Science and Technology Interactions in Africa and the Impact thereof on the South African System of Innovation

Report to the National Advisory Council on Innovation

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September 2009

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Executive Summary

This report sets out to investigate the performance, processes and dynamics associated with South Africa's research, science and technology collaboration on the African continent. The resultant analysis leads to a set of recommendations as to how the South African government could effectively improve its interaction with its African counterparts in S&T initiatives.

The notion of collaborations including the development of multi-country 'big science' projects and platforms have become commonplace in recent times. As a result scientific collaboration has become an important component of science, technology and innovation policy internationally. This collaboration is not without debate of the risks and benefits of such activities. Concerns expressed include that the spending in international collaboration is not always to the benefit of the paying country and that critical technologies and key knowledge for competitiveness are given away to competitors. Additional concerns have been voiced that collaborative agreements subordinate the interests of science and technology to strategic or political ends. Last but not least, researchers have argued that collaboration may be an endogenous self-perpetuating outcome of science with substantial costs and no commensurate benefits.

The expressed concerns related to scientific collaboration gave rise to a number of investigations in the field and policy authorities internationally have developed strategies for targeting research alliances and managing scientific and technological collaboration.

This report starts by introducing the "ophelimity" framework and discusses international collaboration in the context of science and technology policy. It is emphasised that under this formulation collaboration is a policy instrument aimed at achieving particular policy objectives.

The most often mentioned objectives are to:

- Gain access to knowledge unavailable locally;
- Share costs and risks;
- Gain access to partners' markets;
- Achieve standardisation; and
- Fulfil political considerations.

"Gaining access to knowledge" and "sharing costs and risks" are objectives internal to S&T policy. We suggest that in the context of S&T collaboration for the benefit of science and technology, the knowledge of the partner's capabilities and the clear understanding of the objectives of the collaboration, are the determining factors of success.

In the chapter "Foreign Influences" the activities associated with the Official Development Assistance (ODA), the World Bank, certain programmes of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and NEPAD are discussed. We argue that foreign influences, even though well intentioned, are not always beneficial for the recipient country. The World Bank's efforts to ignore and undermine higher education for 30 years may have unknown developmental consequences even today. We suggest that developing countries need to have their own expertise in order to decide priorities and developmental paths.

South Africa has demonstrated a prolific penetration of the continent with regards to science and technology collaboration, both at a multilateral level and a bilateral level, in the last 15 years.

In the chapter "Review and analysis of the S&T related African multilateral platforms", the four S&T related platforms - the AU/NEPAD S&T platform, the AU/NEPAD Environmental platform, the AU/NEPAD Health platform and the AU/NEPAD Agricultural platform are discussed.

The primary S&T platform vis-à-vis the African Ministers' Council on Science and Technology (AMCOST) and the African Consolidated Science and Technology Plan of Action have been developed involving all the regions of Africa. The effort appears to have a successful early implementation phase with certain significant launch projects, three of which are located in South Africa. South Africa's role as both leader and partner, in the early phases has been significant. The remaining challenge relates to moving forward into full-scale sustainable implementation.

In the chapter "Review and analysis of bilateral agreements with S&T content", South Africa's bilateral cooperation agreements with Africa are examined. The coverage of the continent, from a numbers perspective appears to be wide. South Africa has concluded and signed 16 science and technology bilateral cooperation agreements on the continent with countries from all five of Africa's regions. Together with the other bilateral agreements with a significant science and technology content (health, agriculture and education), this number increases to 47. This represents 13% of all South Africa's African bilateral co-operation agreements to date. The field prioritisation associated with the 16 S&T bilateral agreements cover a total of 13 discipline areas. The order of popularity, as defined by the representation in the different agreements and their programmes of cooperation, is: biotechnology followed by agricultural sciences and indigenous knowledge as the top three areas of collaboration. In addition, all the agreements include clauses on collaboration in development of policy and institutions, capacity building and the public understanding of science, engineering and technology.

In the chapter "Science Collaboration with Africa: University and Science Councils" we outline the collaborative engagements South African research and higher education institutions have with their African counterparts.

In the chapter "Scientometrics of Collaboration" the impact of the collaborative efforts are analysed as they are manifested in co-authorship patterns. Africa produced 68 945 publications over the 2000-2004 period or 1.8% of the world's research publications. In comparison, India produced 2.4% and Latin America 3.5% of the world's research publications. In Africa, South Africa and Egypt produced just above 50% of the continent's publications and the top eight countries produced over 80% collectively. Furthermore, disciplinary analysis reveals that few African countries have the minimum number of scientists required for the functioning of a scientific discipline. For example, in the field of ecology (a discipline necessary for environmentally friendly and sustainable development) only four countries (South Africa, Egypt, Nigeria and Kenya) produce 300 or more publications (the minimum threshold).

A co-authorship analysis identifies the countries with which South Africa collaborates. USA occupies the top position participating in more than 34% of South Africa's collaborative effort. England and Germany follow participating in 18.6% and 11.4%, respectively. Only 4% of the country's collaborative effort was with authors from other African countries. The countries with which SA collaborates most in the African continent are Nigeria, Kenya, Namibia and Zimbabwe. Furthermore, South Africa has very little collaboration with North African countries, which are scientifically stronger than the other African countries. Disciplinary analysis of the SA-Africa collaborative effort identifies that the emphasis is in health disciplines (disciplines in which SA can make a contribution).

In the chapter "SWOT analysis of South Africa's S&T collaboration in Africa" we deduce that South Africa's African collaboration efforts rely on its scientific strengths certain institutional strengths and some early successes. We identify that there are a number of opportunities for international participation and potential leadership in certain areas, such as using indigenous crops for nutritional security and research into the so-called neglected diseases and disease interfaces like HIV/AIDS and TB. In spite of the important weaknesses and potential threats, these strengths can be instrumental in an innovative strategy toward realising the opportunities and facilitating beneficially collaborative activity.

In the chapter "Adaptation of the NSI to the African collaboration" we observe that South Africa has made important investments to facilitate collaboration at both the bilateral and multilateral levels in Africa. This includes developing dedicated capacity in DST to dedicated funding through the NRF's STAF mechanism, to a large number of MoUs among the SA universities as well as direct investment supporting the business plans of the AU/NEPAD nodes.

The analysis leads to the following recommendations:

1. We suggest that NACI considers recommending that the DST develops an African Collaboration Strategy to guide the collaboration activities of the different players in the National System of Innovation. The strategy document must describe the different categories of African partners and the engagement modalities associated with each category. The African Collaboration Strategy should include the development of a priority list of countries for maximising the collaborative benefits from a research, science and technology perspective, followed by an exploration of the potential benefits to the developmental and political agendas.

2. In the above context we suggest that NACI considers recommending that South Africa prioritises support for collaboration with those African institutions and countries that fall into the category of strength-to-strength partnerships. Interactions with the LDCs (least developed countries) should make use of third party and donor funding through such mechanisms as trilateral relationships with donor countries or international funding institutions that have prioritised the African partner for donor aid or investment.

3. NACI should consider recommending that the DST plays a monitoring, coordinating and expert advisory role in the implementation of the research, science and technology components of all of South Africa's existing African bilateral co-operation and multilateral agreements. DST should produce a monitoring and assessment document annually outlining the performance of S&T collaboration in Africa including the activities of the various donors. This may be achieved in collaboration with the newly established Planning Commission.

4. The current implementation approach used by NRF appears to be ineffective. We suggest that NACI recommends the move away from "one approach fits all" and that all programmes are preceded by status studies and are accompanied by monitoring and assessment mechanisms.

5. Multilateral organisations and donors have the potential to have a substantial impact on issues of policy and development in the developing countries. Developing countries need expertise in the field of policy in order to assess and take ownership as appropriate recommendations. South Africa and the rest of the African continent have limited such expertise. NACI should recommend the establishment of a funding mode for the "Science, Technology and Innovation Policy Support Programme". The

programme could be managed by NRF with guidelines from DST and could support knowledge and human resource capacity development in the field of relevant policy, including policy analysis for science, technology and innovation collaboration.

Introduction

Globalisation of science and technology has been a growing phenomenon since the early 1980s, even though science has always been an international enterprise. The extent of globalisation and the size of its growth are difficult to estimate. However, from the areas for which data are available, it becomes evident that international collaboration is an important fiscal field in S&T. In the mid-1990s, the USA estimated that it was spending US$3.3 billion on international collaboration and that more than 15% of all of its research was collaborative, as it appears in the articles indexed by the reputable Science Citation Index (SCI) containing at least two authors from different countries.

Scientifically small countries attempt to transfer technology through international collaboration and scientifically bigger countries attempt to capture markets and leverage their innovation capacity through collaboration.

The recognition of the importance of international collaboration, coupled with the increasing fiscal requirements for the activity, has drawn the attention of policy makers who have expressed concerns. In a number of countries fears have been expressed that the spending in international collaboration is not always to the benefit of the paying country. Others worry that critical technologies and key knowledge for competitiveness are given away to competitors. Additional concerns have been voiced that collaborative agreements subordinate the interests of science and technology to strategic or political ends.

The expressed concerns gave rise to a number of investigations in the field and policy authorities started developing strategies for targeting research alliances.

The South African government has been pivotal to the 'New Africa Agenda' since 1994. Presidents Mandela and Mbeki have made South Africa's relations with Africa, on both a bilateral as well as a multilateral basis, priorities of South Africa's foreign policy. This included the efforts to develop continental level governance through the structures of the African Union and its Commission, sub-regional level governance and co-operation through the SADC mechanisms and protocols and at a one-to-one level with several African countries.

To give effect to this policy thrust, various members of cabinet and their departments have responded by engaging counterparts at both multilateral and bilateral levels on co-operation in various sectors. This has resulted in several 'General Co-operation' agreements, some 356 sectoral bilateral co-operation agreements and 50 African multilateral agreements on the continent. In addition there are significant African and SADC level chapters on global multilateral agreements. A large percentage of these agreements have clauses relating to either research or scientific or technological co-operation. Many in this category have all three. Some of the agreements that have both science and technology clauses include the 11 agriculture bilateral agreements, the six education bilateral agreements and a number of environmental agreements, among others. In addition these sectors also have Africa-wide strategies that are expressed as AU/NEPAD plans governed by the sectoral AU level Ministerial Councils. These plans all have very important science and technology co-operation clauses.

In addition South Africa currently has science and technology bilateral co-operation agreements with 16 countries on the continent with at least five more in negotiation. These are in all five sub-regions of the continent with the highest representation in the SADC sub-region. In addition South Africa has been central to the development of the Continental governance of science and technology co-operation – the African Minister's Council on Science and Technology (AMCOST) and its sub-regional counterpart in SADC, i.e. SAMCOST. South Africa was also central to the genesis of the AU/NEPAD Consolidated Science and Technology Action Plan as well as its implementation. South Africa's stated aim in all these agreements is the pursuit of Scientific and Technological co-operation for mutual benefit and the building of a robust Science and Technology platform on the continent for Africa's development.

