	9	423	8	▲
Mozambique	134	10	366	9	▲
Mauritius	96	11	313	10	▲
Lesotho	79	12	68	14	▼
Swaziland	71	13	93	12	▲
Angola	44	14	81	13	▲
Total	**27 439**		**37 760**		

■ No change ▲ Increased output ▼ Reduced output

Table 9 Ranking of SADC countries in terms of ISI-papers per million of the population (2007)

Country	Total population millions 2007 estimate[5]	ISI papers (2007)	Papers/million of population
South Africa	47,0	5 606	119,3
Botswana	1,8	172	95,5
Mauritius	1,2	47	39,1
Namibia	2,0	70	35,0
Zimbabwe	12,3	251	20,4
Swaziland	1,1	18	16,4
Malawi	13,6	209	15,4
Zambia	11,5	155	13,5
Tanzania	39,3	492	12,5
Madagascar	19,4	150	7,7
Lesotho	2,1	13	6,2

5 CIA World factbook available online: https://www.cia.gov/library/publications/the-world-factbook/.

Country	Total population millions 2007 estimate[5]	ISI papers (2007)	Papers/million of population
Mozambique	20,9	91	4,4
Angola	12,3	19	1,5
DRC	65,0	51	0,8
Total	**249,5**	**7 344**	**29,4**

Table 10 lists the most dominant scientific fields (in descending order) in which scientists publish. Again, we compare South Africa (fields listed with more than 500 papers) with the rest of SADC (fields listed with more than 100 papers).

South Africa's output is highly concentrated in those fields that reflect its biodiversity (plant sciences, ecology, zoology, environmental sciences and marine biology) as well as its traditional strength in the health sciences. For the other SADC countries, the dominance of health sciences related topics (public health, tropical medicine, infectious diseases and veterinary sciences) is an indication of the strategic importance of research in these areas[6]. Conversely, it is noticeable how little research is published from the region in high technology fields – materials science, physics, nanosciences and ICT.

Table 10 Scientific output by field (in descending order): A comparison of South Africa and the other SADC countries

South Africa	Total papers (1990-2007)	Other SADC countries	Total papers (1990-2007)
Plant sciences	3 760	Public, environmental and occupational health	2 286
Ecology	2 830	Tropical medicine	1 817
Medicine, general and internal	2 756	Infectious diseases	1 473
Medicine, research and experimental	2 482	Medicine, general and internal	1 212
Zoology	2 259	Veterinary sciences	1 003
Multidisciplinary sciences	1 997	Immunology	975
Environmental sciences (SCI)	1 914	Ecology	954
Surgery	1 841	Environmental sciences	794
Veterinary sciences	1 835	Plant sciences	755
Marine and freshwater biology	1 801	Geosciences, multidisciplinary	686
Biochemistry and molecular biology	1 756	Parasitology	650
Geosciences, multidisciplinary	1 647	Agronomy	599
Water resources	1 585	Virology	544
Astronomy and astrophysics	1 546	Zoology	481
Pharmacology and pharmacy	1 534	Water resources	467
Microbiology	1 287	Pharmacology and pharmacy	411
Infectious diseases	1 281	Geochemistry and geophysics	408
Entomology	1 241	Microbiology	396
Public, environmental and occupational health (SSCI and SCI)	1 240	Food science and technology	368
Engineering, chemical	1 203	Marine and freshwater biology	358

6 It should be kept in mind that the social sciences and especially the humanities – especially papers from developing nations – are not well represented in the databases that we have consulted.

South Africa	Total papers (1990-2007)	Other SADC countries	Total papers (1990-2007)
Immunology	1 198	Nutrition and dietetics	355
Chemistry, physical	1 183	Multidisciplinary sciences	347
Materials science, multidisciplinary	1 147	Entomology	343
Mathematics, applied	1 108	Paediatrics	341
Biotechnology and applied microbiology	1 096	Meteorology and atmospheric sciences	327
Chemistry, multidisciplinary	1 086	Biochemistry and molecular biology	325
Mathematics	1 056	Agriculture, dairy and animal science	325
Chemistry, inorganic and nuclear	1 050	Obstetrics and gynaecology	286
Mining and mineral processing	1 030	Area studies	285
Metallurgy and metallurgical engineering	1 007	Agriculture, multidisciplinary	270
Paediatrics	955	Forestry	258
Oceanography	944	Respiratory system	243
Physics, condensed matter	942	Planning and development	238
Chemistry, organic	933	Social sciences, biomedical	237
Limnology	919	Economics	230
Genetics and heredity	912	Soil science	226
Psychology, multidisciplinary (SSCI) and Psychology (SCI)	903	Chemistry, applied	211
Physics, multidisciplinary	892	Biodiversity conservation	207
Engineering, electrical and electronic	856	Biotechnology and applied microbiology	207
Agriculture, dairy and animal science	856	Chemistry, medicinal	202
Chemistry, analytical	842	Health policy and services	197
Physics, nuclear	801	Energy and fuels	188
Food science and technology	792	Engineering, environmental	176
Evolutionary biology	771	Environmental studies	162
Geochemistry and geophysics	741	Dentistry, oral surgery and medicine	161
Mineralogy	715	Pathology	156
Oncology	707	Genetics and heredity	153
Economics	668	Chemistry, multidisciplinary	153
Physics, applied	632	Education and educational research	152
Nuclear science and technology	627	Ornithology	145
Virology	617	Surgery	144
Obstetrics and gynaecology	612	Biology	144
Crystallography	606	Psychology, multidisciplinary	139
Education and educational research	604	Health care sciences and services	136
Cell biology	594	Ophthalmology	131
Physics, atomic, molecular and chemical	585	Chemistry, analytical	126
Environmental studies	568	Evolutionary biology	123
Cardiac and cardiovascular systems	568	Fisheries	123
Biodiversity conservation	566	Religion	118
Engineering, environmental	561	Anthropology	115
Respiratory system	538	Endocrinology and metabolism	114
Instruments and instrumentation	535	Geology	114
Endocrinology and metabolism	530	Mathematics	112
Geology	529	History	112
Agronomy	523	Cell biology	106
Physiology	506	Oceanography	106
Area studies	504	Information science and library science	104
Ornithology	502	Mathematics, applied	103
Computer science, interdisciplinary applications	501	Engineering, chemical	102

Salient points

Our bibliometric analysis of absolute and comparative article output (as measured in terms of ISI-papers) produced the following key findings:

- South Africa is the most prolific and productive producer of scientific output in the region. In fact, it dominates scientific production by producing on average 80% of all output for the period 1990 to 2007 and being about four times more productive than the average for the region (119 papers per million of the population compared to the average of 29 papers per million of the population).
- Tanzania is the second most prolific producer of output having pushed Zimbabwe into the third position over the past five years.
- Botswana is the second most productive country with 96 papers per million of the population. The only other countries that have above average productivity scores are Mauritius and Namibia.
- Scientific output in the region is dominated by the biodiversity of the eco-systems and the very strategic demand for medical research in fields such as infectious and tropical diseases.

1.1.4 Status of governance of science in SADC region

Modern research systems have a number of critical components: a sufficient stock of human resources, well-resourced and managed scientific institutions, a healthy research culture, and a national ethos that values and supports science. Such systems also need strong and sustained government support. The role of the state in science – although constantly being debated – must at least be to provide the necessary governance framework for the orderly management of science at the national level (this includes explicit policies and strategies that guide the national science effort and required structures such as dedicated ministries, advisory councils and funding agencies) as well as to support science financially and symbolically.

This section is devoted to issues of science and technology governance. We assess the state of governance of science in each country in the region in terms of the existence of the required structures, policy documents, as well as clearly articulated science and technology plans.

Table 11 Summary of science policy and ministries of science and technology

Country	Science policy document	Date issued	Ministry of Science and Technology	Date of establishment
Angola	No	-	Yes	1997
Botswana	Yes	1998	Yes	2002
Democratic Republic of the Congo	No	-	Yes	2003
Lesotho	Yes	2003	Yes	-
Madagascar	No	-	-	-
Malawi	Yes	1991 (revised 2002)	Yes	2004
Mauritius	No	-	Yes	-
Mozambique	Yes	2003	Yes	2000
Namibia	Yes	1999	No	-
South Africa	Yes		Yes	
Swaziland	No	-	No	-
Tanzania	Yes	1996	Yes	1990
Zambia	Yes	-	Yes	1992
Zimbabwe	Yes	2002	Yes	2002

Our review of the 14 SADC countries suggests that it is possible to discern at least three very different trajectories as far as science policy development is concerned.

- The first trajectory refers to those countries that have gone through two waves of science policy development: during the first wave (not too long after acquiring independence) a first science and technology policy was developed, but during the subsequent years this was allowed to become dormant and ineffectual. A second wave of policy revision was instigated more recently (1990s and beyond) in order to recapture the essence of the science policy goals (as in the case of South Africa and possibly Zimbabwe).
- The second category consists of countries that established their first science and technology policy documents in the 1990s and even more recently (after 2000). These include countries such as Botswana, Lesotho, Malawi, Mozambique, Namibia and Tanzania.
- A third small category of countries in the region still does not have an science and technology policy, viz. Angola, the DRC, Madagascar, Mauritius and Swaziland.

Two interesting trends emerge from a cursory inspection of these science policy documents:

- The tendency to imitate – rather slavishly and uncritically – science, technology and innovation policy approaches and paradigms from elsewhere. It is evident in many of these documents that they aim to emulate and adopt the concept of 'national systems of innovation' (NSI) to their own science systems. Such emulation is highly inappropriate given the early developmental state of local science systems. A derivative of this tendency has recently manifested itself in some Southern African countries (most notably Lesotho, Namibia and Botswana) which are strongly influenced by the science and technology policies of the South African government. This is perhaps not surprising given that experts from South Africa have been called in to assist in the development of these policies and plans (e.g. Botswana) and because of the close relations amongst these countries.
- A second pattern is found at the substantive level where one finds a large degree of similarity in the content and emphasis in these documents. Again, this should not be surprising as most of these science policy documents have originated in a globalising world where national boundaries and national goals are increasingly subsumed under international interests. Most of the science policy documents crafted over the past decade or so therefore have very similar contents and identified priorities, e.g. focus on science and technology for development and economic growth, the adoption in many cases of the notion of a 'national system of innovation', linking science and technology with poverty reduction strategies and (more recently) with the Millennium Development Goals, and at the substantive level, identifying biotechnology, ICT and nanotechnology as priority areas.

A few countries as yet have no science policy framework. It is clear that the non-existence of a science policy framework is explained by different reasons in these countries. In Angola the devastating effects of a lengthy war has meant that attention to science and technology has not been foregrounded until very recently. Swaziland has one of the smallest science bases in the region with a very small and concentrated research capacity at the University of Swaziland. This might be a case where a science policy framework was never deemed to be sufficiently urgent or required to deserve attention. There are now signs of an intention to develop such a policy.

A concluding comment: The existence of science policies in a country does not mean that these are either effectively pursued or very clearly manifested in actual science and technology performance. In many countries these policies are still rather vacuous and largely symbolic documents with little or no effect, mainly because of a lack of resources and (in some cases) lack of will to give expression to the goals and objectives of these documents. Perhaps the best illustration of this phenomenon is the fact that many of these policies and associated plans have set themselves the target of expending 1% of GDP on research and development. With the exception of South Africa (which is close to this magical target), not a single SADC country in Sub-Saharan Africa has achieved this target yet or even come close to it.

1.2 The funding base of public science in the region

One of the key aims of this study was to focus on the funding base of public (and especially university) science in the SADC region. Robust science systems have relatively strong endogenous funding sources and appropriate intermediary organisations (such as national funding agencies) to distribute such funds fairly and efficiently. Based more on anecdotal evidence rather than systematic and rigorous studies, we conjectured that many of the SADC countries would not have such structures in place and that most scientists in those countries must rely on international funding for research support. The results of our survey of more than 600 very active scientists in the region confirmed this. Table 12 presents the responses to a question on the proportion of research funding that is sourced from international funding agencies. Again, given the huge disparities between South Africa and the rest of SADC, we have split the responses. The results show that a very substantial 42% of all respondents from SADC (South Africa excluded) indicated that they source between 70 and 90% of their research funding from overseas, compared to only 6% of South African respondents. The responses very clearly show the dependence of SADC scientists on international funding; conversely how little domestic funding is available for research. We should also point out that this picture is even worse if one keeps in mind that the scientists in our sample were identified because they are the most active and productive scientists in their fields in their countries.

Table 12 Proportion of total research funding sourced from international funding agencies

Proportion	Number of responses (n=634)	Total valid (%)	South Africa (%) (n=236)	Rest of SADC (%) (n=342)
0-30%	366	63	82	50
40-60%	57	10	12	8
70-90% +	157	27	6	42

One of the aims of our site visits, therefore, was to ascertain whether the countries concerned have a national funding agency or at least whether the main universities in the country have a central office that co-ordinates funding within the institution. We present below a summary table of the national and institutional funding structures for each country.

Table 13 Country summaries of funding

Country	National funding agency	Central co-ordinating office for research funding at main universities?
Angola	No	No
Botswana	Yes Botswana Research Science and Technology Funding Agency (BRSTFA)	University of Botswana Research Department
DRC	No information	No information
Lesotho	No	Director: Research and Graduate Studies, National University of Lesotho
Madagascar	No	No information
Malawi	Yes National Research Council of Malawi (NRCM)	Research and Publications Committee, University of Malawi

Country	National funding agency	Central co-ordinating office for research funding at main universities?
Mauritius	Yes Mauritius Research Council	No information
Mozambique	Yes National Research Fund (Fundo Nacional de Investigação – FNI)	No information
Namibia	No	No information
South Africa	Yes National Research Foundation	Yes Most South African universities have a central research office which manages external flows of research funding
Swaziland	No	UNISWA Research Centre (URC)
Tanzania	Yes Tanzania Commission for Science and Technology (COSTECH)	Research and Postgraduate Studies Office, University of Dar es Salaam (UDSM)
Zambia	Yes National Science and Technology Council (NSTC) – Science and Technology Development Fund	Directorate of Research and Postgraduate Studies, University of Zambia (UNZA) School of Postgraduate Studies, Copperbelt University (CBU)
Zimbabwe	Yes Zimbabwean Research Council	No information

In the remainder of this section we present information on the funding base of science and technology (by country) to the extent that it is available. In each country discussion, we focus primarily on three issues:

- whether there is a national science funding agency in the country and what functions it performs;
- the nature of the funding arrangements (including a central office) at institutional level; and
- the status and role of international funding and donor agencies in supporting science and technology in the country concerned.

1.2.1 Angola

No information on research and development funding in Angola is available. In 2004, official development assistance to Angola amounted to $11 441-million and constituted 5,9% of GDP. The per capita development assistance was $74. The data do not indicate the amount that is allocated to science and technology.

An internet search indicated the presence of the following international donors in Angola: UNDP (United Nations Development Program), NORAD (Norwegian Agency for Development Co-operation), DFID (Department for International Development, UK), Wellcome Trust, IDRC (International Development Research Centre), UN (United Nations), World Bank Group, Norwegian Government, UNAIDS (Joint United Nations Programme on HIV/AIDS) and UNICEF(United Nations Children's Fund).

1.2.2 Botswana

In July 1998, the Parliament of Botswana approved its first national Science and Technology Policy. The government announced the creation of a new Ministry of Communications, Science and Technology

in September 2002. As part of the 9th National Development Plan (NDP9) presented in November 2002, the new ministry has been allocated a budget estimate for P1,1-billion to be spread over the NDP9 period (2003/04 to 2008/09).

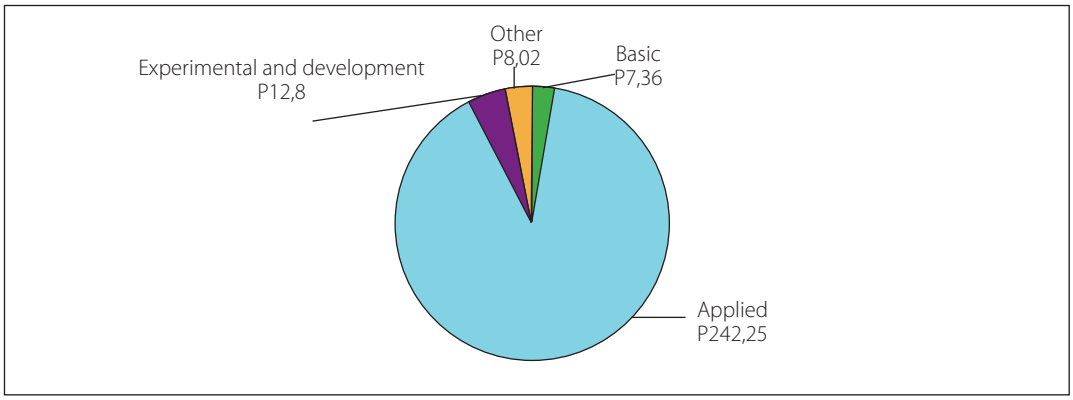
During the 2005 fiscal year the science ministry was allocated P261-million of the development budget. In all, four projects including ICT facilities (P76-million), BTC (Botswana Telecommunications Company) finances (P70-million), development of Department of Information and Broadcasting (P69-million) and science and technology research institutions (P25-million) together accounted for P240-million or 92% of the total budget of the Ministry of Communication, Science and Technology.

The establishment of the Botswana Research Science and Technology Funding Agency (BRSTFA) was approved in 2002. The Department of Research, Science and Technology proposes to formalise BRSTFA through a bill in parliament and provided seed money to start its operation. The agency will be a parastatal under the ministry and will promote competitiveness in government-funded research in science and technology. The agency will administer public funds to ensure that research in science and technology benefits Botswana socio-economically. BRSTFA will target research investments that will result in better lives for the people of Botswana, a positive environment for the achievement of the national policy goals of economic diversification, employment creation, poverty alleviation, human resource development and science and technology development, and endeavour to promote public-private partnerships (http://www.mcst.gov.bw).

The Training of Scientists and Technologists Fund seeks to provide training opportunities for Batswanas in the fields related to research science and technology with the aim of equipping such candidates with strategic and scarce skills, which can drive Botswana to achieving the goals of Vision 2016 – especially in the area of creating an innovative and prosperous nation (http://www.mcst.gov.bw).

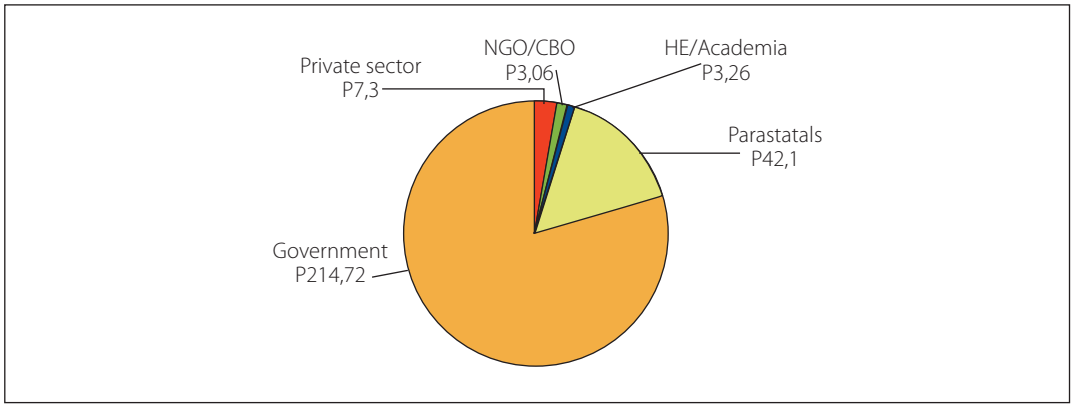
In the Summary of High Level Key Results for 2004/05 of the Botswana National Innovation Capabilities Database for Science and Technology, expenditure by research type was indicated as follow:

Figure 10 Expenditure by research type (Pula-million)



In terms of expenditure by sector the survey found that most of the research funding comes from government, including that of parastatals and academia. The University of Botswana has a small research activity budget compared to that of government and parastatals. This is probably a reflection of the fact that most research is done from small budgets sourced from the University Research Fund. The bulk of the University of Botswana expenditure is therefore for education and training. This is collaborated by the annual report of the Botswana Technology Centre (BOTEC) for 2005 that indicated its income from government grant as P19 474 640 compared to P956 140 from other sources.