Similarly, universities have signed at least 58 MoUs or similar types of agreements and collaborate extensively with counterparts in the African continent (Appendix 1).

All of these agreements, however, were independently negotiated by their primary sectoral sponsors (ministries and departments) in the South African environment. Harmonisation and synergy were not primary considerations in either the negotiations or the implementation of these agreements.

The objective of this study is to provide advice to the Minister of Science and Technology on the decision-making processes affecting S&T on the African continent and to develop recommendations on how the South African government could effectively interact with its African counterparts in S&T initiatives.

International Collaboration in the Context of S&T Policy

The role and objectives of collaboration can best be understood in the context of S&T Policy. In this chapter we outline briefly the ophelimity theory of S&T policy and we introduce international S&T collaboration in this context.

Science and technology policy is a term often used but rarely defined. An operational definition has been used by UNESCO[1] which defines science and technology policy as consisting of "…the principles and methods together with the executive and legislative provisions required to stimulate, mobilise and organise the country's scientific and technological potential so as to implement the national development plan and/or strategy."

This definition can be distinguished into two parts, in the "objectives of policy" such as the national development plan, and the "means in order to achieve the objectives" that is, the legislative provisions, executive orders and others.

Based on the above observation, it has been argued[2] that "science policy can be seen as the effort to maximise an ophelimity function of a particular group (a nation, region, organisation, etc.). The word "ophelimity" comes from the Greek work 'Ophelia' which can broadly be translated as 'usefulness'.

The suggested ophelimity function is a collective one consisting of the sum of the ordinary ophelimity functions of a number of individuals. The ophelimity function of an individual is constituted by a set of attributes providing utility to the particular individual. It can be the pleasure for undertaking research or the utility accruing from a more productive technique in manufacturing.

The sum of the individual ophelimity functions/activities will constitute the ophelimity function of the nation, region, and so on. To put it in a mathematical format, if **O** denotes the general interest, in whatever sense that may be taken, then **O** will be a function of a certain number of activities/variables which we may call "target variables" [$O = f(y_1, y_2 \ldots y_i)$].

A certain numerical value for a variable will be called "a target". The targets (y) will be chosen in such a way as to make **O** a maximum. Activities aiming at attaining this maximum may be called optimum policy, as other sub-optimal policies may be available.

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1 UNESCO. 1979. *Introduction to Policy Analysis in Science and Technology.* Science Policy Studies and Documents, No 46. Paris, France.

2 Pouris, A. (1994) *Ophelimity in Science and Technology- Towards a Utilitarian Theory of science and technology policy.* Report for the HSRC, Pretoria, South Africa

The target variables, although not directly amenable to manipulation by the policy makers, are affected by changes in variables under the command of the government, which may be called "instruments".

To use a mathematical format the targets y are functions of a number of instruments I_k, $y=f(I_1,I_2 \ldots I_k)$.

Examples of such "instruments" may be the size and numbers of bursaries offered by the government agencies aiming at increasing the number of scientists produced by the universities, the taxation rate of research activities aiming at promoting R&D in the private sector, the size of the government funding for R&D and so on.

It should emphasise that the definition of variables as targets and instruments is not standard or permanent. A variable may be characterised in one case as a target while in another as an instrument. The number of engineers produced by the universities of a country can be considered a target when viewed from a bursary-policy point of view, while it would be an instrument when viewed from the human resources needs in industry.

Variation in the value of the ophelimity function can be achieved through two different kinds of activities. These can be characterised as qualitative and quantitative policies. By qualitative policy we mean the alteration of a certain aspect of the structure of the scientific system (the way the variables are intermingled). Examples of qualitative changes are:

- The rationalisation or privatisation of aspects of the scientific infrastructure (e.g. research councils);
- Change in the degree of competition among the participants in the performance of research or advice concerning research (e.g. by allocating overlapping responsibilities to the existing research councils);
- Opening or closing the scientific system to foreign influences and information, and so on.

A quantitative policy denotes the change, within the qualitative framework of the given structure, of variables such as the amount spent for R&D by the private sector, the number of scientists produced by the universities in the country and the number of scientific publications in the country.

Of course there are policies that have both quantitative and qualitative characters. An example may be the introduction of a higher education system free of charge for certain disciplines, while in the previous system homogeneous rates were due. This policy may be considered as having a quantitative character since certain "prices" were put down to zero, as well as qualitative character as the system changes by the introduction of institutions providing free education.

Within this context, efforts to promote collaboration can be analysed, classified and find meaning. It should be emphasised that under this formulation, collaboration is a policy instrument aimed at achieving particular policy objectives.

Obviously collaboration takes place in order to satisfy aspects of the ophelimity functions of the two groups that participate in collaboration. In the context of collaboration these groups may have different ophelimity functions that could affect the terms of collaboration. The participating groups are not only the participating researchers. Government officials conceptualising or funding the effort and agencies managing the collaboration are also participants and their ophelimity functions may affect (and usually does) the collaboration. An important issue that becomes profound is that "advantageous" collaboration may not be easily achievable (or feasible) among different partners and that approaches that maximise national benefits between two partners may not achieve the same effects at a multi-country or regional context.

One country, for example, may enter into collaboration with the aim of acquiring improved industrial technologies while the partner may wish to improve environmental conditions. The availability of the desired knowledge in the partner country and the willingness to share this knowledge are prerequisites for mutually beneficial collaboration. As a consequence, knowledge of the partner's' capabilities and desires is of paramount importance.

The second issue that becomes obvious is that collaboration is an instrument of S&T policy aiming at achieving different policy objectives (targets). The most often mentioned objectives are to:

- Gain access to knowledge which is unavailable locally;
- Share costs and risks;
- Gain access to partners' markets;
- Achieve standardisation; and
- Fulfil political considerations.

"Gaining access to knowledge" and "sharing costs and risks" are objectives internal to S&T policy. The other objectives should be seen as external to science and technology and as achieving objectives in other spheres of governance. For example, they might be based on developing the attractiveness of the country for inward investment in R&D and not just in

R&D; collaboration between countries can create trust and personal friendships between researchers, which can sometimes help diffuse tension and conflicts between the respective countries; collaborative research provides a useful mechanism for engaging the talents of émigré researchers who have joined the brain drain, but still wish to stay in touch with their country of origin and last, but not least, scientific collaboration between developing countries may be necessary in order to help solve regional and global problems.

Obviously there is no reason why collaboration cannot be formulated in such a way as to achieve more than one objective (e.g. one internal to S&T and one external), although such policies may be classified as sub-optimal when viewed from one particular objective. Again, however, the knowledge of the partner's capabilities and the clear understanding of the objectives of the collaboration are the determining factors of success.

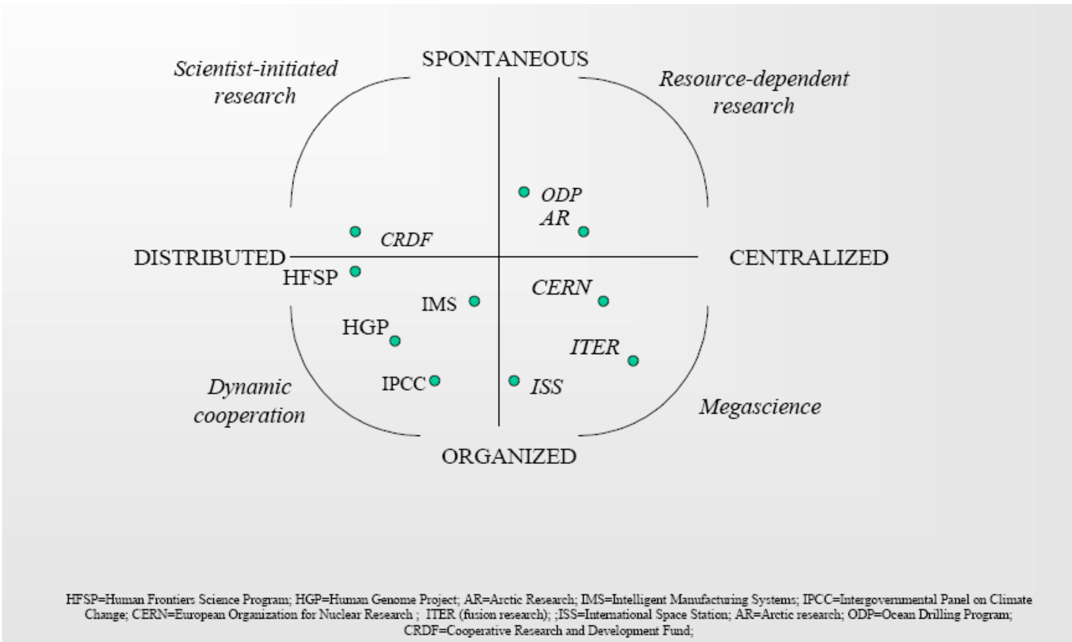
What the developed framework makes apparent is that in S&T collaboration, even if policy goals and objectives have been developed and there is knowledge of the local and the partner's capacity, the number of inter-linkages of national objectives and the variety of partners, both locally and internationally, make decisions maximising national objectives difficult.

In order to assist in the formulation of policy options and in the assessment of the involved trade-offs, a systematic framework for analysing the S&T collaboration system and policy options is required. Such a framework, which we call "Integrated S&T Collaboration Planning Framework", has the potential to integrate the collaboration needs of different government ministries, to identify users whose needs are not being serviced, and identify the possible alternatives to satisfy the "users' needs". Obviously the implementation of an "Integrated S&T Collaboration Planning Framework" will require an integrating agency at the national level and the participation of all government departments/ministries with S&T collaboration needs.

In the context of S&T collaboration it is useful to identify the different types of collaboration. Figure 1 presents the different types of collaboration. It shows two axes that can describe different organisational forms of collaboration. One axis runs from spontaneous ("bottom-up") research deriving from the interests of scientists, to highly organised research defined by a funding party. These two axes form four quadrants that characterise collaborative research. Activities on the left side of the figure might be described as "dynamic" in that collaboration requires active learning and sharing of tasks and of information among researchers who are often geographically dispersed. Activities on the right might be described as material/institutional research in that collaboration relies on a shared resource or common research location. Mega-science projects could be placed in the bottom right quadrant: organised and centralized. Scientist-initiated research would be placed in the upper left quadrant.

It should be noted that differences in organisation, location of research, and dynamism of the communication, require different approaches in the management of each type of collaboration programme.

Figure 1: Types of Collaboration



Source: RAND (2002) *Linking Effectively: Learning Lessons from Successful Collaboration in Science and Technology.* Documented Briefing to White House Office of Science and Technology Policy, DB-345-OSTP

Alternatively, two main categories of collaboration (informal and formal) are usually discussed in the literature. Informal collaboration is that which occurs between scientists in the normal course of doing research. It is a 'bottom-up' type of collaboration, and is seldom governed by formal agreements between governments, although governments may provide financial support. In contrast, formal collaboration involves contractual obligations to undertake specific research activities, and may require approval by the relevant government authorities.

In the context of North-South collaboration there are different reasons why researchers in scientifically advanced countries may choose to collaborate informally with partners in developing countries, such as to:

- work with researchers with specific research skills and talents;
- gain access to geographical regions and environmental conditions that may not be available in their own countries, (e.g. geological formations, fauna and flora, specific diseases, etc);

- gain access to scientific facilities that can operate only in specific geographical locations, such as the optical telescopes placed in specific locations such as South Africa, Chile or Hawaii; and
- maintain contact with former graduate students, to help developing countries to strengthen their scientific capabilities, or even because the researchers involved enjoy working in such countries.

Formal collaborative arrangements are based on government policies. For example, collaboration may be part of a country's foreign aid programmes, part of its general foreign policy or it may have overtly political reasons, namely to promote better relations between their respective countries.

Foreign Influences: ODA, WB, GTZ and NEPAD

In this section we discuss the possible influence and impact of ODA and of the World Bank (WB) on decision making in developing countries like South Africa. Scientifically-advanced countries (e.g. USA, European countries, etc) spend a portion of their budgets on international collaboration. This ranges from 5% for the US to as much as 25% in the case of smaller, advanced economies. These funds are allocated in a "bottom-up" peer-reviewed process, with funds granted to scientifically excellent research, regardless of the partnering arrangements made by national scientists. As such, these types of collaborations differ from spending dedicated to foreign research-for-aid programmes, which tend to be "top-down" in their mission focus and allocation.

Total spending on research-for-aid has been estimated to be approximately US$865 million a year for a subset of the major donor countries. Funds dedicated to collaborative research between scientifically advanced and scientifically lagging countries appear to be about US$1.4 billion per year. Very little is spent on collaboration with scientifically lagging countries; most projects mentioning a scientifically lagging country is research *about*, rather than *with* the country. These values are a subset of total official development assistance which, in 1997, totalled nearly $49 billion for the top 15 donor nations.[3]

Figure 2 provides a summary of ODA statistics for South Africa. The table indicates that South Africa received just below US$800 million during 2007. Approximately 50% of this amount was spent for the category "health and population".

Undoubtedly both ODA and the World Bank have been created and operate on the basis that they make a contribution in economic development internationally. While the benefits of their operations may be self evident and there are a number of successes such as the recent USA support for HIV/AIDS support – if there were no benefits they would not exist today. We concentrate on particular issues that are important for NACI and the national innovation system.

The World Bank affects development internationally through two channels – conditional aid and provision of "scientific" information. In a number of occasions the World Bank links aid disbursements to particular policy issues. For example, privatisation, widespread in industrialised, developing and transitional economies is an example of such influence.

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3 Wagner SC, Brahmakulam I, Jackson B, Wong A, Yoda T. 2001. *Science and Technology Collaboration: Building Capacity in Developing Countries?.* RAND Science and Technology, Santa Monica.

Figure 2: ODA statistics South Africa

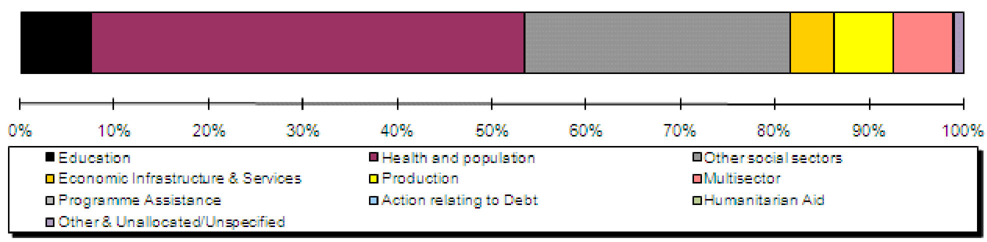
South Africa

Receipts	2005	2006	2007
Net ODA (USD million)	680	720	794
Bilateral share (gross ODA)	69%	78%	75%
Net ODA / GNI	0.3%	0.3%	0.3%
Net Private flows (USD million)	14 060	7 768	10 539

For reference	2005	2006	2007
Population (million)	46.9	47.4	47.6
GNI per capita (Atlas USD)	4 810	5 390	5 760

Top Ten Donors of gross ODA (2006-07 average)		(USD m)
1	United States	184
2	France	149
3	EC	141
4	United Kingdom	135
5	Germany	72
6	Netherlands	49
7	Denmark	23
8	Global Fund	23
9	Sweden	21
10	Belgium	20

Bilateral ODA by Sector (2006-07)



Sources: OECD, World Bank. www.oecd.org/dac/stats

The World Bank has played a key role in the implementation of privatisation in low-income countries, attaching privatisation to aid disbursements and promoting a pro-privatisation culture. The second channel of influence is through the Bank's publications and research. WB publications are often widely circulated in developing countries where access to academic literature may be limited. World Development Reports, produced annually by the WB, are often regarded as text books and the World Bank Research Observer claims to be the most widely read economic journal. Hence the influence of the WB should not be underestimated.

Referring to the example of privatisation, critics[4] have pointed to the weak empirical and theoretical foundations of privatisation policy generally[5]. "More specifically, several problems

4 Bayliss K. 2000. *The World Bank and Privatisation: a flawed development tool*. PSIRU, University of Greenwich.

5 The essence of privatisation theory (derived from theories of property rights and public choice) is that the process streamlines the relationship between enterprise owners and managers, and thereby improves performance. For a detailed exposition of the conventional approach, see Vickers, J. and G. Yarrow (1988) "*Privatisation: An Economic Analysis Cambridge*": The MIT Press. For critiques, see Fine B. (1990) "The *Coal Question*", Routledge: London and New York; Rowthorn R. and Chang H-J (1995) "*Introduction in The role of the state in Economic Change*"; Chang and Rowthorn (Eds) "*UNU/WIDER studies in Development Economics*" Clarendon Press Oxford; Tittenbrun, J. (1996) "*Private versus public Enterprise: in Search of*

emerge when the policy is applied to developing countries. Low domestic savings and weak capital markets may prevent the domestic private sector from participating, thus increasing reliance on foreign investment;[6] competitive forces are less effective because of the prevalence of monopolistic market structures[7] and the common practice of holding interlocking directorships.[8]

In many developing countries (especially in Africa), public corporations were created to fill vacuums left by private capital.[9] Institutional capacity is weak in much of Africa.[10] Hazy property rights can complicate privatisation. There is little regulatory capacity and greater risk of regulatory capture in an environment of patronage. Often foreign companies have substantial market power and as a result they can exert considerable pressure on regulators. The process of divestiture itself is technically demanding. Therefore, implementation in developing countries has relied heavily on technical assistance.[11]

Furthermore WB texts on privatisation have been criticised on several counts. Its publications tend to be selective in use of evidence. The extensive body of critical literature is rarely acknowledged in Bank publications. Rather citations are dominated by Bank-sponsored studies which tend to be more supportive of privatisation. The 1995 Report, *Bureaucrats in Business* attracted substantial criticism for, among other things, the narrow analytical framework and questionable causality assumptions. WB literature on privatisation seems to support a predetermined conclusion, applying a circular logic and developing a framework where all findings are evidence of benefits of privatisation. For example, in the study of

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the Economic Rationale for Privatisation" London: Janus; Martin, S., Parker D. (1997) "*The Impact of Privatisation: Ownership and corporate performance in the UK*" Routledge: London and New York;. Chang H., Singh A (1992) "*Public Enterprises in Developing Countries and Economic Efficiency: A critical examination of Analytical, Empirical and Policy Issues*" UNCTAD No48 August 1992 provide a review of the theoretical and empirical position regarding privatisation in developing countries. For evaluation of privatisation in the context of Africa, see Mkandawire, T. "The political economy of privatisation in Africa" chapter 10 pp192-213 in Cornia G. A. and Helleiner G. K. (editors) *From Adjustment to Development in Africa: Conflict, Controversy, Convergence, Consensus?* Macmillan, Basingstoke: St Martin's Press Inc. New York 1994.

6 Commander S and Killick T. 1988. Privatisation in Developing Countries: A Survey of the Issues in Cook P and Kirkpatrick C (eds) (1988). *Privatisation in Less Developed Countries.* Hemel Hempstead: Harvester Wheatsheaf. pp.91-124.

7 Kumssa Asfaw. 1996. The political economy of privatisation in sub-Saharan Africa. *International Review of Administrative Sciences* **62**: 75-87

8 Christopher A, Cavendish W and Mistry PS. 1992. *Adjusting Privatisation: Case Studies from Developing Countries*. James Currey Ltd, London. Ian Randle Publishers Ltd, Jamaica. Heinemann, USA.

9 Commander S and Killick T. 1988. *op. cit*.

10 Van Arkadie B. 1995. The State and Economic Change in Africa in Chang HJ and Rowthorn R (eds). *The Role of the State in Economic Change*

11 Young RA. 1995. Privatisation: African perspectives in Cook and Kirkpatrick (eds) *Privatisation Policy and Performance: International Perspectives*. Prentice Hall: NY pp.162-177

African experience, privatisation can be shown to be beneficial if an enterprise performance improves or if it fails (as privatisation means that state support for a failing enterprise has been withdrawn).[12] This framework ensures that critical outcomes fail to emerge.

In the field of science and technology probably the best-known failure of the WB is its involvement and advice in education.

While education has not been the WB's primary objective it has a long history of educational involvement. However, the WB's educational involvement has not been always reliable. Individual preferences have affected WB policies. For example during the 1960s under President Woods, higher education was excluded from support and developmental consideration. Woods was acutely distrustful of universities and university financial processes. He frequently reminded colleagues of his perception that university presidents were crafty characters who could not be trusted to spend grant money for the purposes approved by donors. Colleagues considered that as a prohibition against the WB financing higher education.[13]

Furthermore after a decade of "systematically" gathering educational quantitative research and policy analysis, the WB concluded that public primary education should become the centrepiece of development. This conclusion was reached by using strictly economic indicators, such as personal income returns. Based on this data, an additional year of education at lower levels of schooling has been found to bring about a larger increase in income than investments at higher levels of education. From this it was concluded that an investment of funds at lower levels of schooling is likely to yield a larger increase in national income. But such an increase in income assumes that the main resource of a developing country will be its cheap and flexible labour pool, producing goods and services for export. However under those assumptions the true increase in income will be realised not in the developing country but by consumers that import its goods.

If one is to examine the elements that comprise a sustained learning and development process that truly benefits a country, the conclusion would be totally different – more public support of higher education and the national innovation system would be required. Without this support, there will not be enough highly qualified technicians, engineers, communicators, social workers, designers and scientific researchers – all of whom contribute to the ongoing education and development of a nation.

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12 Campbell-White and Bhatia. 1998. *op. cit*. Kikeri *et al* (1992) Privatization: Lessons from Market Economies. *The World Bank Research Observer* . **9(2)**, July 1994

13 Jones WP. 1992. *World Bank Financing of Education: Lending, Learning, and Development*. Routledge.

Because of that policy during the past two or three decades, attention has focused on primary education especially for girls in most developing countries. This has led to a neglect of secondary and tertiary education, with higher education in a perilous state in many, if not most, developing countries. With a few notable exceptions, universities are grossly under-funded by governments and donors. As a result, quality is low and often deteriorating, and by necessity access remains limited.