Figure 11 Expenditure by sector (Pula-million)



The University of Botswana receives the bulk of its funding through government subvention. In 2006/07 the University Research Advisory Committee allocated about P1,8-million to the Office of Research and Development (ORD). The ORD currently supports over 150 active internally and externally funded projects. A total of P278 298 was disbursed in the first round primarily to support the activities for junior researchers, while in the second round a sum of P601 446 was distributed. The university also received major grants during the same period from the EU through its FP6 framework. The sum of P10-million was provided for a seven-country multi-disciplinary collaborative study that will add value to the morama bean research cycle and P1,42-million for a project on Desertification, Mitigation and Remediation of Land, a Global Approach for Local Solutions (DESIRE). The Norwegian Programme for Development, Research and Education (NUFU) provided P5,8-million for a four-country network grant for research on capacity-building in water sciences for improved assessment and management of water. The United States National Institute of Health (NIH) provided P12-million for a project which is being carried out together with the University of Pennsylvania on Partnerships for Capacity-Building for HIV/STD Prevention Research in Botswana (University of Botswana, 2008).

The University of Botswana's external funding budget for the period 1994 to 2005 indicates that external funding has been, on average, ten times more than internal funds and the major source of funds for conducting research at the university. As with many African higher education institutions, donor funds to the university have decreased and this certainly was evident for Botswana when it was designated a middle-income country in the mid 1990s. Since that time, the amount of external funding has decreased over time. This current situation certainly provides the case for increasing government funding. The Ministry of Communication, Science and Technology is developing a

funding institution which is expected to raise the research fund of the university significantly . Equally important is the role of the Tertiary Education Council with respect to funding tertiary institutions. In the near future, the university is likely to have more research funds from these sources (University of Botswana, 2006).

Interviews with the Office of Research and Development and with directors of research centres at the university confirmed that indeed most of their running costs are covered by the university (state-funded), but that most of their research is funded by external donors, mostly international donors, and is focused on specific fields of interest:

> I think with the new strategy, the strategy defines very clearly the focus areas. So in terms of applying for funds, research activities within the faculty, even within the university, it is very clear that the funding will be towards those activities that are within those focus areas. Well I know my colleagues were complaining that you don't have to do applied research all the time - you can do blue sky research and then the results will be beneficial maybe to the next generation, and it's good, but basically the research strategy stops us from looking for funds elsewhere to do things that I really want to do. But in terms of the priorities, we'll sit down and define the priority areas and say this is where we are going to invest the money. So if you write a proposal and then you want the university to fund it, the priority will be given to the focus areas. I think that is fair, but it doesn't stop me from writing a proposal and submitting it to the European Union, it doesn't stop me from doing that. But I think that is the impact of the new research strategy; money or funding is going to be allocated according to the key focus areas.

The university provides support in terms of subsidising salaries and infrastructure, and funds from the Office of Research and Development are usually used as seed money for new projects. Local industry in Botswana has been identified as a potential source that is currently underutilised and is identified for targeting in the new research strategy of the university.

The following international funding agencies were identified during documentation review and interviews: ACHAP (African Comprehensive HIV/AIDS Partnerships), EU, NUFU (The Norwegian Programme for Development, Research and Education), DANIDA (Danish International Development Agency), NIH (National Institute for Health), ALLEN Foundation, GTZ German Government, IPCS (Institute for Peace and Conflict Studies), Michigan State University, OSISA (The Open Society Initiative for Southern Africa), The Open Society Foundation for Southern Africa, UNDP, UNESCO, WHO (World Health Organisation), Bill & Melinda Gates Foundation and Merck & Co. Inc.

1.2.3 Lesotho

The UNDP Human Development Report indicates research and development expenditure for Lesotho at 0,01% of GDP (2000 to 2005) (http://hdrstats.undp.org/countries/data_sheets/ cty_ds_LSO.html).

One of the measures mentioned in the National Science and Technology Policy document for implementing the policy is to increase public funding for science and technology education, technical

training and research. Funding will be facilitated through a proposed Science and Technology Trust Fund for Innovation. Both private and public research institutes will benefit from the science and technology incentives and jointly access public funds for specific research. Research and development is a major focus of the policy. It is envisaged that research and development will be a fundamental part of the strategic agenda of the higher educational institutions, the main activity of research institutes, and the practical expression of industry and commerce (UNESCO, 2006).

Until recently the National University of Lesotho research funds have been administered by a centralised Research and Conferences Committee (RCC), which receives grant applications from the various faculty and institute sub-RCCs. From the 2008/09 fiscal year, these funds have been devolved to the faculty and institute RCCs, which will now be autonomous. The work of these committees will be co-ordinated by the Director: Research and Graduate Studies, under the Office of the Pro-Vice Chancellor. For the 2008/09 fiscal year, the total research and conference fund has been distributed between the faculties and institutes on the basis of head count (though this is a policy that might be revised in the future). The total allocation is M1 218 100 for research (which includes provision for payment of honoraria for published journal articles) and M450 000 for conferences (National University of Lesotho, 2008).

Other sources of funding as indicated by the Director of Research and Graduate Studies are: DAAD (German Academic Exchange Service), AAU Staff Exchange (Association of African Universities), Mellon Foundation, NRF (National Research Foundation), Kellogg Foundation, DFID , DELPHE (Development Partnership in Higher Education), UNESCO, UNDP, WHO, World Bank Group, African Development Bank and the EU.

Although research funding for the university is limited, quite a number of contributions are negotiated at faculty level as indicated by the following interview with a Dean:

> We are very proud of this faculty. As small as we are, and as young as we are, we are in competition and we want to do what is necessary. Only last year we applied for and got a grant from DELPHE (Development Partnership in Higher Education) to do some research and we are doing this in collaboration with the University of Dundee. I am happy to mention to you, although still in the pipeline, the Doris Duke Charitable Foundation, that with other members of our consortium we have made an application [to], and it has gone through to the second round of applications. These are the encouraging factors, there is a lot of good will and we are starting to make some impact.

It is evident from the various interviews that most of the funding for university research is obtained from commissioned work and external funders and not much is budgeted for from the central university fund. A director of one of the National University of Lesotho 's research institutes commented as follows:

> They just fund the research – the specific research only, research activities and outputs. The infrastructure has already been paid for and we are free to use it. Maximum, the cut is 40 000, for whatever per year. If it is more than that you have to phase it over two/three years. The maximum per person/per proposal is 40 000.
>
> So actually this is a very small contribution by the university?
>
> Yes, very small. I think this is why most people don't even bother.

The UNDP, which is responsible for donor co-ordination in Lesotho, organises periodic roundtable conferences that bring together the country's international development partners. Fifteen donor agencies are active in the country, among them the World Bank Group, the African Development Bank and the EU. In recent years, most project support for Lesotho has been multi-donor, with different donors taking the lead based on their comparative advantage.

1.2.4 Madagascar

Currently there are no formal public funding initiatives within the Malagasy science and technology system, such as a formalised government science and technology fund or the like. The national research centres obtain funds directly from the Directorate of Science and Technology within the National Ministry of Education. However, these funds are limited and do not cover the actual research that occurs within the centres. In terms of funding for public science within Madagascar, one respondent indicated the following:

> From the government there is some funding, but it is very, very small, I mean for research … I have no figures. The funding from the government is first for the salary of the scientists, but for the research activities they are funded to a lesser extent, I am afraid. So, most of the research activities are funded by collaboration partners.

Many of the national research centres within Madagascar obtain funding for their research either directly or indirectly (via government) from international funders. These funding arrangements occur at both a national level as well as at the institutional level. With regards to indirect international funding, the French institutions are the ones with which government has closest ties and these institutions also indirectly contribute to the funding portfolio of the national research centres (CNRS (Centre National de la Recherche Scientifique)).

At the institutional level direct international funding is also obtained through collaborative efforts, where those participating from the national research centres are not always the principal investigators:

> [T]here where we have our largest entomology laboratory for research on plants, which was entirely financed by the ... 'California Academy of Science'. There we have a training centre for the protection of the environment ... is financed by the Japanese Embassy.

However, not all of the national research centres obtain external funding. One institution's respondent indicated that they did not receive foreign funds. This national research centre, however, commercialised the vaccines they produced and generated income sufficient to sustain their research.

> No, no, zero dollars. We do not receive any foreign funds, and 1% of our budget comes from the state, there. The research institution exists on independent financing. There is only 20% which belongs to the state. But 80% comes from our own efforts, the efforts of the 66 people.

With regards to researchers obtaining public funding through the university, it was indicated by one respondent from the University of Antananarivo that there simply was no funding available for research to occur within the university in an official manner:

> In fact, one should say that … that the establishment is not involved in research in an official manner, we don't have the money for that – only education. But, the research is that of the directors, the laboratories, the lecturers who themselves look for partners and overall it is work done directly with them … officially, one does not know what goes on here. But in general, one works directly. There is no official financing. It is zero. There is no financing for research.

International and foreign funding of science and technology

Madagascar benefits from substantial bilateral and multilateral donor support, although the number of donors is limited. For example, over 50% of the overall 2004 budget was financed by external resources, and this ratio is over 70% for the investment budget. The International Development Association (IDA) and European Union (EU) are the main donors, accounting for over 70% of the aid flows to the country. Chief among bilateral donors are the United States and France, though other bilateral donors, such as Japan, Germany, Norway, and Switzerland also play key roles in certain areas such as governance, the environment, and the rural sector (World Bank, 2006:12).

Operations of the donor agencies by sector

- Macro-economic thrust

  The International Monetary Fund (IMF) extended the Poverty Reduction and Growth Facility (PRGF) agreement in December 2002, for a total amount of SDR79,43-million (approved in March 2001, the PRGF was suspended during the first half of 2002). The World Bank (IDA) (i) disbursed in August 2002 the last tranche of the structural adjustment credit of an amount of US$42,20-million, and (ii) granted in November 2002, an emergency economic recovery credit of an amount of US$50-million. The European Union, France and Mauritius granted emergency subsidies of €70-million (November 2002), €5,6-million (November 2002) and US$1-million (August 2002), respectively. The bank (ADF) (i) disbursed the last tranche of the SAP III loan in an amount of UA4-million and (ii) intends to support the economic reforms (African Development Bank, 2003:19).

- Agriculture/rural development

  All the major donor agencies are involved, particularly IDA, FAO (Food and Agriculture Organisation of the United Nations), UNDP, the European Union, France and Germany. The ADF has three ongoing projects in this sector, namely: Rehabilitation of the Bas-Mangoky Irrigated Rice Field, the Project for Young Rural Entrepreneurs, and the Project for Preventive Acridian Control (African Development Bank, 2003:19).

- Transport

  IDA, the European Union and France are involved. The ADF has (i) three ongoing projects in the sector on the rehabilitation and repair of damages caused by cyclones, and (ii) it proposes to finance a road rehabilitation programme, the studies of which are currently underway (African Development Bank, 2003:19).

- **Education**
  All the key donor agencies are involved, especially the IDA, the European Union, UNICEF and Japan. The ADF has an ongoing project in the sector (Education III) (African Development Bank, 2003:19).
- **Health and nutrition**
  The following donor agencies are involved: the IDA, WHO, UNICEF, UNFPA (United Nations Population Fund), the European Union, USAID, CARE, France, Germany and Switzerland. The ADF is financing the Health II Project (African Development Bank, 2003:19).
- **Electricity, drinking water supply and sanitation**
  UNICEF and USAID are involved. The ADF is financing the Drinking Water Supply and Sanitation (DWSS) Project in the "Grand Sud" (African Development Bank, 2003:19).

1.2.5 Malawi

In 2006 the Malawi Department of Science and Technology launched a five-year strategic plan (2006 to 2010), intended to foster rapid industrialisation using science and technology. It involved a budget of about US$8,3-million, of which about US$1,5-million was earmarked for developing and commercialising research. This was in addition to the annual science budget. It was also planned to approach international donor agencies to partly fund the activities. Unfortunately, in January 2007, it was clear that the plan would need to be severely curtailed due to a lack of government funding and subsequent reluctance by international donors to participate on their own. As a result, in February 2007, it was announced that some planned science and technology initiatives in Malawi would need to be shelved due to budgetary constraints (MIST, 2005; SciDevNet, 2006, 2007a, 2007b).

In March 2007, the National Treasury announced a tripling of funding for science and technology projects from around US$250 000 to US$673 000 (SciDevNet, 2007c). The Science and Technology Act of 2003 established a Science and Technology Fund that is dedicated to the advancement of science and technology in Malawi (GoM, 2003). This fund is not yet operational, but will finance, by way of loans or grants, any research relating to the development of science and technology.

In 2002, the government established a Biosafety Fund through an Act of Parliament (GoM, 2002). The fund was established to support the safe management of biotechnological activities. The fund may, inter alia, be applied to research and training that can promote safe management. It is unclear whether this fund is operational yet.

Malawi has an active co-ordinating body for research and development, known as the National Research Council of Malawi (NRCM). One technical committee of the NRCM is the Research Programmes Committee, through which the Council administers the NRCM Research Grants Scheme. The scheme seeks to promote research and development by awarding competitive small research grants to researchers to conduct research in identified themes/priorities.

The University of Malawi has a Research and Publications Committee whose task, among others, is to seek research funding from both inside and outside the country. External funding currently comprises

about 80% of the university's research fund. Moreover, less than 1% of the university's overall budget is devoted to research. The university is increasingly steering research centres to be self-sustainable in terms of finances, as the following quotes by two directors of research centres illustrate:

> [T]he University of Malawi … increasingly is saying that research centres should be able actually to stand on their own feet financially. In other words, should be generating a sufficient income which will pay for their salaries as well as operational costs … Generally I think operational cost, yes … operational costs are being met by the research centres themselves. What is missing right now is the salary for the staff. And the thinking within the University of Malawi is that over time ... the centres should be not 'top heavy'. In other words, the number of research fellows [researchers] shouldn't be as many. In fact, they are encouraging that most of the research fellows should operate from departments, only when there's a specific issue, then that person will come from the department, come to the centre, maybe work for two or three years with a specific project, then he can go back to the department. But also in terms of salaries they are saying that while he's here, the centre should meet the salary.
>
> [The money] we are getting from the university is not sufficient and that is why we really have to be on our toes, developing research proposals and to ensure that we generate our own funding, our own funds. Because what you get from the university is very little. We actually have been told that, you know, the money that we get is likely to become less and less. They would want us to be independent in a sense in terms of sustaining ourselves.

1.2.6 Mozambique

The Mozambique government established the National Research Fund (Fundo Nacional de Investigação – FNI) under MCT to promote scientific research, technological development and innovation. In particular, it is intended that the fund will contribute to achieving the government's goal of increasing research and development spend from 0.2 to 0.8% of GDP. The FNI is able to support both public and private entities, including individuals, through five funding instruments for (1) research (based on competitive proposals), (2) capacity building and infrastructure in institutions, (3) the higher-risk phases of innovation and technology transfer, (4) strategic projects, and (5) the popularisation of science and technology. Calls for proposals are issued as funds become available. Following the first call for proposals in 2006 that resulted in 42 submissions (mostly from the agricultural sector), twelve research proposals received funding totalling US$434 000, while a further five innovation proposals received funding totalling US$116 000 (http://info.worldbank.org/etools/docs/library/239731/InnovationinMozambiquePaper.pdf).

International funding agencies

From a web review, the following funding agencies were identified as active funders in Mozambique: DFID, USAID, CRDI, IDRC (International Development Research Centre), Wellcome Trust, CIDA, CFAR, World Bank and UNICEF.

1.2.7 Namibia

Namibia does not have any formal funding structures that fund research activities. There are no overarching statutory bodies that administer or co-ordinate funding for research and science. As a lecturer at the University of Namibia notes:

> … very little in terms of funding is allocated to research. Even if it is being funded by the university, it is quite minimal and highly inadequate. So these are some of the key aspects.

This is further echoed by another respondent:

> We don't have the equivalent of NRF in SA, in this country. Something is being worked on. But we have nothing on the ground. Therefore, on an international level there is a weakness, and that weakness is transmitted to the university; we don't have concrete policies on science and technology.

There are particular funding problems in the fields of natural sciences and engineering. These fields are resource-intensive and are grossly under-funded at all levels in the science and technology system. As one respondent noted,

> It's important to teach history, but for teaching history you will need some support, but not as much … You'll need much more detailed and sophisticated analytical facilities for teaching science and technology, you see, as you go to the higher end of the spectrum..

Furthermore, the issue is not just the lack of funding, but also the unpredictability of funding for research – much of the funding that takes place is ad hoc and cannot sustain long-term resource-intensive research projects:

> Another thing is the unpredictable funding in these research areas … This year we've had funding but how much? R1-million for all seven faculties to share.

1.2.8 South Africa

South Africa has a number of central funding agencies of which the National Research Foundation (NRF) and the Medical Research Council (MRC) are the most important. In addition, the Water Research Commission (WRC) also funds research directly, as do some government departments (including the Department of Science and Technology, the Department of Agriculture and the Department of Trade and Industry). Statistics on research funding at the national level is provided through an annual Research and Development Survey which is conducted by the Human Sciences Research Council (HSRC) under commission from the Department of Science and Technology.

The statistics provided in tables 14 to 16 reveal the following:

- In 2005/06 South Africa expended slightly more than R14-billion on research and development, of which 19% was devoted to research in the higher education sector.

- Slightly more than half of the funds for research and development in the country is sourced from government (53%), followed by own funds (23%), foreign sources (12%) and business (10%).
- As far as expenditure by scientific field is concerned, nearly two thirds of research and development in the higher educator sector is expended in the natural and engineering sciences (48%), 31% in the social sciences and humanities, and 21% in the health and medical sciences.

Table 14 Research and development expenditure per sector (2004 to 2006)

	2005/06		2004/05	
Sector	R'000	%	R'000	%
Business enterprise	8 243 776	58,3	6 766 361	56,3
Government	844 640	6,0	515 331	4,3
Higher education	2 732 215	19,3	2 533 971	21,1
Not-for-profit	226 514	1,6	198 268	1,7
Science councils	2 102 094	14,9	1 996 050	16,6
Total	**14 149 239**	**100,0***	**12 009 981**	**100,0**

*Subject to rounding error

Table 15 Research and development expenditure by funding source (2005/06)*

Source of funds	Business enterprise		Government		Higher education		Not-for-profit		Science councils	
	R'000	%	R'000	%	R'000	%	R'000	%	R'000	%
Own funds	5 488 727	66,6	316 145	37,4	1 601 444	58,6	46 934	20,7	485 702	23,1
Internal resources	5 488 727	66,6	316 145	37,4	1 601 444	58,6	46 934	20,7	485 702	23,1
Government	1 331 740	16,2	439 511	52,0	491 784	18,0	28 470	12,6	1 105 832	52,6
Grants	919 488	11,2	433 842	51,4	N/A	N/A	16 295	7,2	629 237	29,9
Contracts	412 252	5,0	5 669	0,7	N/A	N/A	12 175	5,4	476 595	22,7
All government, research agencies, agency funding and science councils	N/A	N/A	N/A	N/A	491 784	18,0	N/A	N/A	N/A	N/A
Business	142 256	1,7	11 000	1,3	316 740	11,6	27 416	12,1	220 698	10,5
Local business	142 256	1,7	11 000	1,3	316 740	11,6	27 416	12,1	220 698	10,5
Other South African sources	84 282	1,0	19 270	2,3	16 657	0,6	21 354	9,4	35 679	1,7
Higher education	1 623	0,0	8 583	1,0	4 917	0,2	2 304	1,0	4 620	0,2
Not-for-profit organisations	14 158	0,2	687	0,1	9 423	0,3	16 379	7,2	30 006	1,4
Individual donations	68 501	0,8	10 000	1,2	2 317	0,1	2 671	1,2	1 053	0,1
Foreign	1 196 771	14,5	58 714	7,0	305 590	11,2	102 340	45,2	254 183	12,1
All sources	1 196 771	14,5	58 714	7,0	305 590	11,2	102 340	45,2	254 183	12,1
Total	**8 243 776**	**100,0**	**844 640**	**100,0**	**2 732 215**	**100,0**	**226 514**	**100,0**	**2 102 094**	**100,0**

* N/A entered where specific source of funds was not asked of the relevant sector

Table 16 Expenditure in higher education by research field (2003 to 2006)

	2005/06		2004/05		2003/04	
Main research field	R'000	%	R'000	%	R'000	%
Division 1: Natural sciences, technology and engineering	**1 846 022**	**67,6**	**1 646 731**	**65,0**	**1 424 560**	**68,8**
Mathematical sciences	79 707	2,9	81 251	3,2	127 344	6,1
Physical sciences	97 252	3,6	100 761	4,0	52 552	2,5
Chemical sciences	117 914	4,3	101 808	4,0	71 479	3,5
Earth sciences	115 680	4,2	101 262	4,0	94 833	4,6
Information, computer and communication	105 873	3,9	98 240	3,9	58 014	2,8
Applied sciences and technologies	55 779	2,0	43 653	1,7	54 238	2,6
Engineering sciences	268 250	9,8	307 141	12,1	198 163	9,6
Biological sciences	195 380	7,2	192 658	7,6	159 708	7,7
Agricultural sciences	143 104	5,2	97 248	3,8	97 996	4,7
Medical and health sciences	582 798	21,3	440 249	17,4	433 504	20,9
Environmental sciences	42 719	1,6	40 388	1,6	37 358	1,8
Material sciences	29 348	1,1	29 918	1,2	31 685	1,5
Marine sciences	12 220	0,4	12 154	0,5	7 685	0,4
Division 2: Social sciences and humanities	**886 193**	**32,4**	**887 240**	**35,0**	**646 791**	**31,2**
Social sciences	594 579	21,8	577 653	22,8	445 031	21,5
Humanities	291 615	10,7	309 587	12,2	201 761	9,7
Total	**2 732 215**	**100,0**	**2 533 971**	**100,0**	**2 071 351**	**100,0**

1.2.9 Swaziland

Swaziland does not have a national funding agency. Given the dominance of the University of Swaziland in the national science system, it is pertinent to focus only on how science is funded at the university. In terms of funding for the university, funding comes through the Research Board, which is mainly driven by the University of Swaziland (UNISWA) Research Centre:

> The UNISWA Research Centre is the administrative wing of the research board, so whatever decisions are taken by the board, they are implemented by that centre. The research board does provide quite a substantial amount of money for research activities and one of their concerns actually is priority areas which are of interest to national development.

The UNISWA Research Centre (URC) serves as the focal point for research at the university. It endeavours to facilitate the co-ordination, strengthening, promotion, generation, accumulation and dissemination of knowledge and information through research to enhance economic growth and development and promote socio-cultural values. A respondent from the URC commented on the influence that international funders have on the research agenda of the research centre as follows:

> … a lot of time the funding is very specific to certain areas and they are mostly in the interest of those countries in relation to what this country can do with them or for them. So it might deviate a little from our pressing problems, but nevertheless they are also important to us.

In terms of who the funders are, it seems there were many Americans in the past, but, more recently, there are more Europeans and regional funders. The increase in regional funders seems to be directly related to NEPAD and these international and regional policies have an influence on the research areas in Swaziland:

> … especially agriculture and health are very much affected by the regional policies. So international government agency policies like UN Millennium Goals, all these are affecting our research priorities because they have become national priorities.

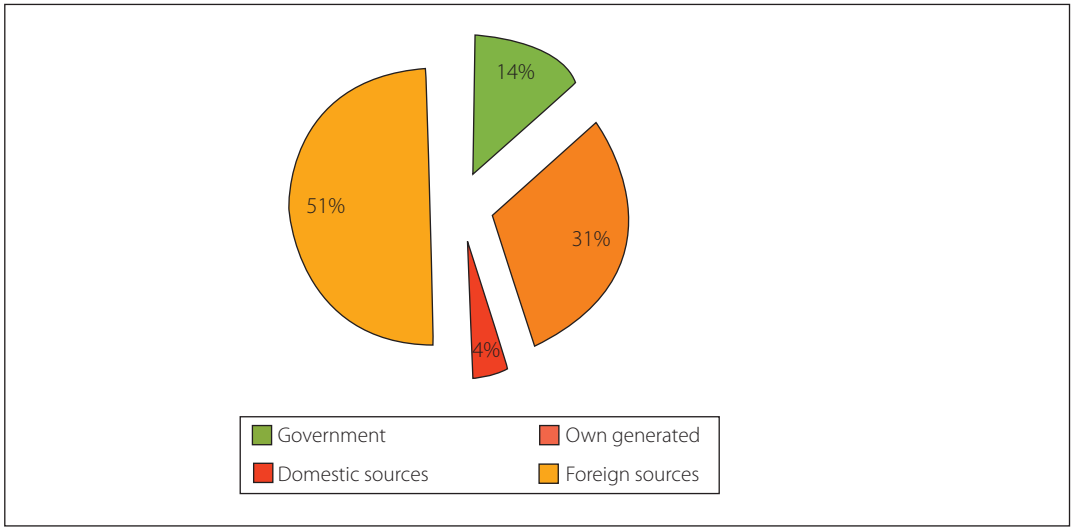
In terms of funding for conference attendance, there seems to be sufficient funding, according to one respondent:

> There are different kinds of funding available. We do get funding for this. Actually funding for conferences is not a problem. We have yearly SADC conferences where we are asked to come and present stuff that we have in the SADC region.

1.2.10 Tanzania

A survey by the Tanzania Commission for Science and Technology (COSTECH) included an estimation of the research and development expenditure in Tanzania. Figure 12 shows the total contributions by sources of funding over a nine-year period. From the figure it is evident that foreign donor contribution to research and development expenditure is the largest, contributing nearly half (51%) of the total funds, followed by own funds (31%), then government funding (14%) and the smallest proportion is from domestic donors (4%). The small contribution from government funding is an indication that research and development agendas are driven by others and not by the government policy and plans or researchers' quest for knowledge, innovation and discovery.

Figure 12 Funding flow for research and development programmes: 1995 to 2004



The Tanzanian system is surviving because it attracts external financial support. Without these major subsidies, very little research would be conducted in Tanzania. The government policy of science for the development of the country has, however, set a target of 1% of the GDP to be allocated to science and technology. From available information, very little private sector funding is available.

National funding

About 98% of the research projects undertaken at Sokoine University of Agriculture (SUA) are externally funded through signed agreements between individual researchers, departments or the university in general, and the funding agencies. The other 2% is funded by the government of Tanzania and internal public and non-governmental organisations. The funds spent on research are estimated to be about TZS2,0-billion per year. Currently the Norwegian government, through NORAD, is funding about 50% of the research projects at the university (www.suanet.ac.tz).

International funding agencies

Foreign donor funding in Tanzania contributes approximately 70% of the research and development expenditure in Tanzania. Foreign funding agencies concentrate on particular institutions or faculties, notably the two main universities: University of Dar es Salaam (UDSM) and Sokione University of Agriculture (SUA). The table below, taken from Gaillard (2001), shows the most important sources of long-term aid between 1980 and 2000. The table lists the donor country and the Tanzanian beneficiary.

Table 17 Long-term aid to Tanzanian research

Agency and country	Tanzanian beneficiary
NORAD, Norway (Norwegian Agency for Development Co-operation)	SUA Faculty of Forestry
NORAD, Norway	UDSM Department of Chemistry
NORAD, Norway	UDSM Department of Chemical and Process Engineering
FINNIDA, Finland (Finnish International Development Agency)	UDSM Department of Geology
DANIDA (Danish International Development)	SUA Department of Animal Science
SDC, Switzerland (Swiss Agency for Development and Co-operation)	UDSM Departments of Mathematics and Physics
GTZ, Germany (Deutsche Gesellschaft für Technische Zusammenarbeit)	UDSM Faculty of Engineering
NUFFIC, The Netherlands (Netherlands Organisation for International Co-operation in Higher Education)	UDSM Department of Microbiology
SAREC-ISP, Sweden	UDSM Department of Seismology
Sweden	UDSM University Library
World Bank, International	Ministry of Agriculture and Co-operatives Rehabilitation of Agricultural Research Centres

1.2.11 Zambia

The creation of a Science and Technology Fund within the Zambian science and technology system was proposed with the promulgation of the Science and Technology Policy in 1996. The creation of this fund did not take immediate effect. Currently, based on available information, there are two formal public funding initiatives that focus on science and technology development. Zambian researchers obtain access to these funds on a competitive basis. The two funds are:

- the Science and Technology Venture Capital and Innovation Fund, set up by the Ministry of Science, Technology and Vocational Training (MSTVT) in 2006; and
- the Science and Technology Development Fund managed by the National Science and Technology Council (NSTC). The fund was established to encourage initiatives in scientific research and technological development, and the commercialisation of technology.

The public research institutions within the Zambian science and technology system obtain funds through the MSTVT and other line ministries, such as Health and Agriculture, and Food and Fisheries. However, when questioned about funding, respondents indicated that the funds obtained from government only covered salaries and other operational costs. Funds for research were obtained from external sources:

> Funding for the actual operations, I mean salaries and, you know, day to day running, paper, taking care of staff, like collecting staff from home and taking them back, funding for that comes from the government plan – which is a monthly grant and then for research it's by collaboration of funders from outside, like WHO. But there are many funders: you have the European Union and then you have CDC, USA, Institute for Tropical Medicine in Belgium, so there are several collaborative funders.

The University of Zambia, one of two public universities, created a Directorate of Research and Postgraduate Studies in 1994, because it realised that research needed to be co-ordinated from a central point. Even with the centralisation of research, there is only a small amount of money available for research and, as one respondent indicated, most of the funding for research comes from external sources:

> I'd put it around 75 to 80% from outside and the balance coming from internal sources (government) here and there. It could even be worse in some areas where you will find maybe 100% coming from outside.

1.2.12 Zimbabwe

A report conducted in 2003 by the Scientific Industrial Research and Development Centre (SIRDC) shows that government and private-sector spending on research and development is only about 0,2% of the gross national product, which is one of the lowest percentages of funding for research and development support in the world. In this regard, a high profile government official in the Ministry of Science and Technology remarked:

> It is difficult for both the government and the private sector to finance the policy [of 1%] because there are other concerns of an urgent nature that are emerging.

Despite the plethora of problems in the country, the government sporadically commits funds to research and development. For instance, in 2003 the government approved three incentives to industry and individuals promoting research: (1) a government budgetary allocation, (2) double deduction on expenses incurred on promoting research, and (3) tax deduction on donations to research and development institutions of up to Z$20-million. Also:

> The Government of Zimbabwe [in 2005] has launched a Z$30-billion (US$5-million) fund intended to promote innovation by harnessing the country's untapped technological skills base (www.allzimbabwean.com).

Most research and development performing institutions are state institutions that depend on the government for funding. In light of the government's meagre expenditure on research and development, institutions have to source funding elsewhere. The plight of state institutions is in contrast to private ones that have other problems such as 'unused funds'**.** The following is from an interview with one Dean at Africa University (AU):

> Our problem is not lack of research funds, but that we have 'unused funds' lying around because staff cannot come up with research ideas and proposals.

Due to the economic situation in Zimbabwe, most research and development activities rely on informal external funding through funding agencies, and personal and institutional collaborations on projects. Sanctions imposed on government officials and the banning of some agencies by the government has impacted negatively on the funding for research and development. The following excerpts from the field interviews reflect this impact:

> We have funding problems! Due to the political situation in the country a lot of donors have left. (Dean, UZ)
>
> Because of sanctions imposed on government officials, we have lost our foreign donors. We now have to source funds through third parties in our neighbouring countries, e.g. Botswana or South Africa. (Senior government official in Ministry of Science and Technology)
>
> Donors have left because of the political situation. However, the French and the Italians are still helping us. We sometimes participate internationally, but donors always exclude Zimbabwe. Sanctions have isolated collaborative efforts. (UZ)
>
> Donor funding has been withdrawn, adversely affecting research. Staff is overstretched. (Dean, UZ)

Not every department has been affected by donor withdrawal. One example is the Faculty of Agriculture at the University of Zimbabwe, which enjoys donor funding because of its contribution

to research regarding food security as well as its high research output and capacity building, as this comment from the Dean of Agriculture at the university illustrates:

> As a department we have funding. We recently received US$350 000 from SADC and €87 000 from the EU. We have the highest output in terms of internationally peer-reviewed journals. We have over 1 000 students graduated through our faculty.

Concluding comments and assessment

Funding of science in the majority of SADC countries remains a huge problem. This problem manifests itself in many ways:

- the lack of national government commitment to the stated ideals of expending 1% of GDP on research and development;
- the lack of a central infrastructure for co-ordinating and facilitating science funding (and its alignment with national research goals);
- the huge dependence on foreign funding for science and technology in the majority of countries and most of the universities in SADC (with the exception of South Africa); and
- the relative lack of institutional research offices for co-ordinating and facilitating research funding within universities.

The lack of sufficient endogenous funding for research (and the converse dependence on international agencies for research support) has two significant consequences: Firstly, governments in the region cannot steer the research efforts in their countries in any meaningful way. Any formulation of a science policy and science and technology priorities is empty if there are no resources to give effect to such national agendas. Secondly, the research agendas and priorities in many SADC countries are therefore shaped and influenced by the research priorities of international funding agencies. Even if the priorities of such agencies are aligned with the needs of the countries in the region (and the emphasis on agricultural and health research would suggest that this is the case), it still means that the research conducted under these programmes remains reactive and often short-term. International funding is usually also project-driven with the result that researcher salaries, laboratory and equipment costs are not funded. Donor funding – even if well-meant and properly used – does not help to build an indigenous scientific infrastructure and capacity. In the long term, governments in the region have to find the funds to build, sustain and grow their own scientific institutions and capacities if they wish to overcome existing dependencies and also wish to more directly steer their own scientific effort.

1.3 The robustness of the institutions of science

Our focus in this section is on the 'robustness' and long-term growth and sustainability potential of the institutions of science. In our discussion we include knowledge production institutions (research programmes, centres and institutes) at universities as well as those institutions that make up the scientific infrastructure of a country (such as academies of science, professional societies and scientific journals). Our general aim is to determine whether academic and government-based researchers

engage in building the institution of science in their universities and centres through long-term research programmes, addressing the challenge of the ageing of academics in many of these systems as well as the levels of support for graduate students and postdoctoral fellows. In addition to the availability of funding (which was discussed in the previous section), the sustainability of scientific institutions is also affected by the available pool of human capital. This section therefore also includes a discussion of human resources for science and technology and those factors (such as poor salaries and working conditions) that continue to force academics and scholars in the region to revert to consultancy as a way of augmenting their income or to seek employment elsewhere on the continent or overseas (brain drain).

1.3.1 Research programmes vs individual (ad hoc) projects

The institution of science is built through medium- to long-term programmes that over time develop the capacity of the next generation of scientists as well as leading to research specialisation (and depth) over time. Research programmes, as opposed to short-term and more individual (ad hoc) projects, are cumulative over time and often attract follow-up funding and ultimately generate more scientific output. Many of these programmes involve graduate students, which is also a way of 'reproducing' capacity.

The issue is also whether scientists and scholars have sufficient resources to engage in more fundamental and strategic research (which is often self-initiated) or whether they are forced – because of lack of continuous funding support – to seek short-term contract and commissioned research.

The survey established that the average respondent is involved in about four projects at any given time. Of these, the respondents indicated that they are the principal investigator in 2,5. There are, however, significant field differences, as is evident from Table 18 below.

Table 18 Average number of projects by scientific field

Scientific field	No. of respondents	Mean no. of projects
Applied sciences and technologies	108	4,3
Arts and humanities	66	2,9
Biological sciences	153	5,3
Chemical sciences	62	3,2
Earth sciences	54	4,5
Economic and management sciences	40	4,0
Engineering sciences	35	4,4
Environmental sciences	137	4,1
Health sciences	112	4,4
Information and communication technologies	46	3,4
Marine sciences	21	5,0

Scientific field	No. of respondents	Mean no. of projects
Materials sciences	21	4,6
Mathematical sciences	35	3,5
Medical sciences: basic	53	4,4
Medical sciences: clinical	42	4,3
Physical sciences	38	3, 5
Social sciences	130	3,6

As Table 19 below shows, there is also a very significant difference in the mean number of projects being conducted by South African scientists (5,3) when compared with their counterparts in the rest of SADC (3,2).

Table 19 In how many research projects are you currently involved?

Country	Mean	N	Standard deviation
South Africa	5,3	238	4,759
Other SADC countries	3,2	375	3,412
Total	**4,0**	**613**	**4,111**

In order to 'test' whether these projects are longer term, we asked respondents to indicate whether the projects that they are involved in form part of a larger research programme or not (Table 20). In total 64% of the respondents indicated that their projects do form part of a broader research programme, either at their own institution (43%), or at an institution inside their country (9%), or at an institution outside their country (12%).

Table 20 Is your research part of a broader research programme of your institution?

	Frequency	%	Valid %
Yes	259	40,9	42,7
No, my research is my own stand-alone project	220	34,7	36,3
No, but my research forms part of a programme of another institution in my country	52	8,2	8,6
No, but my research forms part of a programme of an institution outside my country	75	11,8	12,4
Total	606	95,6	100,0
System missing	28	4,4	
Total	**634**	**100,0**	

We again expected significant differences from respondents in South Africa compared to other SADC countries. The results presented in Table 21 confirmed this.

Table 21 Is your project part of a broader research programme?

		South Africa versus rest		
		South Africa	Other SADC	Total
Yes	Count	82	177	259
	%	31,7	68,3	100
No, my research is my own stand-alone project	Count	127	93	220
	%	57,7	42,3	100
No, but my research forms part of a programme of another institution in my country	Count	18	34	52
	%	34,6	65,4	100
No, but my research forms part of a programme of an institution outside my country	Count	13	62	75
	%	17,3	82,7	100
Total	**Count**	**240**	**366**	**606**
	%	**39,6**	**60,4**	**100**

The fact that two thirds (68%) of respondents from other SADC countries indicated that their projects form part of a larger programme at their own institution compared to the 32% of the South African scientists seemed surprising at first reading. However, on further interpretation it is not unlikely that this reflects the extent to which South African scientists may have access to sufficient funding to ensure that they can fund their own projects as stand-alone projects and need not rely on other programmes for co- or additional funding. This interpretation is supported by another finding presented in Table 21 – the fact that nearly five times more (83% compared to 17%) respondents from other SADC countries indicated that their research forms parts of a programme outside their country. This is highly significant and perhaps a clear indication of their reliance on overseas funding.