Only recently the WB started recognizing the importance of higher education. In the report "Accelerating Catch-up: Tertiary Education Growth in Sub-Saharan Africa" the WB[14] states:

"Private and social returns to education have consistently been high. Earlier research found larger returns for primary education than for secondary or tertiary education. However, the picture is changing and the returns to tertiary education have risen appreciably. Private returns to tertiary education in low-income countries are now frequently on par with the returns from primary education. Each additional year of education can yield 10% to 15% returns in the form of higher wages. Furthermore, micro studies are identifying links between skills and higher productivity at the level of the firm, while research using macro data is showing that research and development (R&D) raises productivity, as does the quality of education (measured by middle school test scores). In fact, a one-year increase in average tertiary education levels would raise annual GDP growth in Sub-Saharan Africa (SSA) by 0.39 percentage points and increase the long-run steady state level of African GDP per capita by 12%. This may be a result of the competitive pressures released by the integration of the global economy, the acceleration of technological change, and the skill intensity of newer production methods and services. By raising the level of education and its quality, countries in SSA may be able to stimulate innovation, promote the diversification of products and services, and maximise returns from capital assets through more efficient allocation and management. In the face of competition from South and East Asian countries, a more skill-intensive route to development could provide both resource-rich and resource-poor countries an avenue for raising domestic value added."

Overseas Development Assistance (ODA) has always been criticised for its conditionality. By definition, aid conditions are donor-initiated policies or mechanisms intended to ensure that resources from donors and related resources provided by developing country *partners*, are used as the donor intended. They are often applied to effect (unrelated) policy and/or institutional changes to which the recipient would not otherwise have agreed.

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14 World Bank. 2009. *Accelerating Catch-up: Tertiary Education Growth in Sub-Saharan Africa*. World Bank, Washington DC.

In the 1990s, aid conditions expanded both in scope and ambition, not only to influence macro-economic policy, but also to micro-manage a wide range of developing country policies and institutions. From 1995 to 2000, there was an average of 41 conditions per IMF loan. They ranged from fiscal policy, exchange rate policy, pricing and marketing, privatisation, financial sector regulation and systemic reforms, to social safety nets and the social security system.

The paradox of a long history of development assistance (ODA) on one hand and persistence of poverty in developing countries on the other started to raise global concern in 1990s. Investigations into the reasons for the failure of aid to deliver sustainable development and poverty reduction led to dialogue and a range of commitments at regional and international levels on how to make development assistance more effective.

In the Rome and Marrakech Declarations, the international community committed to five principles for action: Country Ownership, Harmonisation, Alignment, Mutual Accountability and Managing for Results. This commitment was further reinforced in the Paris Declaration.

Country Ownership refers to the identification of development goals and strategies, and the formulation of national development plans and poverty reduction strategies by countries, under government leadership, rather than donors.

Harmonisation refers to efforts by donors and countries to integrate and streamline all aspects of their development assistance, including adopting common systems and procedures, adopting joint working arrangements that include joint decision-making and shared information.

Alignment refers to donor anchoring their support on country objectives, priorities, and policies based on a consistent set of results indicators, and aligned with strengthened country's processes, systems, budget cycle, etc.

Mutual Accountability refers to shared accountability and transparency in the use of development resources and outcomes, and jointly assessing mutual progress in implementing level mechanisms.

Managing for Results is defined as sustained improvements in development outcomes at the country level through enhanced attention at all phases of the development process.

The five core principles endorsed by the heads of MDBs as well as by the Head of OECD/DAC are briefly summarised as follows:

- Focus the dialogue on results at all phases of the development process;

- Align actual programming, monitoring and evaluation activities with the agreed expected results (to align donor country strategies with Poverty Reduction Strategy Plans or national development plans;
- Keep results reporting system simple, cost-effective and user-friendly;
- Manage for, not by, results; and,
- Use results information for management learning and decision-making as well as reporting and accountability.

Recently donors have agreed to the "Accra Agenda for Action", a forward-looking agreement aimed at strengthening the Paris Declaration. Sadly, this international accord appears to be also weak and insufficient. At Accra, individual donors aimed to agree to more concrete progress on aid effectiveness between now and 2010 amongst themselves.

According to the World Bank's[15] African Poverty at the Millennium "donors have apparently not used recipient governments' revealed commitment to tackling poverty as a basis for aid allocations. Econometric analysis of aid shows that 'donor interest variables' capturing commercial and political considerations are a major determining factor for bilateral aid allocations."

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) is a federal enterprise based in Eschborn near Frankfurt am Main. It was founded in 1975 as a company under private law. The German Federal Ministry for Economic Cooperation and Development (BMZ) is its major client and funder. The company also operates on behalf of other German ministries, the governments of other countries and international clients, such as the European Commission, the United Nations and the World Bank, as well as on behalf of private enterprises. GTZ supports the German Government in achieving its development-policy objectives. It works on a public-benefit basis. All surpluses generated are channelled back into its own international co-operation projects for sustainable development.

GTZ employs approximately 12,000 staff in more than 120 countries of Africa, Asia, Latin America, the eastern European countries in transition and the New Independent States (NIS). Around 9,000 of these staff are national personnel and GTZ maintains its own offices in 69 countries. Approximately 1,500 people are employed at Head Office.

It should be emphasised that Germany's development co-operation takes place within a framework of rules. They are known as 'the principles governing the implementation of

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15 World Bank. 2001. *African Poverty at the Millennium*. World Bank, Washington DC.

development policy'. The aim of these rules is to ensure that due regard is paid to the goals of German development policy in all co-operation with partner countries. Partnership-based co-operation among all stakeholders is the single most important principle for the successful design of German development policy. In order to satisfy this fundamental principle, the BMZ has drafted a set of rules – the design principles of German development co-operation.

Participation and 'ownership' are part of these principles. The people in Germany's partner countries are actively involved in the design of their projects. They are expected to have a decisive voice in how a project should develop. That also means that they are themselves responsible for their project from the outset. This may support expectations that the projects can continue after BMZ support has ended.

A more recent programme, the Basic Energy and Climate Change Adaptation Programme (BECCAP) funded by the German Ministry of Environmental Affairs (BMU), has the aim to increase the adoption of renewable energies and energy efficiency methods and techniques to reduce CO_2 emissions of industries and households in South Africa.

Target groups of the project are, on the one hand, businesses and organizations that work in the field of energy efficiency and renewable energies. On the other hand, the project supports mostly low-income households, to establish and ensure a sustainable energy supply through the use and promotion of renewable energy technologies or energy efficient techniques.

BECCAP is the result of the launching by the German Department of Environment of a 20 million Euro worldwide programme on climate change and energy. They invited project proposals from any interested implementing agency, NGO or organisation such GTZ. As part of the preparations for a new focal area, GTZ agreed with the Department of Environment and Tourism in South Africa to prepare a proposal to the fund. The proposal was one of four accepted – the others were in Brazil, India and Eastern Europe. The mandate was the Government-to-Government agreement between SA and Germany. GTZ also has a good relationship with DEAT from previous programmes that have been implemented. BECCAP is in the process of preparing MoUs with DEAT and DME at a programme level.

While we elaborate about NEPAD in the following chapters here we provide a commentary (Box 2) as provided by Dr J Mugabe, former science advisor of NEPAD.

Box 1: GTZ in SADC and South Africa

The Programme for Biomass Energy and Conservation (ProBEC) is an official SADC energy programme and the only one dealing with traditional energy. ProBEC is implemented by GTZ and started in 1997 with a focus on information exchange between SADC countries and on implementation of pilot projects, based on a request from the SADC Secretariat.

The Programme has three components:

- promotion of efficient and energy-saving technologies
- policy advice
- biofuels.

The GTZ web site states "By providing specific policy advisory services, the programme promotes the creation of framework conditions to facilitate and secure access to energy for low-income households". Furthermore "ProBEC publishes two newsletters per month to inform its readership about the latest findings on biomass and biofuels, and supports studies, workshops and conferences in the SADC region."

Since 2004, the Dutch Government through DGIS made available support for large-scale implementation, specifically in Tanzania, Malawi and Zambia. ProBEC is currently active in six SADC countries: Swaziland, Malawi, Tanzania, Zambia, Lesotho and Mozambique.

As far as achievements are concerned, GTZ states: "The programme has triggered important processes at the political level. ProBEC ensures that biomass remains on the agenda in SADC countries. The programme advises the Governments of Botswana, Lesotho and Malawi on developing Basic Energy Services and Technologies (BEST) strategies and advises Mozambique, Lesotho and Swaziland on biofuels."

Preparatory activities for full-scale national programmes have been carried out in South Africa, Namibia and Botswana. Preparatory activities include baseline studies (energy use, appliance ownership, existing role-players in the efficient energy appliance supply chain), made agreements (MoUs, co-operation agreements, etc.) with local organisations such as Government, NGOs and potential implementing partners) and appointed a national co-ordinator (person to carry out the national activities).

The official partner in South Africa is CEF (Central Energy Fund). An MoU has been in operation for the past three years. The MoU resulted out of a previous collaboration on the solar cooker research programme that pre-dated ProBEC. When this project ended, the MoU was extended to include ProBEC activities. The mandate to have the MoU with CEF and not directly with DME stems from a Ministerial Directive that tasked CEF to implement activities on household energy and poverty relief. For the new programme (Basic Energy and Climate Change Adaptation Programme) funded by a different German Ministry, GTZ will have to sign MoUs with DME and DEAT. Again, the mandate for this comes from the Government-Government agreement signed by Germany and SA – also called the Bilateral Co-operation Agreement.

Box 2: South Africa and NEPAD

South Africa is an active participant in many regional and sub-regional science, technology and innovation policy processes and related programmes. It is engaged in science and technology programmes of the African Union (AU), the New Partnership for Africa's Development (NEPAD), the Southern Africa Development Community (SADC) and has bilateral agreements with a growing number of African countries. The country, through its Department of Science and Technology (DST), is influencing many regional science and technology decisions and contributing to the design of programmes of NEPAD and SADC. It is perhaps the most influential country on science and technology issues in NEPAD and SADC. There are a number of factors that made the country influential. These are: (a) a deliberate strategy to engage in regional science and technology co-operation — unlike most African countries, South Africa has explicit policies for co-operation. These are written in its Science and Technology White Paper and the National R&D Strategy; (b) personnel and resources for promoting regional and international co-operation — a unit with staff in DST dedicated to Africa and SADC co-operation; and (c) political leadership that champions regional S&T co-operation — over the past seven years South Africa's ministers for science and technology have been the main champions for African (NEPAD) and SADC science and technology programmes and processes. The case study below demonstrates South Africa's contributions to and influence on regional science and technology activities and decision-making.

Some staff of DST participated in the preparation of NEPAD's overall development framework document. This exercise was largely co-ordinated by the country's presidency and involved many stakeholders from across a wide range of sectors. DST staff ensured that the framework document of NEPAD contained a chapter on science and technology. Thereafter DST has been actively engaged in promoting the development and implementation of programmes under NEPAD. Some of the key investments that DST has made in NEPAD science and technology are outlined below:

1. In July 2002 DST funded and facilitated the establishment of the NEPAD Office of Science and Technology in Pretoria. It provided approximately ZAR 1 million for one year for staff salaries and office operations. The NEPAD Office of Science and Technology was charged with mobilizing African countries and expertise to design a comprehensive plan of action as well as to create a high-level platform for decision-making.
2. In February 2003 DST and the NEPAD Office of Science and Technology organised an African experts' and policy-makers' workshop on science and technology to identify specific R&D and innovation priorities. The workshop was largely funded by DST and brought together more than 50 experts and decision-makers from at least 10 African countries. South African institutions, including the Council for Scientific and Industrial Research (CSIR), produced most of the technical background papers for the workshop. These formed the basis for priority setting. The main output of the workshop was a list of priorities and a statement of commitment by countries to co-operate and develop a NEPAD science and technology action plan.
3. In October 2003 DST collaborated with UNESCO to organise another experts' workshop to refine the list of priorities from the February 2003 workshop. The workshop was held in Nairobi, Kenya and attended by the then Director General of DST, Dr Rob Adam, and several senior staff of DST. Dr Adam was the only DG or government official of high rank at the three-day workshop. He and his team were very instrumental in getting draft documents for NEPAD science and technology plan of action prepared.
4. In early November 2003 DST and NEPAD organised the first African Ministerial Conference on Science and Technology in Johannesburg. The conference brought together at least 20 African ministers of science and technology and many senior policy-makers from across the continent. At this conference, chaired by the then South African Minister for Science and Technology Dr Ben Ngubane, major or key decisions were made largely influenced by South Africa's delegation and background documents. An African Ministerial Council on Science and Technology (AMCOST) was established and South Africa elected as its first chair for a period of two years. Dr Ngubane became the chairperson of AMCOST and Dr Adam the chairperson of AMCOST's Steering Committee of DGs/PSs.
5. Between January 2004 and September 2005 South Africa organised many meetings of AMCOST Steering Committee and Bureau. Funding for these meetings was provided by DST. It facilitated the preparation of Africa's Science and Technology Consolidated Plan of Action through NEPAD's Office of Science and Technology by providing permanent offices for NEPAD at the CSIR and recruiting several staff. It is the only African country that funds the NEPAD Office of Science and Technology. In September 2005 South Africa handed over the chair of AMCOST to Senegal, but has continued to participate in and facilitate NEPAD's activities.

South Africa's participation in regional and continental science and technology policy processes and related programmes can also be illustrated by the number of centres of excellence and programmes that it is hosting. It hosts the largest number of NEPAD science and technology programmes, including biosciences at the CSIR where a SADC network of centres of excellence is hosted with more than Euro 3.5 million funding from the Government of Finland and DST. The grant for NEPAD biosciences in SADC was actually negotiated and signed by DST on behalf of NEPAD and SADC countries. It is a good example of how South Africa can use its bilateral co-operation with European countries to secure resources for Africa-wide or SADC programmes. South African researchers also influence the content of the SADC biosciences programmes, as they are the main key players in the programme at the CSIR.

South Africa also hosts and provides a large portion of the funding to the African Laser Centre (ALC). The core programme of the ALC is administered and implemented by South African scientists and an African network. Other programme areas where South Africa is having influence are energy, water and STI indicators. The energy programme document was largely drafted by researchers at the CSIR while the water one is co-ordinated by the Water Research Commission of South Africa. South African experts from the University of Pretoria, the National Advisory Council on Innovation (NACI) and the Human Sciences Research Council (HSRC) were instrumental in the preparation of NEPAD's African Science, Technology and Innovation Indicators programme, and the country's questionnaire for R&D surveys was adopted as the framework for surveys by other African countries under NEPAD.

There are other areas where South Africa has influenced NEPAD and AU policies. These include: (a) AU/NEPAD decision to have 1% of GDP expenditure on R&D — this was first proposed by South Africa at the November 2003 AMCOST and subsequently endorsed by AU Summit in Khartoum Sudan in January 2006; (b) AU 2007 decision that each African country should develop a national innovation strategy was first proposed by South Africa's delegation at the Dakar AMCOST in September 2005 and then adopted at the AU Summit in January 2007. Evidence of this can be discerned from the speeches/statements by South Africa's delegations at AMCOST and then from reports of AMCOST and proceedings of AU Summits. (By Prof J Mugabe)

Review and Analysis of the African Science and Technology Multilateral Agreements

In parallel with the discussions on the development of the African Union (AU) platform and the transformation of the Organisation of African Unity (OAU) into the AU, was a set of initiatives to develop an African-led development plan. This began in 2001 when Professor Wiseman Nkuhlu was requested by Presidents Mbeki (South Africa), Obasanjo (Nigeria) and Boutiflika (Algeria) to co-ordinate a process toward such an African plan. The first step in the process was the gathering of experts to develop the framework of the first plan under the banner of what was called the Millennium Africa Plan (MAP). Later, as more countries joined this initiative, this evolved into the New Africa Initiative (NAI). At the same time as the development of NAI, President Wade of Senegal led a parallel process that resulted in the Omega Plan. On instruction of the African Heads of State and Government as well as their partners, the NAI and the Omega Plan were merged into what became the New Partnership for African Development or NEPAD. This became the work programme of the continent and with the establishment of the AU, NEPAD as a functional programme reported via a Heads of State Implementation Committee into the AU Summit. Professor Nkuhlu became the first CEO of NEPAD.

NEPAD organised to develop the project plans of the founding sectors into full-scale continental plans. Science and Technology was not one of the founding sectors, but a number of them including water, environment, health, agriculture and education all had significant research, science and technology components. The Science and Technology platform was a development in the second round. The NEPAD Secretariat became the supporting platform for this development and eventually the implementation of these continental plans.

The establishment of the African Union Commission in 2004 marked a second phase in this development. The structure of the Commission was designed to support these sectoral plans with the appointment of AU Commissioners in different bundles of sectors. The development of the AU Commission brought a further challenge related to the relative roles and responsibilities of the Commission and the NEPAD Secretariat. The further challenge was the branding of the African sectoral platforms, which by this time, were enjoying considerable attention and some real possibilities of resource support in many significant places like the G8, the UN, the European Union (EU) and the OECD in addition to individual donor countries. In theory there should have been no problem given that each of these sectoral platforms reported into a Ministerial structure that came from the AU member countries, and many of the 'NEPAD' plans were endorsed and adopted at AU Summits. They were, therefore, in fact the AU's plans in these sectors. These became the crux of many energised discussions and the eventual result for many sectors was the evolution of AU/NEPAD plans adopted and guided in their implementation by AU Sectoral Ministers Councils, with strategic and policy support from the AU Commission and day-to-day implementation support from the appropriate sector in the NEPAD Secretariat. The AU/NEPAD Science and Technology platform has been reasonably successful in this regard, perhaps more so that many sister platforms. This is expanded elsewhere in the document.

All the AU/NEPAD platforms have had the benefit of the input of academics and academic institutions in their development, and all sectoral plans will be implemented using technology platforms. There is a subset in which there is not only the use of science and technology, but also involves the further development of science and technology. These we believe are the ones most relevant to this assignment. These include the following sectors:

- Science and Technology
- Health
- Water
- Environment
- Agriculture
- Information and Communication Technologies (ICT), and
- The STAP (Short term action plan for African infrastructure) which includes energy and mining (the latter is being further developed into the African Mining Vision)

The AU/NEPAD Science and Technology Multilateral Platform

The AU Summit in Maputo passed a resolution in 2002 giving the NEPAD Secretariat and the South African government the responsibility to develop the NEPAD Science and Technology platform. South Africa hosted and chaired the inaugural meeting of African Ministers responsible for Science and Technology in August 2003. This meeting endorsed the establishment of the African Ministers Council on Science and Technology (AMCOST) as the governing body of the platform, to be supported by a Ministerial Bureau and a Senior Officials Steering Committee. It adopted the proposed framework of the African Science and Technology plan and approved process for the development of the comprehensive plan through a regional process to be tabled and adopted at the 2nd AMCOST in 2005. This was achieved and the African Consolidated Science and Technology Plan of Action was approved and adopted in the Dakar, Senegal, meeting of AMCOST in September 2005.

The African Consolidated Plan of Action, when it was adopted in August 2005, rested on a framework of 12 flagship research and development programmes. These 12 flagship R&D programmes were grouped into four programme clusters. These four clusters were in turn supported by a series of actions that would create the enabling environment for their implementation, described in a section of the plan called "Improving policy conditions and building innovation mechanisms".

The Flagship research and development programmes have been clustered as follows:

Programme Cluster 1: Biodiversity, Biotechnology and Indigenous Knowledge cluster

Programme 1.1 Conservation and sustainable use of biodiversity

Programme 1.2 Safe development and application of biotechnology

Programme 1.3 Securing and using Africa's indigenous knowledge base

Programme Cluster 2: Energy, Water and Desertification

Programme 2.1 Building a sustainable energy base

Programme 2.2 Securing and sustaining water

Programme 2.3 Combating drought and desertification

Programme Cluster 3: Material sciences, manufacturing, laser and post-harvest technologies

Programme 3.1 Building Africa's capacity for material sciences

Programme 3.2 Building engineering capacity for manufacturing

Programme 3.3 Strengthening the African Laser Centre (ALC)

Programme 3.4 Technologies to reduce post-harvest food loss

Programme Cluster 4: Information and communication technologies, and space science and technology

Programme 4.1 Information and communication technologies

Programme 4.2 Establishing an African Institute of Space Science

Since 2005 a 13th flagship research and development programme has been added – that of mathematical sciences, with the African Institute of Mathematical Sciences (AIMS) as the centrepiece.

The enabling environment is to benefit from a range of capacity building initiatives, facilitatory regional and national policy regimes and the building of science and technology infrastructure. The multilateral plan addresses these through the following programmes:

Programme: Multilateral Plan

Programme 5.1 African Science, Technology and Innovation Indicators Initiative (ASTII)

Programme 5.2 Improving regional co-operation in science and technology

Programme 5.3 Building public understanding of science and technology

Programme 5.4 Building a common African strategy for biotechnology

Programme 5.5 Building science and technology policy capacity

Programme 5.6 Promoting the creation of science parks

Since 2005 this continental plan has, in turn, gone through a '*domestication*' process in the African sub-regions. This is a set of processes through which each region determines its short- to medium-term action plan with respect to regional implementation of this continental multilateral plan based on regional priorities.

South Africa's participation in the activities of this multilateral platform can be divided in three distinct phases. The first is the formation of the platform in the context of both NEPAD and the AU, including the development of the governance models. The second is the development of the continental plan or multilateral agreement. The third phase is the implementation of the agreement and the national obligations in this regard.