The qualitative responses obtained from the interviews support some of the findings mentioned thus far. Most people interviewed understand the need to undertake more long-term research, but at the current time there are simply not sufficient funds to achieve this.

> I think for the time being we are leaning more on the short-term research, but we went through a strategic plan and our desire is to move towards long-term research so that we have a number of projects, maybe three, five years kind of research projects and then, that way we have a sustainable base for operations. Commissioned research, I think I will put it at 60% commissioned research, 40% long-term research.
>
> I think in terms of the strategy, as we said, one, we said that we are looking at long-term research, because we think there you have a sustainable financial base once you have three, four projects, running three, four years. In all, the day-to-day operational costs are going to be met. The other strategy we are looking at is to actually intensify training, we are the only area centre and the college of expertise in terms of the Agriculture Centre

> and there is nobody else that is doing short courses in the Agriculture, Natural Resources and Development sector, so, there's a niche there … and we want to intensify that, using the existing expertise. If they want training in animal production, we get the experts, they come here for five days, then they go, that kind of thing. We think we should be able to survive using those strategies with less emphasis on commissioned research. We think that our bread and butter should be these two: long-term research and the training. Commissioned research – it will be one off, if something comes, we'll take it, but we'll not actively reply to every … we'll not go through each and every newspaper, looking for every opportunity. (Respondent from the Centre for Agricultural Research and Development (CARD), Bunda College of Agriculture, University of Malawi)

In terms of the nature of research programmes, there is very limited support, especially for academics at higher education institutions where they have to balance teaching priorities with research activities. Many respondents indicated their teaching loads did not allow them to engage in much research. It appears that research activities are mostly conducted during university recess. As the following respondent illustrates:

> To be honest, for now, teaching is overriding. We have very little time allocated for research. We only go for research at times during the recess, when it is a bit quiet at the university. And for those others with managerial positions that are required to both teach and administer, you know faculties, like deans, you know, that is also another constraint. So how to overcome that you end up creating some time after working hours to accommodate the research activities. (Respondent from the University of Namibia)

Another respondent from the same university commented that:

> We have a critical mass of people who are not enough, so we spend most of our time in teaching. Therefore, we have very little time for research.

This is also true at the University of Swaziland where the university seems to be experiencing severe capacity problems, especially in terms of research capacity. Therefore, many of the research activities involve human capacity development of research skills. This is especially the case in specific fields. For instance, the faculties of agriculture and science are two faculties that appear to have quite strong research capacity, as can be ascertained from the relative proportions of PhD graduates from these faculties. It seems the other faculties do not fare as well in terms of their PhD programmes. Furthermore, it seems the faculties of agriculture and science also fare the best in terms of research output. This is mainly due to many of the academic staff at the university not possessing a PhD. A respondent identified this as a particularly large problem in the social sciences:

> … because our problems now are of a social science nature. HIV/AIDS, poverty – so these are the priority areas and we do not have much capacity. And the problem is not with them really not going to school, but also the available opportunities to go to school. The country's resources are dwindling. From independence they never really financed

> postgraduate programmes. They always look forward to getting assistance from other countries for our citizens to the master's and PhD, but those opportunities have gone now and it's up to individuals now. (Respondent from the University of Swaziland)

The respondent continues by talking about the importance of PhD programmes and how the PhD students and the professor/expert engage in a process of 'building a body of knowledge' in whichever specialist field you are researching. This process is likened to forming the building bricks of knowledge that the respondent feels the university is not investing in at the moment:

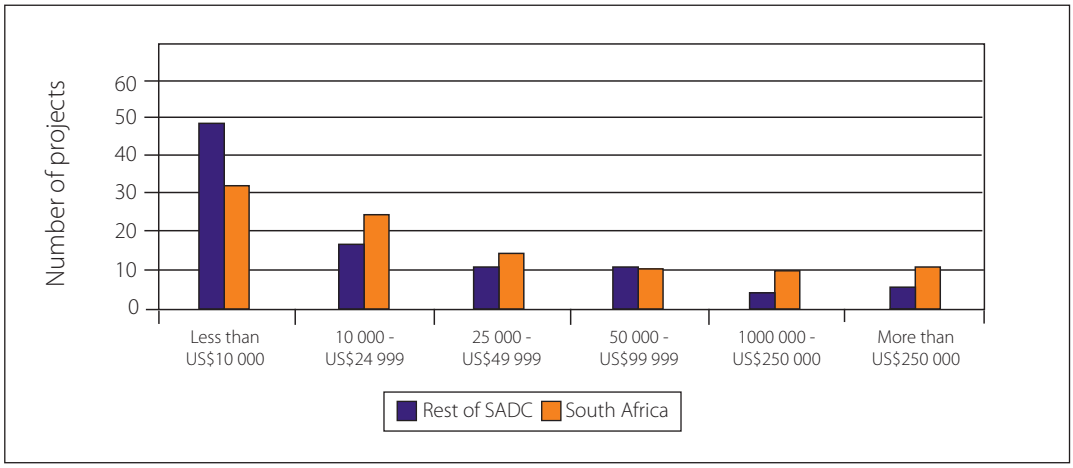
> Science cannot be based on nothing, it should be based on accumulated evidence. So, we don't have that. I feel we can do much better on that.

In order to sustain science and technology research programmes, institutions need long-term funding (three to five years). These kinds of funding opportunities are not always readily available to research institutions. In the case of the Tropical Diseases Research Centre (TDRC) in Zambia they have been able to secure long-term agreements with institutions in Belgium and the USA, where funding is guaranteed over that period of time. However, these kinds of agreements are not the norm, and they would like a greater number of these agreements to sustain the centre's research activities.

> Maybe one of the things is the memorandum of understanding between TDRC and institution of tropical medicine in Belgium and also another memorandum of understanding with institutions in USA. Those memorandums of understanding I think have a period, maybe five years so at least you're guaranteed that there will be some research activities and guaranteed funding over that period time. (Respondent from TDRC)
>
> I think it's not with all the organisations - some have long-term projects where they're employed within the MoU, but some are short-term projects, but we hope most of the MoUs that are going to be signed are going to be long so that we have assurance that we [are] going to have activities over a long period of time. (Respondent from TDRC)

We also asked our survey respondents to indicate to us what the average amount of funding is that they receive for their research projects. The responses provide further support for the differentiated picture that has emerged thus far. A comparison between South Africa and the rest of SADC shows a clear inverse correlation between amount and whether the respondent is from South Africa or another SADC country. The bigger amounts of project funding (above US$100 000) are more likely to be reported by South African respondents, with the majority of respondents from other SADC countries indicating that they receive on average less than US$10 000 per project.

Figure 13 Project funding



Concluding comments

The picture about involvement in research projects is a complex one. On the one hand, respondents on average are involved in more than two projects at any given time and in many fields this increases to three or four. Significant percentages of respondents indicated that they are involved in research that is jointly done with foreign collaborators, but it is also clear that South African scientists overall have more money for projects, which is a likely explanation for the fact that they engage in more stand-alone projects. South African scientists also seem to access the big funding as they were more likely to have projects with funding in excess of US$250 000 than their counterparts in other SADC countries.

The interviews, however, also paint a picture of huge teaching loads, lack of research interest in many institutions and a general lack of funding for the average scientist.

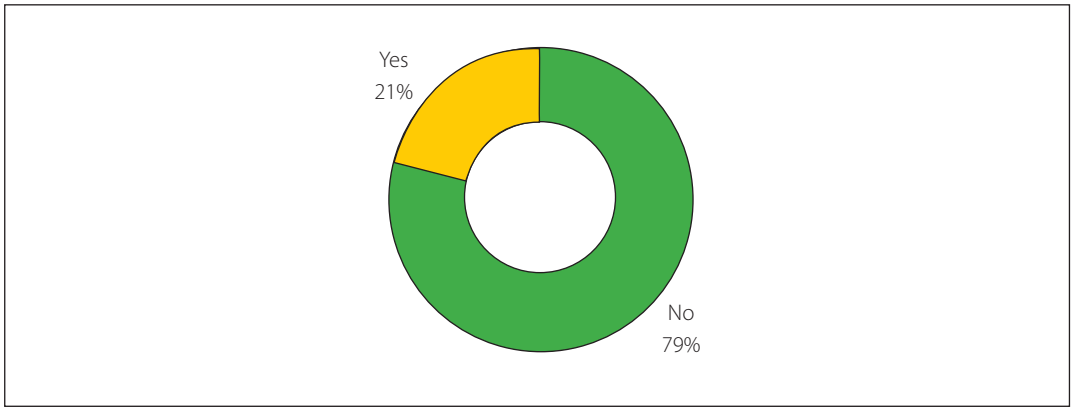
1.3.2 Human capital for science and technology

For a university to reproduce itself (and for science in the country in general), it needs both to train sufficient numbers of postgraduate students and also be able to retain them. The extent of the brain drain problem in Africa is well known, although not necessarily properly documented. We discuss both these issues – the retention and training of high-level human resources for science and technology – in this section.

Brain drain

In response to the question whether the respondent has any plans to move to another country in the near future (Figure 14), the vast majority (79%) replied in the negative. Having said this, it is not insignificant that one in five of the respondents indicated that they have such plans.

Figure 14 Indication of plans to leave country



The breakdown between South Africa and the rest of SADC countries (Table 22) reveals a significant difference in response with one in four of SADC respondents indicating that they have plans to move soon.

Table 22 Do you plan on moving to another country in the near future?

Country			Frequency	%	Valid %
South Africa	Valid	Yes	33	13,5	14,0
		No	202	82,8	86,0
	Missing	System	9	3,7	
	Total		**244**	**100,0**	
Other SADC countries	Valid	Yes	93	23,8	24,8
		No	282	72,3	75,2
	Missing	System	15	3,8	
	Total		**390**	**100,0**	

One of the countries in the region where the brain drain is especially severely felt is Zimbabwe. Various comments from respondents during the field visit there highlighted this as a major factor.

> People have left! Seasoned researchers have left! We cannot employ even part-time lecturers, because conditions are deplorable! Low salaries! Lack of transport! 60% of our staff has left. (Dean, University of Zimbabwe)

> We employ both women and men. We recruit only qualified staff regardless of gender, religious and political affiliations. Both earn the same. However, conditions are not as favourable as neighbouring countries, as a result they have left and it's difficult to retain remaining staff. We have changed the terms and conditions of employment, e.g. the age of retirement is no longer 65 but 70 years of age. We have since called back retired professors to uphold institutional values. To attract young academics, we also offer lecturing assistantships.

> Due to the withdrawal of donor funding, there have been adverse effects, e.g. staff is overstretched. Geophysics, mining, and the master's programmes are suffering. Many have left and engage in consultancy to boost their earning. Retired folk have been recalled. There is low morale, young people are deserting, conditions are poor, i.e. political and economic. (Respondent, Faculty of Science, University of Zimbabwe)
>
> Brain drain has severely affected us, we cannot get lecturers. (Respondent, Department of Engineering, Harare Institute of Technology)

The extent of the problem in Zimbabwe is illustrated by the huge number of Zimbabweans (nearly 480 000) that is estimated to be in the diaspora (see case study below).

The Scientific and Industrial Research and Development Centre (SIRDC) conducted a study entitled: An analysis of the cause and effect of brain drain in Zimbabwe (2003). The following is a summary of the findings of the study (SIRDC, 2003):

1 The study was able to establish that there are 479 348 Zimbabweans in the diaspora, although the study team is aware that there is a large number of diasporans that it could not contact. The diaspora destinations of a majority of Zimbabweans are the United Kingdom, Botswana and South Africa.

2 The highest proportion of respondents to the questionnaire were from Mashonaland (26,7%), while Manicaland contributed the least proportion of the respondents (15,1%).

3 The study shows that most of the respondents held bachelors degrees, followed by those who were polytech graduates. About 20% held master's degrees, while 5% held PhD degrees.

4 The health and teaching professions are the most affected, while accountants constitute a significant proportion (16,9%) of the total number of Zimbabweans in the diaspora.

5 More than half of the respondents emigrated due to work-related factors. About a quarter had emigrated due to the need to attend school in their new country of abode. A tenth gave marriage/relationship factors as the reason for emigrating, while 8% mentioned political factors.

6 The most common work-related reasons for emigrating given by 34,5% of the respondents, were the low salaries in Zimbabwe, followed by the exchange rate mentioned by 32,5%, while 29,0% gave better career advancement opportunities as a reason for emigrating.

7 The majority of the respondents (62,5%) intended to return to Zimbabwe. About a quarter of the respondents were not sure whether they would return to Zimbabwe or not.

8 All those in the clergy expressed a desire to come back to Zimbabwe after five years. Half of the farmers would like to come back within two years. Half of the nurses would like to return after five years, while 37,5% of engineers would like to return within two years.

9 Nearly half of the respondents in the middle age group clusters of 30 to 39 and 40 to 49 were not sure about when they were going to return home. About 40% and 33% of the young (20 to 29 years) and old (50+ years) respondents respectively, expressed a desire to return to Zimbabwe within the next two years. Less than a third of respondents in all age groups indicated a desire to return to Zimbabwe within three to five years.

10 Finally, the study also shows an increasing trend in the number of people leaving Zimbabwe. The trend exhibited by the curve suggests that the process has not yet leveled off.

Postgraduate training

The brain drain in many SADC countries is exacerbated by the fact that many students in the region do not study in their home country. From the perspective of building an indigenous reproductive capacity, the outbound mobility rate is an useful indicator, as it indicates what proportion of the (theoretical) student population is studying overseas, whether because of push factors (poor local facilities, lack of graduate programmes, and so on) or pull factors (scholarships, prestigious institutions, and so on). The countries with the highest outbound mobility rates in the region are: Lesotho (74%), Botswana (72%), Namibia (58%), Angola (46%), Mauritius (41%), Swaziland (32%) and Zimbabwe (30%). Students from Angola tend to go and study in Portugal. Students from Mauritius prefer studying in France as first choice. In both cases, South Africa is the second preferred destination. For the other countries in this list, South Africa is the first choice. This is also reflected in South Africa's inbound mobility number with nearly 50 000 foreign students studying in the country in 2004 (Table 23).

Table 23 International flow of students at the tertiary level (2004)

Country	Students from a given country studying abroad			Top five destinations for outbound mobile students	No. of students from abroad studying in given country	Net flow of mobile students	
	Total	Outbound mobility rate (%)	Gross outbound enrolment ratio			Total	New flow ratio (%)
Angola	5 942[-1]	45,9**	0,4**	Portugal (3 367)[-1], South Africa (839)[-1], USA (442), Namibia(354)[-1], France (205)	50[-1]	-5 892	-45,4
Botswana	9 471[-1]	71,6	4,5	South Africa(7 012)[-1], Australia (792), UK (700), USA (488), Malaysia (152)[-2]	n/a	n/a	n/a
DRC	3 956	6,6**	0,1**	Belgium (1 271), France (816), South Africa (378)[-1], USA (340), Burundi (276)[-2]	n/a	n/a	n/a
Lesotho	4 537[-1]	74,3	2,0	South Africa (4 366)[-1], UK (42), USA (39), Australia (15)	116[-1]	-4 421	-72,4
Madagascar	3 995	9,5	0,2	France (3 487), USA (109), Germany(100), Switzerland (80), Canada (41)[-4]	1 219	-2 776	-6,6
Malawi	1 438	28,3	0,1	South Africa (417)[-1], UK (404), USA (399), Australia (77), Canada (22)[-4]	n/a	n/a	n/a
Mauritius	7 224	40,6	7,0	France (1 893), South Africa (1 732)[-1], UK (1 646), Australia (860), India (366)[-1]	75	-7 149	-40,2
Mozambique	2 366[-1]	10,6	0,1	Portugal (1 066)[-1], South Africa (815)[-1], USA (93), UK (71), Australia (67)	n/a	n/a	n/a
Namibia	6 847[-1]	58,1	3,5	South Africa (6 530)[-1], USA (95), UK (74), Australia (24), Germany (16)	1 026[-1]	-5 821	-49,4
South Africa	5 619	0,8	0,1	USA (1971), UK (1 408), Australia (643), Cuba (340), Germany (196)	49 979[-1]	44 360	6,2
Swaziland	2 106[-1]	31,9	1,7	South Africa (1882)[-1], USA (86), UK (67), Lesotho (17), Australia (13)	127[-2]	-1 979	-30,0
Tanzania	3 907	9,1	0,1	USA (1 471), UK (1 053), South Africa (283)[-1], Australia (119), Germany (115)	275	-3 632	-8,5
Zambia	3 610	14,7**	0,3**	South Africa (1363)[-1], USA (859), UK (541), Australia (317), Namibia (228)[-1]	n/a	n/a	n/a
Zimbabwe	16 669[-1]	29,9**	1,1**	South Africa (10 586)[-1], UK (2 741), USA (1 999), Australia (892), Namibia (71)[-1]	n/a	n/a	n/a

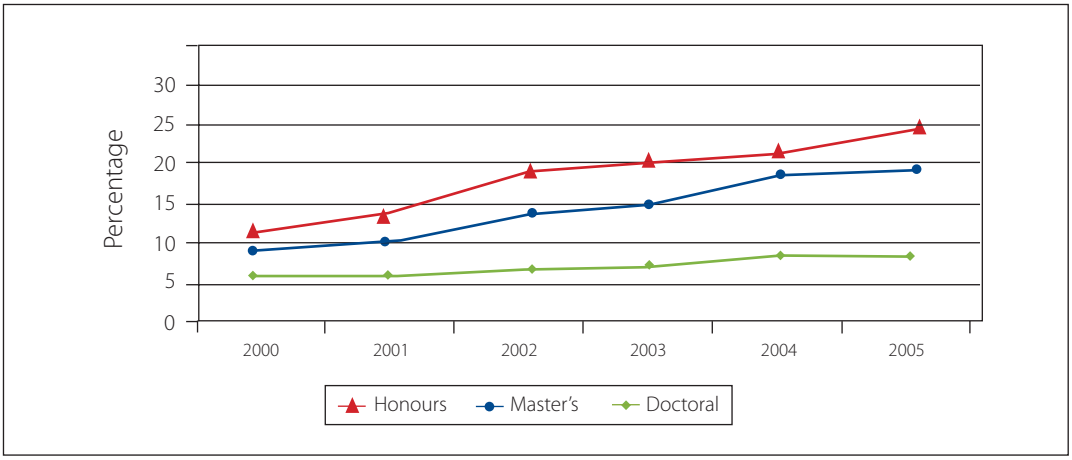
Source: UNESCO Institute for Statistics (2006:135-136)

Key to table

…	No data available
*	National estimation
**	UNESCO Institute of Statistics estimation
-	Magnitude nil or negligible
.	Not applicable
(p)	Data for the reference year or more recent years are provisional
x	Data included in another category or column
+n	Data refer to the school or financial year (or period) in years or periods after the reference year or period
-n	Data refer to the school or financial year (or period) in years or periods before the reference year or period

In recent analyses conducted by CREST, we have focused on these patterns and trends at the postgraduate level in South Africa. Figure 15 below presents the proportions of non-South African (from SADC, other African countries, Europe or the rest of the world) graduates per qualification type, for the period 2000 to 2005.