Phase One: This phase was at its highest momentum in the period 2002 to 2004. Continuing on the momentum of hosting of the World Summit on Sustainable Development in 2002, coinciding with the transformation of the Organisation of African Unity (OAU) in to the more powerful African Union (AU), the concept of the African S&T multilateral platform took root. The Department of Arts, Culture, Science and Technology (DACST) took a lead by sponsoring the creation of a S&T officer in the NEPAD Secretariat with a dedicated NEPAD S&T Executive in the form of Dr. John Mugabe.

South Africa, through President Mbeki, was pivotal to the Maputo Summit decision to sanction the meeting of African Ministers responsible for science and technology. South Africa hosted and chaired this meeting in 2003 with a view to developing the Continental Science and Technology platform. South Africa, led by Dr Rob Adam, co-ordinated the senior officials process that resulted in the following major negotiated milestones – the proposed governance model for the platform, the framework that would eventually lead to the Consolidated S&T Plan of Action (CSTPoA), the process to develop the CSTPoA, and the first set of donor and partner engagements.

Minister Ben Ngubane successfully guided the 2003 Ministerial meeting to adopt the many key decisions. The first was the governance model for the platform with the African Ministerial Council on Science and Technology (AMCOST) becoming the political management body of S&T on the continent, reporting directly to the AU Summit. The AMCOST is supported by a Ministerial Bureau and a Steering Committee of Senior Officials. The second was the adoption of the framework and the process toward the development of the full-scale plan. In addition, the 2003 inaugural meeting also launched the first major initiative under the auspices of AMCOST, i.e. the African Laser Centre (ALC). This was through the determined efforts of the National Laser Centre of South Africa under the leadership of its director Phil Mjwara. Minister Ngubane and subsequently Minister Mangena oversaw the completion of the continental S&T plan, which was launched in Dakar, Senegal, at the 2005 AMCOST meeting when South Africa handed over the leadership of the platform to Minister Gossama Dia of Senegal.

Phase 2: The plan was unique in that it was developed through a bottom-up process of regional workshops in all five of Africa's regions. South Africa played pivotal roles at two levels in the development of the plan. The first is the leading role it played in the SADC process. The second was the oversight and guidance of the overall plan through leadership of the steering committee. The third was the engagement with Africa's international partners with respect to participation and assistance in the implementation of the plan.

Phase 3: Even before the platform was formerly launched in August 2003, South Africa was active in implementing core components of the impending plan. This was built on the firm notion that a demonstration of early winners would provide the required impetus for further investments both by the African players as well as Africa's partners in implementing the plan. In the early years this took shape in three forms of South African investment. The first was through institutional development – through the continued sponsorship of the NEPAD Secretariat Office, the secondment of Bothlale Tema, a senior official of the DST, to be the first Director of Human Resources, Science and Technology in the AU Commission supporting the first AU Commissioner for S&T – Nagia Essayed. The second was through the direct government investment in lead AU/NEPAD projects. These include the highly successful AIMS, the ALC and the Southern African Biotechnology Network (SANBio). The third was through the development of a funding support instrument, the Regional Co-operation Fund, to enable South African institutions to participate in AU/NEPAD flagship projects together with other African partners.

South Africa clearly has been an enthusiastic partner both in word and material investment since the beginning of the platform. In financial terms South Africa has been the highest investor to date in implementation of the platform. The bulk of this investment, it must be noted, has been in support of South African institutions to participate in the implementation of the plan, in particular the three nodes of the flagship programmes that South Africa hosts.

There appears to have been a de-emphasis in the platform in recent times beyond the three flagship nodes. There has also been a decline in the general support instruments for African co-operation through the STAF.

The AU/NEPAD Environmental multilateral platform

The African Ministerial Conference on the Environment (AMCEN), at its second special session on 10 -June 2003, adopted Africa's environmental multilateral agreement in the form of the *Action Plan of the Environment Initiative of NEPAD*. This is a response to NEPAD's call for the development and adoption of an environment initiative to address Africa's environmental challenges while concomitantly combating poverty and promoting socio-economic development. This also represents the core objective of the Action Plan.

In addition, it has 12 specific objectives, one of which is to '*build a network of regional centres of excellence in environmental science and management'*. Another is to 'enhance human and institutional capacities of the African countries to address effectively the environmental challenges facing the continent'.

These objectives are expressed in six programmes. These are:

1. Combating land degradation, drought and desertification,
2. Conserving Africa's wetlands,
3. Preventing, control and management of invasive alien species,
4. Conservation and sustainable use of marine, coastal and freshwater resources,
5. Combating climate change in Africa,
6. Cross-border conservation or management of natural resources with the special foci being freshwater, biodiversity, bio-safety and plant genetic resources, and forests.

These six programmes are in turn supported by addressing the following four cross-cutting activities:

- Health and the environment,
- The transfer of environmentally sound technologies,
- The assessment and early warning for natural disaster, and,

- The development of the 'NEPAD environment directory'.

There is clearly a great deal of overlap between the environment action plan and the CSTPoA. It can be argued that the whole of the CSTPoA's programme cluster 1 (biodiversity, biotechnology and indigenous knowledge), and programme cluster 2 (energy, water and desertification) are devoted to addressing the programmes of the *Action Plan of the Environment Initiative of NEPAD.* In addition, the remote sensing foci in the CSTPoA programme 4.2 (space science and technology) is also well orientated to potentiating the implementation of the Environmental Plan. In addition, the implementation of the CSTPoA programme cluster 3 (material science, manufacturing, laser, and post-harvest technologies) would be strongly guided by the principle of the Environmental Initiative.

While it is useful that there is a sound reinforcing theoretical overlap of the two multilateral platforms, their implementation currently occurs largely in isolation of each other. Not only is co-operation, co-ordination and synergy desirable between these two multilateral platforms, it is fact imperative for the realisation of their objectives.

The AU/NEPAD Health multilateral platform

The continental health platform operates under the auspices of the African Health Ministerial. The First Conference of Health Ministers of the African Union met alongside the AU Summit in Maputo and adopted the NEPAD Health Strategy which is supported by the Africa Health Strategy: 2007-2015.

NEPAD health vision is that of 'An Africa rid of the heavy burden of avoidable ill-health, disability and premature death'.

The goal of the NEPAD health strategy is to dramatically reduce the burden of disease, especially for the poorest people in Africa.

The objectives are stated as follows:

The heavy preventable burden of disease in Africa is underpinned by poverty and under-development. At its core NEPAD seeks to address the socio-economic, political and environmental factors undermining health. The NEPAD health sector strategy specifically seeks to:

1. Strengthen commitment by and the stewardship role of Governments and mobilise and harness a health and multi-sectoral effort that should include the resources of government, civil society, the private sector and regional and international partners.

2. Strengthen health systems and services so that they can provide effective and equitable health care, built on evidence-based public health practice, including incorporating the potential of traditional medicine.

3. Scale up communicable and non-communicable disease control programmes, especially recognising the unprecedented challenge posed by HIV/AIDS, tuberculosis and malaria.

4. Strengthen and scale up programmes to reduce the burden due to conditions related to pregnancy and childbirth.

5. Empower individuals, families and communities to act to improve their health, achieve health literacy and integrate effective health interventions into existing community structures.

6. Mobilise and effectively use sufficient sustainable resources to enable health systems and disease control programmes to operate at the level required to reach health targets.

7. Share available health services equitably within countries.

The health targets are therefore:

1. To halt and begin to reverse the spread of HIV/AIDS by 2015,

2. To halt and begin to reverse the increase in the incidence of malaria and other major diseases by 2015,

3. To reduce mortality rates for infants and children under5 years of age by two-thirds by 2015,

4. To reduce maternal mortality by 75% by 2015.

The Africa Health Strategy 2007-2015 has a special section in the 'Health Systems' chapter on Health information and research. This section emphasises the need for research at both a health systems level as well as disease and intervention levels. It also registers a target for the funding of essential national health research needs 'at least 2% of national health expenditure and 5% of project and programme aid'. The Health Research Plan for the multilateral platform will be contained in a continental position paper in due course.

The Agriculture multilateral platform

The continental agricultural platform operates under the auspices of the Conference of Ministers of Agriculture of the African Union. The meeting of this conference of ministers in

July 2003, in Maputo, endorsed the Comprehensive Africa Agriculture Development Programme (CAADP). The ministers further declared that 'Governments should strengthen agricultural research through technology transfer, promotion of centres of excellence, appropriate institutional reforms and additional financing, as well as the adoption of new approaches including impact assessment strategy.

CAADP has been endorsed by the Heads of State and Government as a framework for the restoration of agriculture growth, food security, and rural development in Africa. In order to meet the primary goal of agriculture-led development towards the elimination of hunger, reduction of poverty and ensuring food insecurity, and organising for Africa to be a global food basket. CAADP has the following specific targets for achievement by the year 2015:

1. Improve the productivity of agriculture to attain an average annual growth rate of 6%, with particular attention to small-scale farmers, especially focusing on women;
2. Have dynamic agricultural markets within countries and between regions;
3. Have integrated farmers into the market economy and have improved access to markets to become a net exporter of agriculture products;
4. Achieve a more equitable distribution of wealth;
5. Be a strategic player in agricultural science and technology development; and
6. Practice environmentally sound production methods and have a culture of sustainable management of the natural resource base.

The CAADP also outlines four specific thrusts for improving Africa's agriculture. These are:

1. The extension of the area under sustainable land management and reliable water control systems;
2. Improving rural infrastructure and trade related capacities for market accesses;
3. Increasing food supply, reduce hunger, and improve responses to food emergency crises; and
4. Improving agriculture research, technology dissemination and adoption.
5. In addition, there are three clusters of crosscutting issues. These are:
6. Capacity Strengthening for agriculture and agribusiness: academic and professional training; and
7. Information for agricultural strategy formulation and implementation

Review and analysis of South Africa's African Bilateral Agreements with S&T Content

With the dawn of democracy in 1994, President Mandela's government sought to consolidate and formalise South Africa's relationships with various international partners on a one-on-one basis through a series of bilateral co-operation agreements. These agreements in many cases were international legal instruments to formalise existing co-operation between South Africa and the partner country, while in other cases it signalled the beginning of the relationship in that sector. In the science and technology sector the former is true for many of the north American and western European country partnerships, as these were relationships that were developed and nurtured from colonial times through the period of the Union of South Africa governments, and finally through the apartheid Republic governments pre-1994. The latter is true generally for the rest of the world including Africa with some exceptions.

The state protocol for the concluding and signing of sector agreements on bilateral co-operation is that the agreement must be approved directly by the President, who would then delegate the signing of the agreement to a member of cabinet on behalf of the Republic, usually by the sector minister. We mention this specifically because in the science and technology space, this protocol was only strictly adhered to from the second administration. Many of the earlier science and technology agreements were signed on behalf of the Republic by the Department of Foreign Affairs. This may have some implications regarding the activity levels of the agreements.