Figure 15 Percentage of non-South African postgraduates per qualification (2000 to 2005)



Between 2000 and 2005, there has been a gradual increase in the proportion of non-South African honours graduates, from 6% in 2000 to 8% in 2005.

- For both master's and doctoral qualifications, the share of non-South African graduates increased more sharply than honours qualifications over this time.
- The share of non-South African master's graduates increased by 10% over this six-year period, from 9% in 2000 to 19% in 2005.
- The share of non-South African doctoral graduates increased by 14% over this six-year-period, from 9% in 2000 to 25% in 2005.

Table 24 disaggregates non-South African graduates in terms of their country of origin. Percentages are reported below:

- Of the non-South African honours graduates, the largest proportion comes from SADC countries (64% in 2000 and 72% in 2005). In this category there was a decline in students from Europe, from 19% in 2000 to 10% in 2005.

- As with honours, for master's qualifications, non-South African graduates came mostly from SADC countries (47% in 2000 and 45% in 2005, which shows a slight decline). Once again, as with honours, there was a decline in the share of master's graduates from Europe (from 22% to 14%).
- The share of doctoral graduates follows similar patterns to the other two qualifications where the largest share of graduates are from SADC countries (43% in 2000 and 32% in 2005), although there is a difference in that 37% of non-South African doctoral graduates come from other African countries. There has also been a significant decline (of almost 10%) in non-South African doctoral graduates from SADC and, conversely, a significant increase in graduates from other African countries (from 16% in 2000 to 37% in 2005).

Table 24 Percentage of non-South African postgraduates by region of origin and qualification (2000 and 2005)

Region of origin	Honours		Master's		Doctoral	
	2000 (%)	2005 (%)	2000 (%)	2005 (%)	2000 (%)	2005 (%)
SADC	64	72	47	45	43	32
Other African countries	11	11	21	27	16	37
Europe	19	10	22	14	19	15
Rest of world	6	7	11	14	22	16

We conclude this introductory section on key indicators with a table on the distribution of graduates from the SADC countries by field of study. Table 25 presents this information where available. Perhaps the most salient point is the fact that very small percentages of students study science and technology subjects. This is a serious matter for concern if these countries wish to become self-sufficient in the provision of adequate numbers of engineers, doctors, scientists and technologists.

Table 25 SADC postgraduates by field of education (2004)

Country	Total number of graduates		Science and technology fields		Other fields	
	Total	% Female	Total (%)	% Female	Total (%)	% Female
Angola	172	41	19	41	78	41
Botswana	Not available	Not available	Not available	Not available	Not available	Not available
DRC	Not available	Not available	Not available	Not available	Not available	Not available
Lesotho	1 319	Not available	4	Not available	62	Not available
Madagascar	6 652	47	22	34	78	51
Malawi	Not available	Not available	Not available	Not available	Not available	Not available
Mauritius	4 151	53	26	33	74	60
Mozambique	2 878	35	15	23	85	38
Namibia	1 981	56	6	35	79	56
South Africa	109 685	58	16	36	84	62
Swaziland	1 026	54	6	43	94	55
Tanzania	4 028	Not available	21	Not available	59	Not available
Zambia	Not available	Not available	Not available	Not available	Not available	Not available
Zimbabwe	Not available	Not available	Not available	Not available	Not available	Not available

Source: UNESCO Institute for Statistics (2006:144-147)

Our discussion thus far has focused on public science at the country level. There are large differences between particular universities. To illustrate some of these, we present four brief institutional descriptions: Agostinho Neto University (Angola), the University of Botswana, the National University of Lesotho and the University of Dar es Salaam.

The first postgraduate courses at **Agostinho Neto University** started in 2002 with only 15 master's degree programmes courses. These courses were attended by 454 students – 40% of whom were Agostinho Neto University professors. Likewise, three doctorate projects are also in progress in the Chemical and Environmental Laboratory Engineering Centre of the Faculty of Engineering. The doctorate projects are in the areas of environmental engineering, medicinal plants and processes (www.uan-angola.org/).

The **University of Botswana** offers programmes for master's and doctoral degrees following the establishment of the School of Graduate Studies. The first graduate programme at the university was introduced in 1983. Today, more than 35 master's and eight doctoral programmes are offered. Currently there are over 700 graduate students. Master's enrolments increased from 308 in 1998/99 to 899 in 2005/06. Doctoral enrolments over the same period increased from 3 to 32. The overall output for the university was 3 417 during the 2004/05 academic year. Of these, 32% were undergraduate certificates and diplomas, 51% undergraduate degrees, 13% postgraduate diplomas, and 4% at master's/MPhil/PhD level (University of Botswana, 2006:7).

The university's enrolment growth strategy for the next two strategic plan periods places great emphasis on increasing both the proportion and absolute number of graduate students. In particular, it is envisaged that by 2015, 1,5% of the student body should be MPhil/PhD students, rising to 3% by 2021. The target for 2015 is 250 MPhil/PhD students. Growing the student body will be a key task for the School of Graduate Studies and for the professoriate, and the university will approach the government to establish a scholarship scheme for citizen graduate study. However, it will be important not only to focus on increased numbers, but also to ensure high quality MPhil/PhD supervision and good completion rates. Attention will also be given to improved research training at the senior level of undergraduate programmes and in master's programmes in order to strengthen the potential of students to follow research careers (University of Botswana, 2008).

The information for postgraduate level at the **National University of Lesotho** shows that the composition of the postgraduate student body in 2002/2003 comprised 129 students. The majority of these were in law (100) and the social sciences (15). The 2006/07 calendar of the university indicates the following PhD programmes which students can apply for: Agricultural Economic and Rural Sociology, Crop Science, Soil Science, Philosophy, English Language and Linguistics, Theology and Religious Studies, and Sociology.

In an effort to address the quality and number of PhDs at the university, a workshop on "Demystifying the PhD" was held in 2008. Participants were the ten holders of Kellogg Foundation grants for doctoral studies, all of whom are university staff members, and other members of staff and students who

recently embarked or were about to embark on a PhD programme. Feedback recommended that workshops of this kind be held on a regular basis (perhaps once every three years), focusing especially on topics such as constructing a research proposal and relating to one's supervisor (National University of Lesotho, 2008).

Tanzania has about 21 universities, of which eight are public, and the remainder private. The student population was appallingly low, but this situation has improved in recent years. Registration of postgraduate students at the **University of Dar es Salaam** in 2005 came to 223, comprising 218 master's and five doctoral students.

Concluding comments

The development of human capital for science and technology in the region remains one of the biggest challenges. The fact that nearly a quarter of our respondents from SADC countries other than South Africa indicated that they are considering moving to another country is yet another indication of the pervasiveness of the brain drain problem in the region. The interviews furthermore attested to the devastating effects of the diaspora in many countries (Zimbabwe is a case in point) where the human capital base has been eroded to the point where effective research and teaching is barely possible.

Our findings also highlighted the mobility of high-level students in the region where students in many countries do not study in their home country, but prefer (both because of lack of postgraduate teaching programmes and resources) to study elsewhere (and most notably in South Africa). There are also positive signs as an increasing number of the top universities in these countries (such as the University of Dar es Salaam, the University of Botswana and Agostinho Neto University in Angola) are introducing master's and doctoral programmes and setting up offices for postgraduate studies to counteract this flight of students.

1.3.3 Institutional research building and consultancy work

A key tenet of the de-institutionalisation thesis maintains that many academics in developing countries – because of various resource constraints, lack of meaningful research opportunities, inadequate scientific infrastructure and equipment, and woeful salaries – are forced to augment their income through, amongst others, doing consultancy work. As far as we are aware, very little research has been done on this topic in the region. We therefore included a number of questions aimed at establishing the extent, nature and reasons behind consultancy work.

As far as the extent of consultancy work is concerned, the majority of our survey respondents (62%) indicated that they are involved in consultancy of some kind. The proportions of respondents by country that indicated that they engage in consultancy range from 50% (Lesotho) to 72% (Malawi and Zimbabwe). (Note: Given the small country responses for Angola, Lesotho, Mauritius and Swaziland, we would not place too much emphasis on these findings.)

Table 26 Do you consult? (By country)

Country	Do you do consultancy? (n=621)			
	Yes		No	
	Count	%	Count	%
Angola	1	50,0	1	50,0
Botswana	31	62,0	19	38,0
DRC	20	71,4	8	28,6
Lesotho	4	50,0	4	50,0
Madagascar	23	62,2	14	37,8
Malawi	34	72,3	13	27,7
Mauritius	8	61,5	5	38,5
Mozambique	19	100,0	0	0,0
Namibia	20	57,1	15	42,9
South Africa	129	54,0	110	46,0
Swaziland	8	50,0	8	50,0
Tanzania	35	66,0	18	34,0
Zambia	17	70,8	7	29,2
Zimbabwe	36	72,0	14	28,0
Total	**385**	**62,0**	**236**	**28,0**

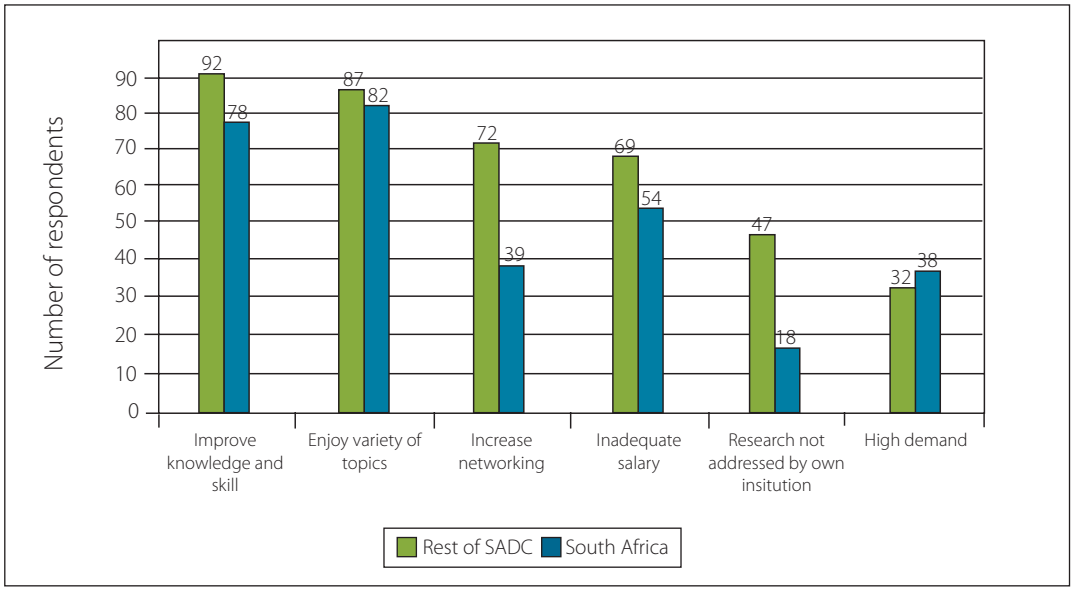
In what types of consultancy are the respondents involved? Based on follow-up responses it transpired that:

- 21% indicated that they do consultancy for academics in their country;
- 8% said that they consult for academics in other African countries;
- 7% do consultancy for academics in non-African countries;
- 36% consult for their governments;
- 8% consult for governments of other African countries;
- 30% consult for the industry sector in their country; and
- 4% consult for industry in other African countries.

What are the main reasons respondents provided for engaging in consultancy? Figure 16 presents a comparison of the South African and other SADC responses. There are some noticeable (and statistically significant) differences. In two areas we noticed very little difference: firstly, the fact that consultancy is undertaken because the respondent enjoys the variety of topics that this brings (87% vs 82%); secondly, that consultancy is done because of the demand in the market (32% vs 38%). The other reasons given demonstrate large differences between South African and other respondents:

- Inadequate salary is cited as a reason by more SADC respondents: RSA (54%)/SADC rest (69%).
- Consultancy advances my networks and my career: RSA (39%)/SADC (72%).
- My research interests are not addressed by my own institution: RSA (18%)/SADC (47%).
- Consultancy improves my knowledge and skills: RSA (78%)/SADC (92%).

Figure 16 Reasons for consultancy



A further breakdown by scientific field revealed significant field differences, but mostly in the expected direction (Table 27). Respondents in very applied fields (where there are close links with industry and also government) such as applied sciences and technologies, earth sciences, engineering, material sciences and social sciences (with policy work), reported high percentages of consultancy engagement. In other fields, such as mathematical sciences, few consultancy opportunities exist.

Table 27 Consultancy by scientific field

Scientific field	Yes		No	
	Count	%	Count	%
Applied sciences and technologies	76	68,5	35	31,5
Arts and humanities	43	63,2	25	36,8
Biological sciences	88	57,1	66	42,9
Chemical sciences	33	51,6	31	48,4
Earth sciences	42	76,4	13	23,6
Economic and management sciences	31	77,5	9	22,5
Engineering sciences	48	84,2	9	15,8
Agricultural sciences	91	69,5	40	30,5
Environmental sciences	102	73,4	37	26,6
Health sciences	77	67,5	37	32,5
Information and communication technologies	30	61,2	19	38,8
Marine sciences	11	55,0	9	45,0
Material sciences	18	81,8	4	18,2
Mathematical sciences	14	36,8	24	63,2
Medical sciences: basic	27	52,9	24	47,1
Medical sciences: clinical	24	57,1	18	42,9
Physical sciences	21	53,8	18	46,2
Social sciences	98	76,0	31	24,0
Other	24	58,5	17	41,5

Interviews in some countries revealed interesting new developments and views on the matter of consultancy.

The University of Malawi, in its Policy on Research and Consultancy, has developed guidelines for consultancy and contract research. However, the required institutional structures (e.g. University Directorate of Consultancy Services and College Consultancy Bureau) are not yet in place and may even differ for the five constituent colleges, depending on own initiatives. Nevertheless, the relevant extract from the policy goes as follows:

a. Consultancy and contract research projects will be sourced through the University Directorate of Consultancy Services, College Consultancy Bureau, departments, faculties, research entities, or by individual staff.

b. The University Directorate of Consultancy Services and College Consultancy Bureau will maintain a data bank of multi-disciplinary expert groups, including the curriculum vitae of individual members.

c. The University Directorate of Consultancy Services and College Consultancy Bureau will make bids for consultancies by mobilising available expertise to formulate proposals for the bids and submit these in a timely manner.

d. The University Directorate of Consultancy Services and College Consultancy Bureau will mobilise available expertise to respond in a timely manner where clients make approaches to offer sponsored, contract and commissioned activities.

e. For consultancy work that has been mobilised through the University Directorate of Consultancy Services and College Consultancy Bureau, consultants will be required to pay to the university 25% of the net amount realised from the consultancy, to be distributed as follows:
   i. 10% will go to the department;
   ii. 5% will go to the faculty; and
   iii. 10% will go to the University Directorate of Consultancy Services and College Consultancy Bureau.

f. For consultancy work that has been mobilised by individuals, departments, faculties, and research entities, the 25% will be distributed as follows:
   i. 10% will go to the department;
   ii. 10% will go to the faculty; and
   iii. 5% will go to the University Directorate of Consultancy Services and College Consultancy Bureau (UNIMA, 2006).

Respondents from universities in Zimbabwe commented in different ways about consultancy:

> As a private university [Africa University], we emphasise not only teaching, but [also] consultancy. Through these activities we make a positive impact in the surrounding community in terms of "applied research" vs "basic research" and "educational" vs "monetary value".

> I do consulting work in financial management for the environment on a personal basis. Sometimes I have contracts lasting as a long as three years.
>
> HIT does consulting work for industry, especially for food companies that want to come up with nutritious products to be used in home based care for AIDS victims.
>
> We have the best facilities, e.g. laboratories (even though they need upgrading) in the country. For this reason we engage in consultancy.

Individual researchers are also involved in consulting work, as mentioned by a respondent from the University of Zambia, due to the poor remuneration from their institution. Consultancy provides researchers with additional income, yet does not contribute to the university's research activities or to the researcher's prospects of promotion.

> I would rather do consultancy you see, so you find a lot of people that are going to research consultancies. It brings you money; you might get twice the amount you get in a month … Yeah, you can't do research when you are starving.

Concluding comments

Consultancy is widely prevalent across the region – whether people see it as a positive form of academic work (to enrich themselves, to increase their networks, to transfer knowledge to industry), or as a necessity borne out of poor academic salaries and working conditions. The challenge for universities in the region is to ensure that such activities do not further undermine and weaken the already fragile base of many scientific institutions.

1.3.4 Scientific collaboration or new forms of dependency?

The extent of scientific collaboration

Our discussion on scientific collaboration in the region begins with a look at the results of bibliometric analyses of collaboration based on co-authorship patterns of ISI-papers.

We have analysed the collaboration patterns of the five most productive SADC countries (South Africa excluded[7]). In each case we list the top 10 countries (in descending order) with whom scientists in that country have collaborated over the past 18 years.

It should perhaps not come as a surprise that collaboration with the most productive countries in the world (USA, UK, Germany and other European countries) is at the top of the list of each country. In addition, collaboration with countries such as Canada, Sweden and the Netherlands may also be influenced by the role of donor agencies in these countries. Collaboration within the region is not extensive, except with South Africa (which figures in four of the five country tables) and Kenya (which figures in three of the country tables).

7 Given the size of South Africa's output and the fact that our database on South African science includes output in local journals, it would seriously distort any picture on scientific collaboration in the region.

Table 28 Collaboration of Botswana authors

Botswana	Total	1990-1995 (%)	1996-2001 (%)	2002-2007 (%)	Average (%)
USA	248	8,2	8,3	18,0	13,2
South Africa	166	2,9	5,1	13,2	8,9
UK	116	5,4	4,6	7,5	6,2
Australia	62	0,4	2,5	4,8	3,3
Germany	51	1,1	2,6	3,3	2,7
Norway	46	0,0	1,4	3,9	2,5
Canada	41	0,7	0,9	3,5	2,2
Sweden	41	1,4	3,2	1,7	2,2
Cameroon	40	0,00	2,0	2,9	2,1
Netherlands	36	3,2	0,9	2,2	1,9

Table 29 Collaboration of Malawian authors

Malawi	Total	1990-1995 (%)	1996-2001 (%)	2002-2007 (%)	Average (%)
UK	581	17,2	27,9	35,3	29,0
USA	554	25,2	25,2	30,6	27,7
Netherlands	109	2,4	6,3	6,3	5, 5
Switzerland	81	3,8	5,2	3,4	4,1
South Africa	79	0,00	2,1	7,1	4,0
Australia	65	0,5	3,1	4,7	3,3
Tanzania	56	0,9	1,8	4,3	2,8
France	53	1,7	1,8	3,7	2,7
Germany	48	2,4	2,4	2,4	2,4
Canada	46	1,4	3,2	2,1	2,3

Table 30 Collaboration of Tanzanian authors

Tanzania	Total	1990-1995 (%)	1996-2001 (%)	2002-2007 (%)	Average (%)
UK	992	16,2	17,4	24,9	20,6
USA	964	13, 8	15,1	26,3	20,0
Sweden	384	6,1	10,2	7,5	8,0
Switzerland	357	4,7	8,1	8,4	7,4
Netherlands	337	7,2	6,6	7,2	7,0
Denmark	291	3,6	6,8	6,8	6,0
Kenya	242	3,2	3,8	6,8	5,0
Germany	212	3, 5	4,3	5,0	4,4
Norway	189	3,2	3,3	4,7	3,9
Canada	165	2,4	4,0	3,6	3,4

Table 31 Collaboration of Zambian authors

Zambia	Total	1990-1995 (%)	1996-2001 (%)	2002-2007 (%)	Average (%)
USA	437	15,5	18,2	37,9	25,4
UK	341	14,5	26,3	18,8	19,8
Belgium	99	2,2	5,6	8,5	5,7
South Africa	97	1,0	6,4	8,5	5,6
Japan	86	3,6	7,3	4,3	5,0
Kenya	71	2,9	4,1	5,0	4,1
Zimbabwe	70	2,0	4,1	5,6	4,1
Switzerland	63	2,8	5,0	3,3	3,7
Sweden	49	2,4	4,4	2,0	2,8
Netherlands	47	0,6	4,4	3,0	2,7

Table 32 Collaboration of Zimbabwean authors

Zimbabwe	Total	1990-1995 (%)	1996-2001 (%)	2002-2007 (%)	Average (%)
USA	761	10,9	19,9	20,1	17,0
UK	569	11,0	14,7	12,3	12,7
South Africa	343	2,5	8,0	12,6	7,7
Netherlands	215	2,7	4,6	7,1	4,8
Kenya	137	1,4	3,5	4,3	3,1
France	129	1,7	2,9	4,1	2,9
Switzerland	126	1,3	2,8	4,3	2,8
Sweden	123	2,3	2,5	3,5	2,8
Canada	121	1,7	2,8	3,6	2,7
Denmark	118	0,7	2,8	4,4	2,6

The nature of collaboration

Bibliometrics cannot provide qualitative information on the nature of scientific collaboration as such. To get a better idea of whether collaborations are equitable (between equal partners) and mutually beneficial, we turn to the responses to our survey.

What kinds of research activities are performed jointly with other scientists and researchers? The responses in descending order are:

- joint publication of research (81%);
- joint execution of research (77%);
- joint conceptualisation and planning of research (67%); and
- joint writing of funding proposals (62%).

A comparison between the South African responses and those from the other SADC countries reveals a very systematic pattern – scientists and scholars from the other SADC countries are involved in many more joint activities across the whole spectrum of the research process (from conceptualisation and writing of proposals to execution and publication (Table 33)) than their South African counterparts.

Again, we would suggest that this collaboration is a correlate of the fact that scientists in these countries co-operate more internationally because of their greater reliance on overseas funding. A manual inspection of the articles in question reveals, for instance, that the principal author (usually listed first) in the vast majority of these cases is not from a country in the SADC region, but from an overseas country.

Table 33 Joint research activities – South Africa and other SADC countries

		Country		
		South Africa	Other SADC country	Total
Yes	Count	151	240	391
	Joint writing of funding proposals (%)	38,6	61,4	100,0
Yes	Count	184	241	425
	Joint conceptualisation/ planning of research (%)	43,3	56,7	100,0
Yes	Count	193	294	487
	Joint execution of research (%)	39,6	60,4	100,0
Yes	Count	212	300	512
	Joint publication of research (e.g. writing reports, articles) (%)	41,4	58,6	100,0

Two other questions that were posed to respondents allowed us to further probe this issue. We first asked respondents who collaborate to indicate who takes primary responsibility for the writing of an article (Table 34). A second question asked them to indicate who takes the decision to publish the article (Table 35).

Table 34 Responsibility for writing of articles – South Africa and other SADC countries

			Country		
			South Africa	Other SADC countries	Total
One or more of my research collaborators normally take responsibility for the writing of an article	True	Count	8	49	57
		% within South Africa versus rest	12,9	33,6	27,4
	False	Count	54	97	151
		% within South Africa versus rest	87,1	66,4	72,6
	Total	Count	62	146	208
		% within South Africa versus rest	100,0	100,0	100,0

Table 35 Decision to publish article – South Africa and other SADC countries

			Country		
			South Africa	Other SADC countries	Total
My research collaborators normally decide in which journal to publish	True	Count	5	47	52
		% within South Africa versus rest	8,1	32,0	24,9
	False	Count	57	100	157
		% within South Africa versus rest	91,9	68,0	75,1
	Total	Count	62	147	209
		% within South Africa versus rest	100,0	100,0	100,0

The findings from these analyses seem to confirm the view that – for many SADC scientists – the 'locus of decision-making' in collaborations with foreign scientists lies with the collaborating author. Although two thirds of respondents in both cases indicated that they take responsibility for the writing of the article or where to publish, it is in the comparison with the South African respondents where the differences are stark (approximately 90% of respondents saying that they take these decisions).

During our site visits we encountered references to strong international collaborations. So, for example, we found in Madagascar that the National Botanical Gardens partners with foreign universities and institutions in Belgium and the United States.

> In addition, we also have partners from foreign universities. For example, the thesis I mentioned earlier was undertaken in collaboration with the Royal Botanic Garden Scheme of Belgium, as well as the Historic Botanical Garden of the United States, I believe.

Another respondent from Madagascar (Madagascar Institute for Animal Vaccines, Ministry of Science, Technology and Vocational Training), however, said that there were simply no funds available for collaboration with SADC countries. The financial costs incurred through travelling to other SADC countries were simply not part of their budget.

> There is no financing for collaboration. To write here in Madagascar, one has to pay for support. As far as I am concerned, to go elsewhere, it costs too much and I don't have the finances for that.

These sentiments were also expressed during an interview with a respondent in Zambia:

> **Interviewer:** What recommendations do you have for collaboration with your university and other universities? Should collaboration between African universities be managed differently to collaboration between African and European universities for instance?

Respondent: Well the African universities, outside universities, for example outside Africa, they bring with them funds, and that is a little bit of a problem. If African universities had funds, we would collaborate beautifully well, yah. University of Cape Town for example, Durban University, University in Pretoria and WITS, so we do get to send some of our young scientists there. So when they come back they get to do research on a professional basis.

Interviewer: OK, so the funding is a problem?

Respondent: It is a problem yes. That's right, I don't think that most of the universities in Africa would fund their own reseach. But on the other hand there are marked ... When you do research you have marked centres, marked centred research. I mean where you have Tanzania, Kenya, Uganda and Zambia doing research together. So in that aspect we do also collaborate, although the funding might be from elsewhere. (University of Zambia Medical School, Chintu)

A respondent from the University of Antananarivo felt that the language barrier restricted collaboration with other SADC countries. To remedy this problem the university is in the process of implementing an English programme for all the courses of study at the university to facilitate trans-continental communication.

A director of a research centre at the University of Malawi expressed a clear preference for a collaborative model based on equality, where all partners participate in the conceptual stage and assume joint ownership of the collaboration.

What the kind of collaboration is we really value is whereby you start from the concept – two, three people sitting down, two, three centres sitting down and starting from the concept, thereby saying this is what we should do, this is the proposal that we should develop and send it to this, you start from there. You create the budgets, you send the proposal, everybody knows what their roles are within that – that we have managed to do. But also we have had collaboration where some other organisation has managed to get funding and they want a junior party. They will come and just say that we have this funding, kind of sub-contracting. It's a collaboration, but it's not what we prefer. What we prefer is that we are there at the design stage.

We also had these regional networks, whereby you are part of the network and then funding comes as a pool and everybody does their bits and pieces. That we also welcome in terms of the regional network. There's one on poverty, the poverty network, poverty environmental network. There's a business experiences network. There you have a pool of people doing bits and bits region wide, that we prefer … I think I would say the network approach is better, on a regional basis. We have a problem we would like to look at, say, what is the state of wetlands in the SADC. Then we have a number of collaborating institutions, we write a general proposal, we send it for funding, maybe three, five years, and then everybody knows what their roles are. That would be a preferred model. If it's not a network, maybe two research centres or two institutes coming together, but starting from the conceptual.

Research collaboration is also seen as an entry point to compete successfully for international funding:

> I think that for us to sustain ourselves we need to collaborate more with institutions outside the country. I think that is one area we have not done very well in. It would be very difficult for us to compete for major … for big funding, very, very difficult. But when we collaborate with more established institutions we are likely to attract more funding.

The capacity strengthening aspects of scientific collaboration also need to be stressed. One particular collaborative effort is the Johns Hopkins Project at the College of Medicine, Malawi, where researchers from the College of Medicine submit grant applications together with researchers from Johns Hopkins University – applications that are funded by the National Institutes of Health (NIH), Communicable Disease Centre (CDC), etc.

> Most of the investigators come straight from a clinical background and have not really done research and publication, so it has been a process of learning and this has happened mostly in the past five years or so … [R]egistrars or interns in the hospital or those who are in the College of Medicine, those would be assigned to a project to work with a PI and that's the sort of system that we have … So the research provides them with something extra, because their consideration for promotion is dependent on research publications and without that they basically remain junior staff within the University of Malawi. And that's not attractive to anyone, so I would say that it [the Johns Hopkins collaborative effort] helps keep them here in the country … [I]t [also] provides the support and the guidance on how to apply for grants.

In terms of collaborating with other countries, it seems the University of Swaziland has a relatively close working relationship with various institutions in South Africa and other African countries.

> … different departments, work very closely with some universities in South Africa and other countries in Africa. We are in contact with what is happening around Swaziland in terms of, you know, working with NGOs.

As the respondent explains below, one seemingly common way for collaboration to come about is through the informal or professional networks that academics from institutions have with one another across countries, which often come from maintaining contact with a supervisor after studies that have been pursued abroad,

> It's where I did my PhD [University of KwaZulu-Natal]. I still go there to work with my supervisor and the Durban group. I was hooked up by my supervisor with his friends, people he also works with sometimes at UNISA … there are three of them and I have become the fourth. We also use the internet. When you are trying to work on something and something comes up, you contact them via e-mail.

A respondent from Zambia also had some ideas on furthering more regional collaboration:

> Well you see collaboration can be at an individual level for the major issues, but there must be a stronger driving force at a higher level. And regional units as we have seen from other countries on the continent make a very big difference in that regard. You can if you have priorities at a regional level. These are the critical areas that we see in the region, then you can say, well let's tackle this, how do we tackle this? We'll have a team … naturally you will collaborate. So it is the need that forces people to collaborate, not simply to be fair. Secondly, we need to have some leadership at a regional level. I am not obligated by my personal responsibility or institutional responsibility to have an agenda. But I feel regional bodies or units make a difference, and again I say, look at what other regions have done. Makes a very big difference, so to me those two. Have a region point for co-ordinating or whatever they may be doing, strengthen the issue over information sharing. (University of Zambia)

Concluding comments

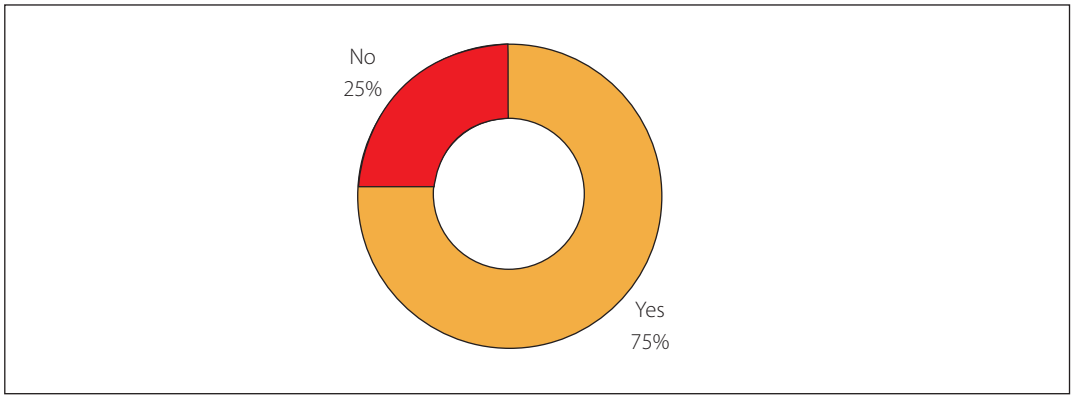
Our study provides strong evidence for collaboration in most fields of science in the region. The survey also points to meaningful collaboration in many areas where scientists collaborate on developing ideas jointly, submitting joint proposals and execute the publication of research. However, intra-regional collaboration amongst countries in the SADC region is evidently less than extra-regional collaboration. Collaboration is mostly with countries in the north – whether such collaboration is driven by well-established networks based on mutual interest, or by the availability of funding from donor agencies in the north (which often make collaborations with scientists in the donor country easier), is not clear.

The qualitative comments suggest that collaboration is still hampered by lack of funding for travelling and exchange of scholars in the region, as well as the lack of regional organisations that should play a more facilitative role in bringing scientists in the region together.

1.3.5 Scientific academies, associations and societies, and conferencing

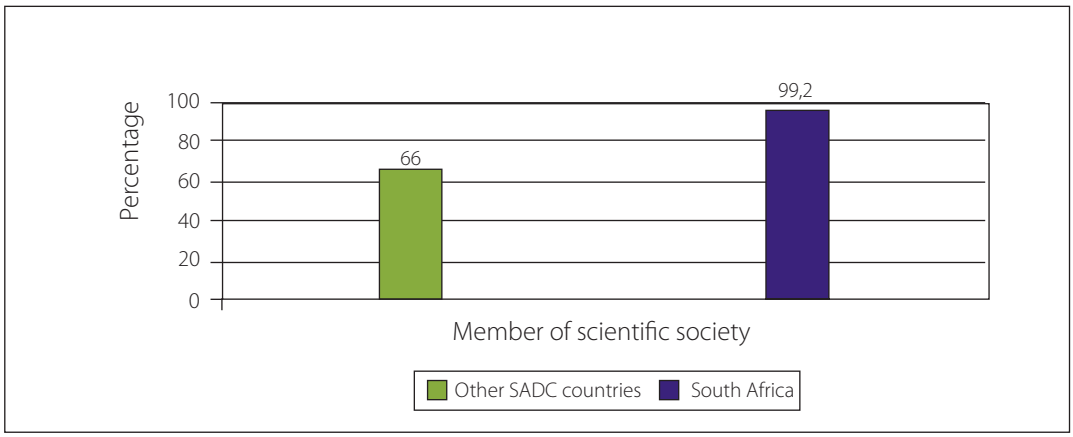
Scientific academies and professional societies are essential to the effective functioning of a science system. They are facilitative and co-ordinating structures to promote networking, the dissemination of information, knowledge transfer, as well as sites for the public inscription of science in a society (where science can be showcased in the public sphere) and in doing so promote and advance science amongst various stakeholders.

Figure 17 Membership of academic societies



How many of our respondents are members of a professional society or academy of science? Figure 17 shows that three quarters of the respondents indicated that they belong to a scientific society. This, in itself, is interesting, as one would expect that nearly every academic or scientist would belong to at least one scientific society. A comparison between South Africa and the rest of SADC again reveals big differences, with only two thirds of respondents from other SADC countries indicating that they are currently a member of a scientific society (Figure 18).

Figure 18 Member of a scientific society (% yes)



During our field visit to Malawi, we conducted a very interesting and informative interview with the President of the Association for the Advancement of Science and Technology in Malawi (AASTOM), which is worth quoting at length as it clearly illustrates some of the constraints that scientific societies face in the region.

> The association was initiated in the 1963-65 period. At that time it was felt among few scientists and academics that it was necessary as a country that we have a body that can co-ordinate all research activities … The idea was to allow the various scientists and academics to come together, share their research work, research, discuss that and

out of that to … come up with the technologies that can directly be used in Malawi, in different sectors of the society. It [AASTOM] was basically [originally] for Agricultural Sciences and the Engineering and to some degree, much more on the basic sciences of economic industry. Now it has expanded to include the social sciences, the medical sciences, general natural resources, science-based education and everything. [W]e have expanded the original mission to include also aspects of capacity building in which we're having, you know, people coming from school being mentored to do some good research work that can benefit the country. But also, we are focusing more on addressing issues that are topical for the country.

It [AASTOM] is very much aligned to the Malawi Growth and Development Strategy areas and also targeting the national government focus area of development, so we encourage the scientists to work in areas that can help contribute to the national… solving national problems. So that's the … what we're currently to do, and the idea of all ... inviting all, we normally have annual conferences where these scientists, they mix, they can notice the policy makers, even some captains of the industry are invited. There are presentations, demonstrations of what must have come out of the various research. And then there's a lot of discussion after that, and from that, there's some areas that are very much promising, advised to stay with that to come up with something that can be useful.

We have an Executive Committee, which is elected, and this Executive Committee includes the President, the Executive Secretary and the Treasurer. Those are the original functional organs that man the Association. We do it on a voluntary basis because we do not have a secretariat, a functional secretariat with full-time employees. I think that's one of the maybe contributory factors that we have not been able to keep on sustaining the AASTOM activities, as we wished to have been the case. At the moment, I don't know exactly [how many members there are] ... But, as of last time, I think it was in the excess of two hundred.

So, at the moment, I would say [AASTOM] is not growing, but we intend to keep on maybe revitalising it when we are trying to solicit the resources. [W]e have plans to even elevate it to the National Academy of Science. So once we get to that, after this coming annual conference [in December 2008], then we hope to establish a functional secretariat and also have a full time secretary for administration and communication, because we think that science and technology, now, people including government, are appreciating the role it can play to develop a country. Because in the past, when we were talking about science and technology, rarely support and even appreciation was there for what we are talking about, see it maybe as a waste of money and that. But now, I think they … starting from government to many people and institutions have come to appreciate that science and technology is key to development, you can't go anywhere without it. So with that realisation and support, we think we should be able to get AASTOM on track and get more and more people subscribing to it as members, but also to get considerable support, even from government, to run the association's activities.

And we also want to promote, specifically for women scientists, you know, to be part of the whole scientific community in Malawi and contribute to the science and technology

> development. The only … difficulty we have run into in the past is that we make such appeals, but very few come forward. This is reflecting the overall picture of the country that you may have fewer women scientists.
>
> [Funding has] been the major, major constraint. We have big ideas … elevation to an Academy of Science and Technology, you know, have, you know, annual conferences, where we are prepared to invite as many people as possible, but we cannot do it, when we don't have the funds. That's the major bottleneck we face.

Attendance of conferences is another form of networking that strengthens the institution of science. When asked to indicate how many conferences they attend on average per year, the comparison between South African respondents and the other SADC countries revealed interesting differences again (Table 36). Respondents from South Africa consistently indicated that they attend more conferences – 72% attending at least two conferences compared to 52% from other SADC countries.

Table 36 Number of conferences attended per year

			Country		
			South Africa	Other SADC countries	Total
On average, how many conferences do you attend per year?	None	Count	3	42	45
		%	1,3	11,6	7,5
	1 conference	Count	60	131	191
		%	25,4	36,3	32,0
	2 conferences	Count	104	112	216
		%	44,1	31,0	36,2
	3 or more conferences	Count	69	76	145
		%	29,2	21,1	24,3
	Total	**Count**	**236**	**361**	**597**
		%	**100,0**	**100,0**	**100,0**

Table 37 Location of conferences attended per year

			Country		
			South Africa	Other SADC countries	Total
Where are the conferences located?	All in my own country	Count	3	39	42
		%	1,3	12,9	7,9
	All in foreign countries	Count	17	33	50
		%	7,5	10,9	9,4
	In both my own country and foreign countries	Count	208	231	439
		%	91,2	76,2	82,7
	Total	**Count**	**228**	**303**	**531**
		%	**100,0**	**100,0**	**100,0**

Concluding comments

Scientific networking occurs in many forms. Scientific societies and scientific conferences are two of the normal forms of networking. The findings from our study again confirm that scientists in the region – and more so outside South Africa – are constrained by lack of funding in fully utilising the opportunities and value that such forms of networking offer. The fact that a third of respondents from other SADC countries (and these are active scientists) are not members of a single scientific society or academy of science and that 12% of this group indicated that they do not attend a conference in an average year, is an indication that normal scientific practice is not the norm in many of these countries.