South Africa has signed bilateral agreements with 40 other African countries since 1994. In this context bilateral agreements include all official intergovernmental agreements and Memoranda of Understanding, but do not include Declarations and Letters of Intent. There have been 356 such agreements signed, of which 50 have significant science and technology content. These agreements include the early 'General Agreements' on co-operation in multiple fields included in which are 'scientific and technological co-operation', the science and technology agreements, the health agreements, the agriculture and livestock agreements and the education agreements. These are summarised in the following Table (Table 1).

Table 1: List of S&T Related Bilateral Co-operation Agreements with African Partners

Country	**Agreements since 1994**	**S&T related**	Listing of the S&T related components
1. Algeria	27	4	▪ Science & Technology ▪ Animal Health ▪ Mining & Energy ▪ Information & Communication

			technologies
2. Angola	14	6	▪ Science and Technology ▪ Gen agreement on Economic, Scientific, Technical and Cultural fields ▪ Health ▪ Agriculture and livestock farming ▪ Electricity ▪ Petroleum
3. Benin	2	0	
4. Botswana	12	3	▪ Science and Technology ▪ Agriculture and livestock farming ▪ Health
5. Burkina Faso	3	0	
6. Burundi	3	0	
7. Cameroon	4	0	
8. Cape Verde	1	0	
9. Central African Republic	2	0	
10. Chad	2	0	
11. Cote d'Ivoire	1	0	
12. DRC	26	3	▪ Health ▪ Agriculture ▪ Education
13. Egypt	18	3	▪ Science and Technology ▪ Phytosanitary Measures ▪ Veterinary Public Health
14. Equatorial Guinea	3	0	
15. Ethiopia	7	1	▪ MoU regarding industrial and technical co-operation
16. Kenya	2	1	▪ Science and Technology
17. Lesotho	19	3	▪ Science and Technology ▪ Health ▪ Agriculture
18. Liberia	1	0	
19. Libya	4	0	
20. Madagascar	2	0	
21. Malawi	3	1	▪ Science and Technology

22. Mali	7	2	▪ Science and Technology ▪ Preservation of the 'Timbuktu Manuscripts'
23. Mauritania	3	1	▪ Petroleum and energy
24. Mauritius	6	0	
25. Morocco	3	0	
26. Mozambique	34	3	▪ Science and Technology ▪ Agricultural development & Agriculture and livestock ▪ Health
27. Namibia	51	5	▪ Science and Technology ▪ Mining, geology, minerals and energy ▪ Education ▪ Agriculture ▪ Health and medical sciences
28. Republic of Congo	4	0	
29. Rwanda	16	3	▪ Education ▪ Agriculture and livestock ▪ Health
30. Sao Tome & Principe	2	0	
31. Senegal	6	1	▪ Science and Technology
32. Seychelles	3	0	
33. Sudan	11	0	
34. Swaziland	3	0	
35. Tanzania	8	1	▪ General agreement on co-operation in economic, scientific, technological and cultural fields
36. Togo	1	0	
37. Tunisia	17	2	▪ Science and Technology ▪ Public health and medical science
38. Uganda	9	1	▪ Health (MoU)
39. Zambia	7	2	▪ General Agreement on economic, scientific, technological and cultural fields ▪ Science and Technology
40. Zimbabwe	9	1	▪ Science and Technology
40 Countries	**356**	**47**	(13%)

The African bilateral agreements with science and technology content can be divided by those that are led by DST (and formerly DACST) and those led by other departments.

The DST-led African bilateral co-operation

From 1994 to 2008, South Africa concluded and signed science and technology bilateral co-operation agreements with 16 African governments. The first of these was signed with Egypt in August 1997 by the DFA. The most recent African agreement was the Bilateral Agreement on Scientific and Technological Co-operation signed by Minister Mangena and his counterpart from Angola in April 2008. Of the 16 countries, 50% are in the SADC region, one from East Africa, three from West Africa, and four from North Africa.

In addition the DST has officially received on sent delegations to Rwanda, Ghana, Ethiopia, Sudan and Gabon with a view to possible future agreements.

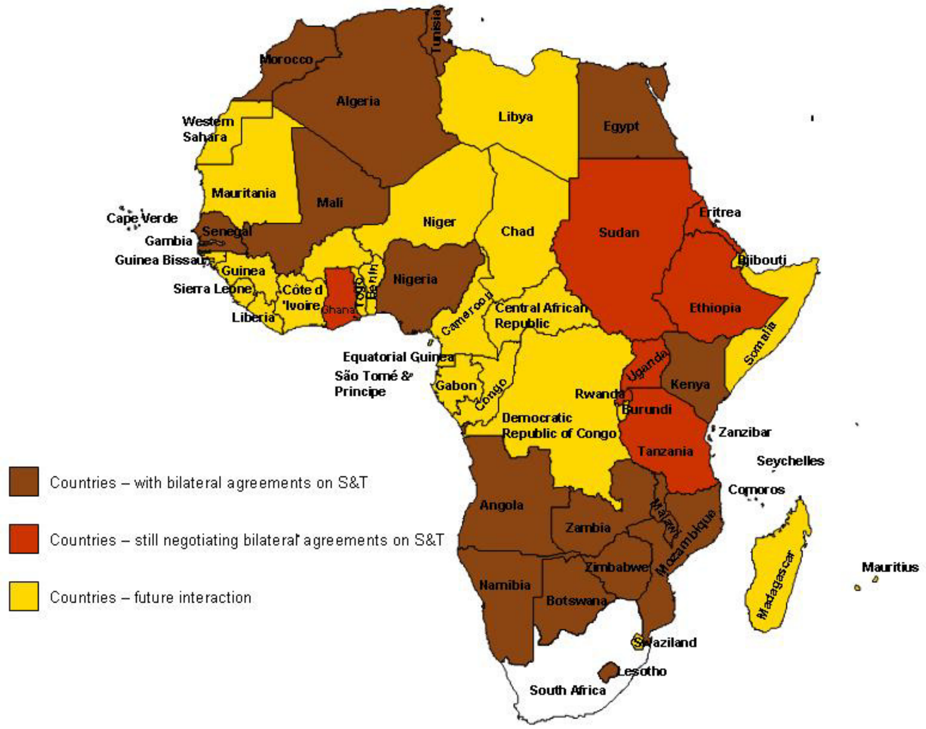
All the formal Bilateral Agreements on Scientific and Technological Co-operation contain clauses on general scientific and technological co-operation. The objectives of the agreements are to:

- Develop information sharing about the Parties' policies with regard to research, technological development and innovation; and,
- Promote the emergence of scientific and technological research involving the Parties' scientific and industrial communities in areas of mutual interest.

The agreements further expand on the modalities of co-operation in order to achieve the stated objectives as being:

- Organise bilateral events bringing together experts from the Parties' academic, industrial and institutional circles to promote scientific and technological cooperation between the two countries;
- Initiate exploratory missions by researchers and experts to develop programmes, projects and activities;
- Undertake joint scientific and technological programmes with emphasis on bilateral, regional and international networking in areas of mutual interest;
- Promote exchanges between scientists, including doctoral and post-doctoral students, technical personnel and experts as part of programmes and projects;
- Co-operate in respect of all agreed programmes or actions and implement any other co-operation modality.

Figure 3: Countries with Bilateral Agreements



In order to give effect to the objectives of the agreements, each of the 16 agreements have areas of co-operation specific to the partnership related to the multi-year business plan of the relations, sometimes formalised into a 'Programme of Co-operation'. What follows is a short précis on each of the 16 formal African bilateral partnerships led by the DST.

Algeria

The agreement was signed by the DFA in 1998. DST signed the Programme of Co-operation in 2003. There is a further MoU with COMENA (the Atomic Energy Commission of Algeria).

The specific areas of co-operation agreed to are:

- Neutron Sciences and Nuclear Reactor
- Research, Development and Production of Radio-isotopes
- Particle accelerator and utilisation
- Research Nuclear reactors: Exploitation and Utilisation
- Satellite Technology
- Laser Technology

- Biotechnology
- Information Technology
- Agricultural research
- Desertification and water management
- Poverty alleviation
- Micro-satellites
- Mineral beneficiation
- Scientific Co-operation between universities and research institutes

Angola

The agreement was signed in April 2008. The relationship has, however, been active for a while under the auspices of the MoU signed by the Deputy Ministers of Science and Technology from the two countries in April 2008.

The specific areas of co-operation agreed to are:

- Exchange of researchers, specialists and technical staff
- Creation of research centres and the development of human resources with regard to mutually agreed science and technology priorities
- Exchange experience and expertise in information and communications technology
- Agriculture
- Water and sanitation
- Health and medical plants

Botswana

The agreement was signed in August 2005. The Botswana relationship is closely related to the SA-SADC relationship because of the location of the SADC Secretariat in Gaborone.

The specific areas of co-operation agreed to are:

- SKA
- Molecular biology
- Accreditation of laboratories
- Assisted reproduction (farm animals)
- Refining analytical systems
- Drought resistant crops (production)
- Mechanisation on small scale
- Development of indigenous crops
- Satellite imagery (fire control and other applications)
- GMOs – collaborate on research and capacity building and broader issues for consumers

- Transition to business orientation
- Technological Transfer
- Strategies for drought mitigation
- Strategies for rehabilitation degraded lands
- Efficient irrigation
- Water recycling
- Food safety in rural areas
- Agro processing
- Indigenous knowledge systems
- Management of trans boundary diseases

Egypt

The agreement was signed in August 1997 by the DFA.

The specific areas of co-operation agreed to are:

- Biotechnology in food production, agriculture and health
- Development of new materials and manufacturing
- Information technology and systems and information society
- Sustainable management of environmental issues of natural resources: energy, water, coastal resources, etc. through environment-friendly technologies.

Kenya

The agreement was signed in August 2004. It was unique in that it was the only African bilateral agreement having the concept of a joint call procedure for projects with equal funding contributions by both partners. The recent political events in Kenya have had a negative impact on the activity levels of the agreement. DST has reported that a DG-led mission to Kenya in August 2008 has been effective in resuscitating the agreement where a Plan of Action for Collaboration was initiated.

The specific areas of co-operation agreed to are:

- Square Kilometre Array (SKA)
- Technology for competitiveness
- Nuclear energy
- Satellite technology
- Human health research-HIV/AIDS, cancer research
- Agricultural research – veterinary, biotechnology, domestic animal and wildlife animal health.
- Social science

- Governance and institution building
- Technology for development – IKS, technology incubators, technology transfer programmes, ICT
- Multilateral co-operation
- Building technologies
- Laser technology
- SA-Kenya Roundtable S&T partnerships in Infrastructure – Building and Construction, Transport, Energy, Water and Sanitation, ICT.

Lesotho

The Science and Technology agreement with South Africa's neighbour was signed in June 2005. In addition to the regular areas of co-operation, there has been a significant amount of activity related to the development of Lesotho's science and technology institutional framework.