1.4 The visibility of academic science in the SADC region

There are a number of reasons why science produced in Africa tends to be less visible on the international stage. Firstly, the competition for being published in the top (high impact) journals in any field is extremely strong. Most scientists only manage to publish in these journals when they form part of large collaborating teams, which are usually based in the most prestigious universities in the north. Secondly, the vast majority of local journals – especially in the social sciences and humanities – in many developing nations are not indexed in the big bibliographic indexes such as Medline or the ISI citation databases. We therefore set out to find out where scientists in the region publish and what the reasons are that motivate them to publish in particular journals and not in others.

In response to the first questions, the vast majority of respondents indicated that they publish in journals, although the difference between South African respondents (98%) and other SADC respondents (86%) responding in the affirmative is noticeable.

Table 38 Publication in journals

Do you publish articles in journals?						
Country			Frequency	Column %	Valid %	Cumulative %
South Africa	Valid	Yes	239	98,0	98,4	98,4
		No	4	1,6	1,6	100,0
	Missing	System	1	0,4		
	Total		244	100,0		
Other SADC countries	Valid	Yes	328	84,1	86,1	86,1
		No	53	13,6	13,9	100,0
	Missing	System	9	2,3		
	Total		390	100,0		

In a follow-up question, we asked whether they only publish in peer-reviewed journals. Interestingly enough, 76% of South African respondents compared to 54% of other SADC respondents said that

they only publish in peer-reviewed journals. A further 24% of South African respondents and 45% of other SADC respondents indicated that they publish both in peer-reviewed and non-peer-reviewed journals. The large proportion of other SADC respondents in the latter case might be an indication of lack of opportunity to publish in peer-reviewed journals. Anecdotal evidence gained from our field visits would tend to suggest that many journals in the region – especially journals published by a specific university department – are not peer-reviewed journals.

Another question addressed preferences to publish in local or foreign journals. As Table 39 shows, we found some interesting results. The biggest single group of South African respondents (36%) indicated that they prefer to publish predominantly (but not exclusively) in foreign journals with a further 21% saying that they only publish in foreign journals. Interestingly enough a larger proportion of the SADC respondents outside South Africa indicated that they only publish in foreign journals (27%), but the largest single grouping here (40%) indicated that they tend to publish equally in local and foreign journals.

Table 39 Publication preferences for local or foreign journals

Do you publish these peer-reviewed articles in local or foreign journals?						
South Africa versus rest			Frequency	Column %	Valid %	Cumulative %
South Africa	Valid	Only in local journals	9	3,7	4,1	4,1
		Predominantly, but not exclusively in local journals	22	9,0	10,0	14,1
		In both local and foreign journals	64	26,2	29,1	43,2
		Predominantly, but not exclusively in foreign journals	80	32,8	36,4	79,5
		Only in foreign journals	45	18,4	20,5	100,0
		Total	**220**	**90,2**	**100,0**	
	Missing	System	24	9,8		
	Total		**244**	**100,0**		
Other SADC countries	Valid	Only in local journals	20	5,1	6,6	6,6
		Predominantly, but not exclusively in local journals	17	4,4	5,6	12,3
		In both local and foreign journals	122	31,3	40,4	52,6
		Predominantly, but not exclusively in foreign journals	61	15,6	20,2	72,8
		Only in foreign journals	82	21,0	27,2	100,0
		Total	**302**	**77,4**	**100,0**	
	Missing	System	88	22,6		
	Total		**390**	**100,0**		

In a final follow-up question, we attempted to find out why respondents might prefer publishing in local

journals. In response to the question whether they would prefer publishing in local journals, because their research has a national focus, 56% of all respondents indicated some degree of agreement with this sentiment. Slightly more respondents from other SADC countries outside South Africa hold this view (62%), compared to their South African counterparts (48%). The vast majority of all respondents (75%) rejected the view that they publish in local journals because they tend to accept articles more readily than foreign journals.

Conversely, what are the reasons scientists prefer to publish in foreign journals?

- 84% said that they prefer publishing in foreign journals because they have more exposure;
- 78% said that they prefer publishing in foreign journals because their research field is of an international nature;
- 76% said that they prefer publishing in foreign journals because of their superior scholarly quality.

Our interviews during the country visits also generated some interesting perspectives on the matter of publishing. We present some illustrative examples below.

1.4.1 Madagascar

When asked whether researchers published journal articles within the Malagasy science and technology system, most of the individuals interviewed from the national research centres indicated that researchers were indeed publishing. In the case of the Centre National d'Applications et des Recherches Pharmaceutiques (CNARP), due to a lack of funds, the centre no longer produced their own internal journal, but researchers were still participating in international journal article output as co-authors.

> Yes. In terms of publications, there are especially high-level researchers, that is to say, the doctorates, at least, the researchers who have a doctorate participate in international journals, but I do not know exactly, but according to the information we have there are some who send their articles to international scientific articles. (Centre National de la Recherche Appliquée au Développement Rural – FOFIFA)

Those researchers who did publish were the ones who had more extensive collaborative networks. A problem that the researchers from the centre encountered was that once the research activities had concluded and journal articles were produced, the Malagasy authors did not feature and were forgotten by their French counterparts.

> Yes, we have internal publications, but they still need lots of attention … Especially the publications in English. As we are especially busy with the development of the population masses, thus we put all our efforts, we contribute our efforts to imparting know-how to the Malagasy population and to researchers who have to publish, they certainly have connections that are probably more extensive. For example, our researchers, the head of the laboratory and the head of the department, they have much more contact with

> outside researchers. However, very often that is the problem, for example, with French research organisations, very often the Malagasy authors do not feature. Once the publication is complete they are completely forgotten. (Madagascar Institute for Animal Vaccines (IMVAVET))

To improve the visibility of the institution the Centre National de la Recherche Appliquée au Développement Rural (FOFIFA) produces an internal journal of sorts, CAROCA. Researchers from the institution are encouraged to contribute to the journal, especially those who are working on their doctoral dissertations. Even though the journal is primarily for internal research results dissemination, its audience is far reaching – lecturers from the universities, students, groups of farmers, as well as directors of the relevant ministries have access to the journal based on their topics of interest.

> But here at the heart of FOFIFA, we have a journal called CAROCA. With CAROCA we encourage researchers to contribute … to write for this journal and there is also, it is not really a journal but an internal dissemination among FOFIFA and a system of publication regarding researchers who are preparing for example their memoirs of DUA, something like that in this article. The readers are mainly lecturer researchers, students, the directors of the relevant ministries. For example, we are now discussing the results obtained on manioc, for example. In this case, we have the agriculture ministry, the ministry responsible for statistics, for example, who are interested. There are farmers, groups of farmers, economic operators. So it varies a little according to the topic. (FOFIFA)

1.4.2 The Democratic Republic of the Congo

The ability to write research papers in English is seen as a major constraint among researchers in the DRC. As a result, some established researchers encourage their assistants and students to spend some time in an English-speaking country in order to master the language.

> Let us say that it is really not easy to publish in international journals. It is not easy. And the people, maybe, lack the courage because they [the reviewers] may say that no, your article has to be rewritten. So then you have to rework it and especially, so, good. Let us say that the big problem is English, because, for the most part … the most is English. And that is really the problem in our case … It is like that for me, all my assistants, I send them to … at least I send them to English speaking countries. So that they can also learn to speak the language and so that it is easier … As far as we are concerned, language is quite important. And also because of the fact that we do not have many researchers, certainly the volume of publications is quite restricted.

1.4.3 Malawi

Due to the fact that researchers at the University of Malawi engage in consultancy services and commissioned research, the institution's output is skewed towards unpublished research reports rather than research papers in peer-reviewed journals.

> We generally produce between three and five … articles for journals as the overall output for the Centre. It's not where I want us to be, we wanted maybe two, three papers per individual, but generally three to five end up into the academic journal on an annual basis. But we tend to produce a lot of reports. Whether it's commissioned research reports or the annual reports, there is quite a lot of that and most of the commissioned research does not end up in journals.

Publications in peer-reviewed journals serve as criteria for promotion in most institutions in Malawi. The guidelines for academic staff are as follows: three articles to be promoted to senior lecturer, five articles to be promoted to associate professor, and seven articles to be promoted to full professor. The respondents were in disagreement as to whether or not the number of co-authors per article is taken into account. Moreover, the criteria appear to be different (and more stringent) for staff at research centres, which contribute towards some research centre staff being de-motivated to pursue publishing in peer-reviewed journals.

> The [article] output is a bit low, not as much as we would like. There are time constraints on the research fellows, but also the rewarding structure of the University of Malawi for journals is not at a point where we think it is really encouraging. What we mean by that is that for centres, they have put the more … you know for promotion, maybe from lecturer to senior lecturer to associate professor, they are saying that the research centres, they are doing full-time research and what they have done is to increase the number of publications for you to jump from one rank to the other.

The role of international collaborators in establishing a culture of research publishing needs to be underscored:

> [T]his is a small centre, I've been here for the last four years now, and most … some of the people that have been here, haven't been here for that long anyway. So, their inexperience of a team, to sit down together and be able to come up with a paper ... We might have good data, but to put that into something that is acceptable by the international community might be a problem. But with this support from the CDC [Centre for Disease Control, USA], one of the things that we have got from them is to have technical support coming from the CDC. And their influences have been really to get the data that we produce into the public arena, so they try as much as possible to push and provide the technical support in order to come up with good papers that are publishable. So … we've been quite productive and it has helped people here, to lay the insides on how you can make a very good paper to be able to put it out for publication. (College of Medicine, University of Malawi)

Previously at the Polytechnic the general sentiment among engineers and technicians was that they should primarily concern themselves with technical service delivery. The pursuing of postgraduate qualifications and research publications was seen as falling outside their domain-specific requirements. This devaluing of research contributed towards the relative absence of peer-reviewed publications among engineers. Attitudes are, however, changing:

> As I said in terms of research we need first of all to stimulate members of staff to conduct research and from there you can generate output. Even [if] it was in terms of, let's say, postgraduate programmes, people with masters' have objected that, no I need only this and there were people here who were saying it is not necessary to have a PhD because more of what Malawi requires … technicians to maintain the equipment and that kind of thing, but you don't require people with PhDs, masters' they are not necessary. So those ones were the sentiments. You can judge from there that coming up with … research and then publish it is kind of asking too much from that kind of group. But now things are changing. Over the years I think I have seen the attitude of people changing. People are aspiring … they know that you can be an engineer and also conduct research. (The Polytechnic, University of Malawi)

The remark was made that Malawians appear to be most productive in terms of publications when they are studying outside the country – most probably under influence of (foreign) study advisors who live by the 'publish or perish' principle.

> Most people publish when they are outside, when they are at school [studying elsewhere], so you find most of the guys will publish. The moment they come back – let's say they studied in South Africa and they have published a lot of papers – the moment they come back you can see the graph going down. ([The Polytechnic, University of Malawi)

Other constraining factors mentioned in terms of peer-reviewed publishing are the limited bandwidth to download electronic materials, and the lack of data support staff.

> [F]or the past … let's say from 1992, or before 1992, most of our funding was coming through the donors and then, for example, you find out that through bilateral agreements, mainly with Britain, you would have access to journal papers. After 1992 all those things were not there. So from 1992, our libraries didn't have reference materials. And for somebody to come up with a paper that would be published and accepted somewhere, it was difficult. But things are changing now, mainly using ICT facilities whereby our library instead of subscribing to a number of journals they subscribe to a database and we are able to access some of the research periodicals through electronic means. So that is helping us a little bit. Of course, the challenge remains the bandwidth. Sometimes you can't download a paper. You try to download a paper it takes two hours, three hours, and you just leave it. At least if you come in the evening maybe you will be able to download a paper and that will help us. So the publications, it's just a few. (The Polytechnic, University of Malawi)

I think the major thing is, first, is the experience in writing up articles, manuscripts and all that. You know, we don't have a Biostatistician at our place, we don't have data personnel and these people are very critical to look at your work before you start writing up a proposal and still get to formatting the questionnaire, how you are going to analyse the data and make that data look, you know, so that it's making sense and then helping the write up. So this has been a major, sort of, constraint to us that we have to, you know, borrow and even use other means of trying to meet this gap, so that can be internal within the college … or it can be external due to our collaborators. So this is an area we try to … in a sense that we have embarked on sending our staff for further training and try to recruit maybe a Biostatistician as soon as possible and also looking at the data management system. (College of Medicine, University of Malawi)

1.4.4 Namibia

In terms of publishing, respondents indicated a variety of ways they disseminate their research findings. At the University of Namibia (UNAM), an online journal was launched in 2007, namely the Namibia Development Journal (NDJ). It is a peer-reviewed journal aimed at submissions from researchers, academics and development practitioners in the field of development. Although there is much excitement surrounding this journal, there appears to be some reservations among some of the respondents:

But I think it's a bit new – the volume of the papers that are coming is maybe exceeding the capacity to handle. The papers don't come out in the time that is expected. (UNAM)

… at first people were very excited, but because it didn't come out regularly, then there was a bit of disillusionment with it. So many of those who have been published externally have continued to published externally because the journal has not shown that it is going to be a regular journal as it should be. (UNAM)

… because it is also a basic requirement leading to promotion, we often prefer international journals because you're peer-reviewed internationally and recognition is also another issue, and most importantly, the points allocated to internationally published journals is much higher than that of local journals. So comparatively, publishing outside Namibian Development Journal is still remaining a priority for us as academics. Because the peer-review process with Namibian Development Journal appears to be very slow. (UNAM)

In terms of choosing which other journals to publish in, one academic – who is a chemistry professor and does research on malaria – described the following procedure:

But for the time being I've been concentrating on middle-ranked journals. The reason is simple. When you send to top ranked journals, you are competing with Nobel Prize winners; they come with so many questions. You see, I have to struggle with the compounds I'm making. I don't have sophisticated equipment. It took me a long time to think of this project which has applications that are easy to do with the facilities available. I don't have the equipment … (UNAM)

1.4.5 Swaziland

In terms of publishing, there are three local journals at the University of Swaziland for staff to publish in. There is the *UNISWA Journal of Agriculture,* mainly for those publishing in the field of agriculture. For academics working in the field of natural and agricultural sciences, there is an option to publish their research in the *UNISWA Journal of Agriculture, Science and Technology*. The respondent explained that most faculty staff in the field of science and agriculture publish in this journal, but publishing in international journals takes place in an ad hoc manner. The *UNISWA Journal* caters for those publishing in the social sciences, humanities, education, commerce, etc. In terms of funding of research proposals and publishing the findings, it is compulsory for beneficiaries of research grants (from the university) to publish in one of these journals. However, due to the capacity issues, not all the funding is allocated to researchers every year and the surplus must thus be returned to the central financial system. As the director of the UNISWA Research Centre (URC) described it:

> I feel very sad giving back the money from the centre to the main pool every year and I see there is money, but it's not claimed by researchers. We lack researchers. It's not the money that is a problem, for now.

This quote highlights the severe lack of research capacity there is at the university. The respondent further says, referring to the number of article submissions received for the various journals, "… the issue is not quantity, the issue is quality".

There is also quite fierce competition between researchers from West and Southern Africa who also send article submissions to these journals. In fact, the majority of submissions received are from non-Swazi residents:

> Because this is fully funded by this institution and our journals are flooded by foreign contributors … It's not that we don't want them to be here, but we cannot have more than 50% space for them.

There also seems to be a link between funding (such as from institutions with whom there is collaboration) and where research findings are published:

> The funding determines who publishes where. Maybe if I could do something on my own, I could maybe publish in our local journal.

1.4.6 Zambia

To improve the visibility of the Tropical Disease Research Centre (TDRC), researchers at the institution are encouraged to publish. Publications are also one of the criteria looked at for the purposes of promoting researchers, so producing research articles is to the researchers' benefit. Researchers at the TDRC are also encouraged to attend international workshops and meetings in their research

areas. When asked about where researchers published, the respondent indicated that they mostly published in international journals.

> **Respondent:** Yes, actually publication is one of the criteria of promotion, yes so scientists are encouraged to publish and get published yes, again related to whatever research interests or research activities scientists do attend international workshops, meetings and so forth.
>
> **Interviewer:** And where are these scientists publishing? Are they publishing in the local Zambian journals or are they publishing in international journals?
>
> **Respondent:** International, international mainly.

In the case of the University of Zambia, when asked about whether researchers obtained financial support for publication outputs, attendance of workshops and the like, the respondent said no. The respondent also described the publication output of the department as extremely poor. The respondent felt that one of the main constraints in terms of researchers publishing was their inability to write skilfully; even if researchers were capable of scientific writing, there was also the fear of rejection.

> You know that writing is a skill, everybody who can write a lot of them can do a lot of research, but you see writing is a skill and sometimes people are not taught scientific writing; they may know why they should publish but they just can't throw themselves into the deep end of it. If we do have the skills for scientific writing, there is the fear of rejection, that their writing may not be accepted. (University of Zambia)

Concluding comments

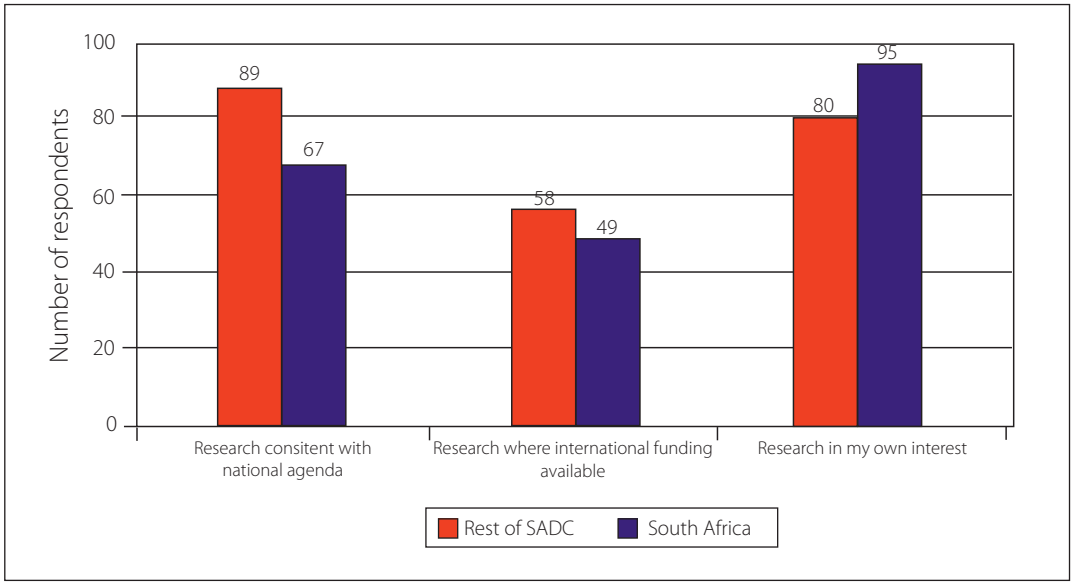
Our study demonstrates the complex patterns of scientific publishing in the region. Although scientists in all countries appreciate that publishing in foreign journals is preferable because of their high visibility of scholarly quality, lack of opportunity to publish in such journals acts as a constraint to many. There are, however, many other constraints: lack of funding for proper equipment that impacts on experimental results, lack of scientific writing skills, perceived unfair competition, even for local journals, and so on. These constraints force many scholars and scientists to publish in local journals, even if they are not peer-reviewed, as the pressure to publish is a pervasive criterion in all performance appraisal systems. The lack of a culture of publishing in certain highly applied environments (such as engineering) coupled with the need and practice of consultancy and technical service-delivery also impact negatively on scientific publication. Language is an issue, as was evident from our interviews in francophone countries, and the de facto dominance of English as the international publishing language is seen as a serious constraint and challenge.

1.5 National development goals and scientific research

To what extent is science in the region addressing or attempting to address the most important development goals of the respective countries? Do scientists pursue research topics and projects that are consistent and supportive of national socio-economic priorities in the country, or are these of secondary concern?

A cluster of three statements were put to respondents to determine what motivates their own research: a fairly self-centric concern (My own interests largely determine my research agenda); a more altruistic interest (I prefer researching topics that are consistent with the national agenda in my country) or a very pragmatic interest (I prefer doing research in areas where there is international funding available).

Figure 19 Research and development link



The results show that scientists in all countries are primarily driven by their own interests and preferences, but with an interesting difference of 15% between South African and the other SADC respondents. Respondents across all countries are motivated by the availability of international funding, but this is more the case (not surprising given our previous results) among scientists from other SADC countries. Perhaps the most significant result is the fact that a much bigger proportion of respondents from SADC countries other than South Africa (89% compared to 67% of South African respondents) are motivated by a concern for the development agenda of the country.

The overall picture remains consistent with our previous findings: South African scientists – given their access to more (local) funding and better scientific infrastructure – have the 'luxury' of pursuing their own interests (rather than national interests) to a larger extent.

A breakdown by scientific field shows, however, that one always needs to keep in mind differences between scientific fields. We have selected two of the statements discussed above. Fields that scored significantly below the average across all fields have been highlighted (where less than 80% indicated their agreement for either statement).

Table 40 Research consistent with national agenda by scientific field

Scientific field	I prefer researching topics that are consistent with the national agenda in my country							
	Strongly agree		Agree		Disagree		Strongly disagree	
	Count	%	Count	%	Count	%	Count	%
Agricultural sciences	66	50,8	53	40,8	9	6,9	2	1,5
Applied sciences and technologies	45	41,3	51	46,8	10	9,2	3	2,8
Arts and humanities	21	31,3	29	43,3	16	23,9	1	1,5
Biological sciences	46	30,7	73	48,7	24	16,0	7	4,7
Chemical sciences	24	39,3	29	47,5	8	13,1	0	0,0
Earth sciences	16	30,2	21	39,6	12	22,6	4	7,5
Economic and management sciences	17	43,6	17	43,6	2	5,1	3	7,7
Engineering sciences	15	25,9	36	62,1	6	10,3	1	1,7
Environmental sciences	56	41,2	66	48,5	10	7,4	4	2,9
Health sciences	56	50,9	38	34,5	13	11,8	3	2,7
Information and communication technologies	17	37,0	21	45,7	7	15,2	1	2,2
Marine sciences	6	28,6	10	47,6	3	14,3	2	9,5
Material sciences	5	23,8	11	52,4	4	19,0	1	4,8
Mathematical sciences	5	13,9	9	25,0	16	44,4	6	16,7
Medical sciences: basic	20	38,5	22	42,3	10	19,2	0	0,0
Medical sciences: clinical	24	57,1	13	31,0	4	9,5	1	2,4
Physical sciences	11	28,9	16	42,1	11	28,9	0	0,0
Social sciences	50	38,8	57	44,2	18	14,0	4	3,1

Table 41 Own interests largely determine my research by scientific field

Scientific field	My own interests largely determine my research topics							
	Strongly agree		Agree		Disagree		Strongly disagree	
	Count	%	Count	%	Count	%	Count	%
Agricultural sciences	27	21,6	59	47,2	30	24,0	9	7,2
Applied sciences and technologies	34	32,1	46	43,4	23	21,7	3	2,8
Arts and humanities	34	50,7	22	32,8	9	13,4	2	3,0
Biological sciences	53	35,6	64	43,0	27	18,1	5	3,4
Chemical sciences	14	23,0	27	44,3	17	27,9	3	4,9
Earth sciences	19	36,5	22	42,3	10	19,2	1	1,9
Economic and management sciences	17	41,5	16	39,0	8	19,5	0	0,0
Engineering sciences	17	30,4	27	48,2	9	16,1	3	5,4
Environmental sciences	41	30,1	56	41,2	35	25,7	4	2,9
Health sciences	39	35,5	50	45,5	14	12,7	7	6,4
Information and communication technologies	18	39,1	14	30,4	11	23,9	3	6,5
Marine sciences	12	57,1	6	28,6	3	14,3	0	0,0
Material sciences	9	40,9	10	45,5	2	9,1	1	4,5
Mathematical sciences	19	50,0	14	36,8	5	13,2	0	0,0
Medical sciences: basic	18	34,0	29	54,7	5	9,4	1	1,9
Medical sciences: clinical	16	38,1	20	47,6	6	14,3	0	0,0
Physical sciences	18	47,4	15	39,5	5	13,2	0	0,0
Social sciences	51	39,8	55	43,0	21	16,4	1	0,8

Our field visits again elicited interesting qualitative comments on these issues.

1.5.1 Madagascar

When asked whether FOFIFA's research activities were in line with government priorities, the respondent pointed out that the Madagascar Action Plan (MAP) was their point of reference. Whether the Madagascar Institute for Animal Vaccines' (IMVAVET) research activities were aligned with the country's national developmental goals did not come across as clearly; however, its main aim is to engage in activities that would uplift the entire population, and this is what the MAP is also fundamentally trying to achieve.

> That also, because we have the MAP reference, I do not know if you have heard of it, it is the Madagascar Action Plan in English, you know that. So, that is the government. If it is entered into that plan without problems, we are on our way. (FOFIFA)

> Working extensively is what is needed to uplift the population masses. So, I don't know

> if I have made it clear, but we give priority to concrete and real actions for the real development of the population masses. Our concern at the moment is to have tangible results which are directly applicable and which will lead to the improvement of the living conditions of the population. That is our present concern. For persons who simply want degrees and titles, that is their problem. But for us at present, we will support the population masses. There! (IMVAVET)

One respondent from the University of Antananarivo (UA) felt that changes with regard to research prioritisation were needed within the national science and technology system. The respondent felt that government did not see research as useful and as a waste of time, but hoped that things would change.

> But perhaps matters will improve if things change a little, especially with regard to research, because research is necessary … It is difficult. They do not understand, the government does not understand that it could be useful. The government thinks that it is a waste of time, done by chance, it is not useful, that … that … I do not know. It is only for the training of profs to teach … that is all. (UA)

1.5.2 Malawi

The general opinion of directors of research centres (across all fields) at the University of Malawi is that they enjoy very good relations with government and even are in a position to exert influence at national level.

> [W]e have very strong relationship with the government departments. Most of our work, the commissioned work, kinda comes like … can you come to the office we are thinking of this, rather than the route that says we are going to tender … There is a good personal relationship with the minister of agriculture, forestry, very good relationship. Also water, education. There is that linkage that we would be the first place of call if they want something done in those fields, so we welcome that. And we get invited to a lot of meetings with the government. When they are thinking of something, or they are thinking of signing a document, they'll send it to us to kind of go through it and see what we have to comment on what they are about to sign. That kind of relationship. We don't always charge, but sometimes it brings you new business later on. Ja, but there is that, good relationship with the government.
>
> I think this centre finds itself to be quite unique in a sense that we are not just doing research in isolation, but we are trying to ask questions that are going to be of interest to the country at that particular point, or at that particular moment. So we listen to the points they make as they say 'What needs to be answered? What are the problems on the ground?' And then we take on those questions and look for funding to address those questions. And once we get research findings from there, then we go back to the policy maker, that this is what could be done to change this, sort of, present scenario … I think we have found ourselves to be quite useful as a centre to the ministry [ministry of health] in that when we were starting, we were seen, maybe, as a competitor; now we are seen,

> more like, as an ally, as a collaborator, by the ministry. We … in some circumstances the ministry has actually come to us and said: "We would like you to do this, this, this, okay, on our behalf," which is quite good.
>
> [O]ne area which we didn't touch on is the influence we have at a national level. You know, we do have a lot of professionals within the faculties, sitting in at various advisory boards at the Ministry of Health, at technical working groups. We are involved in the stakeholder meetings and all that, where we could do influence in our policy … and also when the ministry wants some direction and understanding of various issues ... And in areas of outward activity, particular to advocacy and networking, we have worked very, very hard with the journalists in Malawi. You know, one of the things they came to us and asks us to help them with is just to train them so that they could understand the concepts, the terminology in reproductive health, which we did. We trained over 30 journalists and with that effect, we're seeing a lot of coverage of reproductive health issues because they're able to write without any fear … They've got a better understanding of sexual and reproductive health.
>
> Yes we really try and align our activities with the government, particularly the one ministry of irrigation and water development, that's our lead ministry. So the vision, the mission, the objectives, the strategies, that they are looking at, focusing at, we try to line ourselves with that, so that really we should be seen as partners and we are the research and academic aspect and they decide on the policy issues, implementation of policy and we are following on what policy they have set.

Still, the comment was made that government officials seem to value the consultancy and service delivery function of research centres much more than they value their research function:

> I think in terms of government, even in industry, the only problem is somehow some of the officers do not value research. They value consultancies, but not research whereby you're creating something new. Even if you come up with new results, but if they are contradicting what they've been doing, they may not trust that. So we still got a problem with the system that we are not innovative in using new knowledge. We want already mature knowledge. So somehow it must have been used somewhere, it has been proven then; unfortunately we sometimes copy it blindly whether it fits or not. Sometimes it's not. As long as we can quote they used it somewhere, they used this kind of thing.

1.5. Namibia

In terms of funding of science and technology activities and how this contributes to the attainment of national development goals, one respondent pointed out a problem that is common among many developing countries by asking, "If science underpins development, why is it that the values attached to those in the sciences are so low?" The respondent illustrates this point by saying:

> Because if you are a scientist, normally your benefit structures are very lower. Nowadays you find people had studied as scientists, but they end up with … having a nuclear physicist ending up in finance … Is it a strategic investment having a biologist running

a shebeen? Is it strategic? Because sometimes people have to make choices in terms of livelihoods.

In terms of biggest obstacles and challenges for science and technology, the first is the issue of the "… retention of scientists because of the global nature of operations that we are entering in".

Another challenge, as mentioned above, is the balancing act between development imperatives and investing in science, and in this vein, one respondent asks, "So do you build the laboratories or do you build houses?"

1.5.4 Swaziland

In terms of choosing research areas and projects, the university staff seem quite aware of the general needs that exist in their communities, especially the extent to which research in specific areas can address these needs. This is illustrated by the following:

> I mean, like the work we are doing on water filtration is very relevant. Directly relevant to the needs of the country, so we are in touch with the private sector, we are in touch with the government in as we do the research, you know, its not just for purposes of academic curiosity, but we are also aware of the need to do research that can help the people.

1.5.5 Zambia

In the Zambian science and technology context officials from government ministries engage with the University of Zambia on a regular basis in the form of meetings and seminars to determine how the university could contribute to the development of science and technology within the country. However, as the respondent from the university indicated, the funding provided from government does not match what is required on the ground:

> I mean obviously, every government I mean, there is a lot of talk, and meetings, seminars, ministry of science, technology, ministry of health, ministry of education, all of them get involved. We regularly meet to see how the university can contribute to the development of science and technology, etc. But on the ground it doesn't match with the money that is put in.

According to the respondent from Copperbelt University (CBU), staff members are involved with industry on different committee boards and are contributing to research that has national relevance:

> There is co-operation between staff, and right now we have some who have been carrying, undertaking research for the bulk of Zambians. The schools are the component we have been dealing with. Some of our staff have been dealing with the National Road Board Agency, and a number of our staff are on various committees and boards of parastatal companies. So their effect on service and contribution to the nation is quite relevant. (CBU)

A respondent from the National Science and Technology Council indicated that for universities and research institutions to address the national development goals of the country, greater planning was needed to avoid duplication.

> One of the things is planning; I think we need committed planning to avoid duplication, re-inventing the wheel. We need to have more co-ordinated planning, that's where we come in as the NSTC, because our act is not supposed to be this weak. If you learn our act which has a focused planning system, so at table stage every institution is addressing the issues of the nation but now we are working in isolation. (National Science and Technology Council)

Concluding comments

Research agendas are driven by a complex set of interests as well as material conditions. Under conditions of proper resourcing and access to funds, equipment and other forms of academic capital, scientists would tend to prioritise their own interests. Where access to funding is limited and competition for resources scarce, other interests (available funding and congruence with national goals – which in turn can lead to more funding) may become more prominent. Our findings show that majorities of scientists in the region pursue their own research interests. For South African scientists alignment with national goals is a secondary interest, followed by access to funding. For scientists in the other SADC countries, alignment with national goals, as well as access to funding, is a more important consideration. These findings are moderated by field differences. The field visits confirmed the saliency of these issues and, in general, point to a sensitivity amongst scientists to do work that serves or supports national socio-economic priorities.

Part 2: Recommendations

2.1 The case for science

Although the countries in the SADC region have committed themselves to the advancement and strengthening of the science base of their countries and have pledged to pursue an increase in expenditure on research and development, these commitments have yet to be demonstrated at the level of university funding and support. The main finding of this study is that there is overwhelming empirical evidence that institutionalised scientific research in the region is on the decline. It is imperative that this trend, which is manifested in the diminishing share of world science output, the reliance on more consultancy-type research, the casualisation of research workers, continuing brain drain, heavy dependence on international funding and collaboration with northern partners (rather than with regional partners), has to be reversed.

Our first (and overarching) recommendation, therefore, is that SARUA considers various practical ways to bring home to key stakeholders the absolute essential role and value of public science (and especially university research) in the region. We recommend that SARUA convene a small group meeting with key stakeholders in the field (decision-makers, researchers and possibly donor agencies) to strategise ways in which the case for science could be made more strongly and effectively. Various modalities could be considered as part of these strategic deliberations, including:

- supporting (case) studies that demonstrate the value of science in developing countries elsewhere as well as in the region;
- developing initiatives that would communicate to various constituencies (from policy makers to the general public) the impact of science in different fields;
- developing mechanisms to collaborate with other regional and international bodies that have similar aims and objectives; and
- commissioning studies on the history of science and scientific institutions in the region illustrating the rich tradition and legacy of significant research institutions and their contributions to the respective societies and economies (a case in point is the Onderstepoort Institute for Veterinary Sciences in South Africa and the Pasteur Institute in Madagascar – both established more than a century ago).

2.2 Intra-regional research collaboration

Scientific collaboration in the SADC region is mainly a function of traditional (in some cases colonial) linkages as well as available international funding support. This has led to a situation where south-north collaboration is the norm, rather than collaboration with countries in the region. It is desirable to increase intra-regional collaboration, not only because of the positive effect it would have on strengthening regional institutions, but also because of significant commonalities in scientific

priorities in such areas as infectious diseases, astronomy, water and marine resources, environmental biodiversity, social cohesion, regional history, democracy and citizenship.

Our recommendation is that SARUA considers various mechanisms to improve intra-regional scientific collaboration, especially amongst university researchers in the region. In addition to the strengthening of scientific journals and regional networking (cf. below), the development of a regional knowledge base of scientific projects and scholars in the region could be utilised to support various regional collaborative ventures.

2.3 Funding of research

Our study shows that the lack of sufficient funding for research is the reason cited most often for research constraints in the region. This is mainly because the majority of governments in the region do not allocate sufficient national funds for research and development, which results in the huge dependence on international funding sources.

We recommend that SARUA considers the following three mechanisms to address this problem:

- embark on a deliberate advocacy and lobbying campaign to persuade national governments to make good on their commitment to allocate 1% of GDP to research and development;
- assist universities in the region to gain access to international funding sources through services such as Research Africa; and
- conduct workshops with researchers on developing funding proposals so as to increase their success rate in the application for overseas funding.

2.4 Institutional research management

The field visits that were conducted as part of our country visits confirmed that most universities, including the most research active, do not have adequate research management infrastructures in place. Most universities in the region do not have well-developed and well-functioning research directorates. Crucial functions such as gathering research and postgraduate statistics, developing and implementing research capacity-building programmes and advising on matters related to the integrity of research, intellectual property and knowledge transfer do not always take place.

We recommend that SARUA consider collaborating with organisations such as the Southern African Research and Information Management Association (SARIMA), the Association for Commonwealth Universities (ACU) and the Society for Research Administrators (SRA) in strengthening the research management capacity of universities and other research organisations in the region. These organisations have, for some years now, been involved in developing and conducting courses for research directors and officers in African countries, in order to strengthen the institutional capacity in research management.

2.5 Human capital development

Although our study did not aim to focus on the brain drain in any detail, the findings from our survey show that this remains a major issue. The fact that academic salaries are poor and working conditions in many universities are not conducive to research, forces many academics into consultancy and/or to consider leaving their countries. Similarly, the lack of sufficient master's and especially doctoral programmes at many universities forces postgraduate students to consider studying at great cost elsewhere. Although it is unlikely that SARUA can directly address the extent of the brain drain from the region, it can make a positive impact on student and staff mobility rates.

We recommend that SARUA considers a number of initiatives that would make it more attractive for postgraduate students in the region to study and stay in their own countries rather than consider studying abroad:

- Firstly, that SARUA uses its own communication media to provide doctoral students in the region with information on doctoral programmes offered in the region.
- Secondly, that SARUA gets involved in regional initiatives (such as AIMS and the African Doctoral Academy initiative at Stellenbosch University and the Human Rights Programme at the University of Pretoria), which aim to prepare and train postgraduate students better for doctoral studies.
- Thirdly, that SARUA considers conducting workshops for academics in the design and implementation of new doctoral programmes.

2.6 Scientific journals

African science in general and science in the SADC region suffers from a lack of international recognition. One of the reasons for this state of affairs relates to the lack of sufficient high-quality scientific journals in the region, as well as the lack of sufficient resources for efficient peer review and editorial practices.

We recommend that SARUA considers initiatives that would strengthen regional journals with regard to quality and editorial management. We would also recommend that consideration be given to the establishment of one or two regional journals of high quality that would serve the needs of local researchers. In these efforts, SARUA should consult with the Academy of Science of South Africa (ASSAf) who is currently involved in such a venture in South Africa as well as the work of African Journals Online (AJOL) housed at Grahamstown.

2.7 Further research

Various bodies and organisations (international and African) are involved in some way in promoting and supporting research in the SADC region. These bodies include the AU, NEPAD, ICSU, SARIMA, OECD, UNESCO, ACU, EU, and many more. International funding agencies such as the World Bank, USAID, the Bill and Melinda Gates Foundation, SIDA/Sarec, DFID, NORAD, DANIDA, the Ford

Foundation, Carnegie Corporation of New York, the Kellogg Foundation, and many more, are all active in the region. There are a few organisations – such as Research Africa and SciDevNet – that gather systematic information on scientific activities in the region. However, there is no central database or study of all of these initiatives as they apply to SADC. Our survey has begun to identify the main role players and agencies, but further follow-up work is required in order to produce a more comprehensive picture of these initiatives.

We recommend, therefore, that SARUA considers commissioning a study that would map existing actors and initiatives (funding, training and information gathering) in SADC that would provide stakeholders with a more comprehensive picture of the state of research in the region. Such a study would be a useful resource to support many of the actions proposed under the recommendations above.

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