The specific areas of co-operation agreed to are:

- Technology Business Incubation of the Small Scale and Medium Enterprises (SMME's)
- Development of a National Science Centre for promotion of Public Understanding of Science, Engineering and Technology (PUSET)
- Biotechnology for health and food security
- Indigenous Knowledge Systems and good practices in advocacy to promote indigenous technological capability
- SKA
- Tissue culture to improve potato seed and other local crops
- Policy formulation and institutional arrangements.

Malawi

The agreement was signed in August 2007. The government-to-government agreement has been followed up with the negotiation of institution-to-institution agreements. The CSIR and the ARC are currently in discussion with their Malawian counterparts.

The specific areas of co-operation agreed to are:

- Biotechnology
- Agriculture
- IKS
- Aqua Resources
- R&D Survey and Indicators
- S&T Policy

- Biosciences.

Mali

The agreement was signed in July 2006.

The specific areas of co-operation agreed to are:

- The scientific exploration into the secrets of the Archives of Timbuktu.
- Researcher exchange programmes aimed at staff capacity building
- Student training, including sandwich programmes (joint supervision short student visits as part of post-graduate studies).
- Research in traditional medicine and IKS
- Plant biotechnology,
- Biosciences, biology and health related issues (malaria, HIV/AIDS vaccine research)
- Agricultural research
- Strengthening of relations between Central Veterinary Laboratory and Onderstepoort Veterinary Institute (OVI) and the Onderstepoort Biological Products (OBP)
- Veterinary research
- Soil science and soil erosion
- Land use management
- Technology transfer including research and development of low cost equipment
- Management of the S&T system
- S&T policy formulation.

Morocco

A general agreement that included mention of the fields of science and technology was entered into in May 1998. The following areas were discussed:

- Nuclear technology
- Biotechnology
- Laser technology
- Information and communication technology, geosciences and
- Minerals research.

There has been no further development as a result of the strained diplomatic relations between Morocco and South Africa following South Africa's and the African Union's recognition of the state of Western Sahara.

Mozambique

The agreement was signed in July 2007. A plan of Action has also been finalised.

The specific areas of co-operation agreed to are:

- SKA
- S&T popularisation
- National record of animals
- Exchange of students
- Low cost housing
- Biotechnology
- ICT – e.g. digital doorway.

Namibia

The agreement was signed in March 2005.

The specific areas of co-operation agreed to are:

- Minerals research
- Mining technology
- Geological mapping techniques
- Laser technology
- Meteorology
- SKA
- Biotechnology
- Capacity Building in ICT
- Geological survey of the Kalahari basin, use of mineral resources.
- HESS and SKA collaboration

Nigeria

The bilateral agreement was signed in March 2001. It is a relationship that has not managed to get high levels of activity in the science and technology arena, in spite of the fact that politically this is a priority relationship for both parties. To signal the latter, the Bilateral National Commission is already co-chaired at Deputy President level and there are currently discussions underway to elevate this to Presidential level.

The specific areas of co-operation agreed to are:

- Biotechnology projects
- Materials science projects
- Satellite technology projects
- Environmental science

- Specific projects designed for mutual assistance in appropriate policy development, S&T capacity building.

Senegal

The agreement was signed in September 2005 during the 2nd AMCOST meeting in Dakar, Senegal.

The specific areas of co-operation agreed to are:

- Laser technology
- Renewable energy
- Biotechnology.

Tunisia

The agreement was signed by the DFA in February 1999. An updated Bilateral Agreement on Scientific and Technological Co-operation has been negotiated by the parties.

The specific areas of co-operation agreed to are:

- Agricultural research
- Biotechnology
- Renewable energy
- Laser technology
- Nuclear technology
- S&T policy
- Intellectual property.

Zambia

The agreement was signed in November 2007. The bilateral co-operation agreement is not as strong as the relationship as partners in the multilateral platforms.

The specific areas of co-operation agreed to are:

- Indigenous knowledge system
- Agriculture
- Human capital development and scarce skills.

Zimbabwe

The agreement was signed in December 2007. The specific areas of co-operation agreed to are:

- Agriculture
- ICT
- IKS
- Energy – Biodiesel & Mineral
- S&T Indicators
- Biotech
- Veterinary Science
- S&T Policy.

In summary, these 16 agreements cover 13 discipline areas in addition to policy and institutional collaboration, capacity building and the public understanding of science, engineering and technology. The most popular are is biotechnology, as it is priority research collaboration in 12 out of the 16 (75%) African bilateral agreements. This is followed by agricultural sciences (including veterinary sciences) which appears in 11 agreements; IKS in eight; IT or ICT in seven; the fields of laser and health sciences in six each; water sciences, astronomy and energy with five each; nuclear sciences, minerals and mining sciences and satellite and earth observation appearing in four; materials and manufacturing in three; environmental sciences in two; and social science collaboration in one agreement.

The African bilateral agreements are supported by South Africa through the Science and Technology Agreements Fund (STAF), a DST grant administered through the NRF. In at least one case (Kenya) there is an agreement on reciprocal funding from the government of the bilateral partner, although this has not yet been done at the Nairobi end. The STAF has committed a total of R38,582,962 over the period 2007–2010 to support the African bilateral agreements. This includes R2,500,000 to support the activities of the Southern African BioSciences Network (SANBio). This leaves the STAF commitments to the bilateral agreements exclusively at R36,082,962.

Table 2 shows the resources spent by NRF for scientific and technological collaboration mainly during the period 2006–2008. Tanzania and Namibia appear to have attracted the most funds (R3.3m and R2.6m, respectively). An important issue that should be mentioned is the fact that NRF distributes resources based on demand (scientist initiated research) and usually covers only transport expenses. There are no NRF programmes that financially support the time of the researcher.

Table 2: SA-African Collaboration: 2006–2010

Collaborating African Country/Activity	Funding Year					Grand Total
	2006	2007	2008	2009	2010	
Algeria	-	-	1,077,900	-	-	**1,077,900**
Angola	-	344,400	1,018,740	-	-	**1,363,140**

Botswana	147,970	971,264	2,842,756	-	-	**3,961,990**
Ghana	95,608	181,899	99,418	-	-	**376,925**
Kenya	55,731	226,947	458,198	-	-	**740,876**
Lesotho	-	61,288	1,572,712	-	-	**1,634,000**
Madagascar	-	-		148,700	-	**148,700**
Malawi	389,822	351,219	793,859	-	-	**1,534,900**
Mali	-	446,379	606,621	-	-	**1,053,000**
Mauritius	-	53,687	2,065,313	-	-	**2,119,000**
Mozambique[1)]	11,450	458,240	486,690	-	-	**956,380**
Mozambique and Zambia	53,157	-	70,157	-	-	**123,314**
Namibia	109,855	1,119,417	2,664,795	-	-	**3,894,067**
Nigeria	-	-	1,781,250	952,612	-	**2,733,862**
Nigeria/Congo (Brazzaville) and Burkina Faso	-	-	1,427,965	1,705,979	1,756,400	**4,890,344**
Rwanda	-	-	295,545	-	-	**295,545**
SANBio (Southern African Network for Biosciences)	-	-	2,500,000	-	-	**2,500,000**
Swaziland	109,800	-	173,000	-	-	**282,800**
Tanzania	174,848	24,412	3,314,569	-	-	**3,713,829**
Workshop involving Botswana, Malawi, Mozambique and Namibia	-	-	122,000	-	-	**122,000**
Workshop involving SADC Countries on Space Geodesy	-	-	95,020	-	-	**95,020**
Zambia	-	109,640	924,680	-	-	**1,034,320**
Zimbabwe	250,051	1,283,257	2,397,742	-	-	**3,931,050**
Grand Total	**1,398,292**	**5,832,049**	**26,788,930**	**2,807,291**	**1,756,400**	**38,582,962**

1) an amount of R700 000 will be committed in collaboration with Mozambique for 2009 and 2010 but has not been processed on Phoenix pending approval by the Director of International Relations

Science Collaboration with Africa: University and Science Councils

In addition to the government to government agreements various South African research and higher education institutions have collaborative engagements with their African counterparts. In some cases these overlap and are empowered by the formal bilateral cooperation agreements, while in many cases they are not. In this chapter we examine briefly the African collaborations of South African universities and science councils.

It should be emphasised that both types of institutions function under relative autonomy. While Government appoints the governing councils of universities and science councils, the institutions operate without any further interference in order to achieve their missions. It should be expected that collaboration will be more profound if it fulfils parts of the main objectives of the institutions. It should be emphasised that the profit motive is entrenched within the operations of both types of institutions. As African institutions are expected to have limited financial capabilities they cannot acquire the services of science councils and universities and hence it should be expected that there will be limited collaborations.

During 2008 HESA undertook a survey of the SA universities in order to identify the degree of collaboration with the rest of the African continent. Thirteen institutions responded. The following were some of the points derived from the survey:

- There are 58 MoUs or similar agreements between South African universities and those in Africa.
- There are currently 12,552 students from the SADC region studying at South African institutions. Some 49% of these students (under- and postgraduate) come from Zimbabwe followed by Botswana, Lesotho, Kenya and Namibia. African students originate from 26 countries on the continent.
- Presently, there are 70 African students visiting to complete part of their degree or as exchange students.
- There is very little African travel that has occurred at student levels. Collectively, the institutions record only 49 students who have visited African institutions during the 2007–2008 period.
- Ninety-nine staff members who have visited South Africa from other African countries stayed for periods ranging from a few days to 12 months. In the same manner, 77 staff members who have visited African countries have done so for a period no longer

than 12 months. Many institutions were unable to provide figures because these visits were organised at departmental level and were not part of a larger strategic focus.

- Of the recorded 497 African academics employed at South African institutions, the bulk is from the SADC region, especially countries like Zimbabwe and Namibia.

- When institutions were asked to provide academic programmes with a focus on Africa, two types of response were evident. The first was to understand involvement in terms of projects confined to a particular discipline within the university. Areas such as history and cultural studies naturally lend themselves to a distinct African focus. The second trend was to understand 'Africanisation' as a process that will increasingly impact on every part of the university's functioning.

- Institutions were also requested to indicate the number of research collaborations they might have with African institutions. According to the information received, UP and SU focused extensively on African research networks and together had 175 research collaborations with fellow institutions on the continent.

- Over 75% of the institutions surveyed conducted some training for African students, academics and in some cases, diplomats.

- In response to a question on joint development of study programmes, 13 study modules were mentioned by respondents. The curricula of these have been jointly fashioned by the partner universities or they have embarked on a short-term project around a specific need. Only four institutions recorded any kind of consultancy programmes and/or projects within Africa. Of these, two were recorded as acting as external examiners.

Our contact with the science councils indicated that they do not have readily accessible lists of collaborators in the African Continent. For example, MINTEK provided us with a list of all their clients all over the world but they could not disentangle easily the African component. We interpreted this to mean that science councils collaborate with African counterparts on the same way that they do with the rest of the world (no special emphasis). The ARC has traditionally managed its international engagements via the individual research units with very few registered at corporate level. The CSIR, South Africa's largest science council is examined in more details below.

The CSIR interacts in Africa at both the bilateral as well as the multilateral level in support of many of South Africa's African cooperation agreements at government level. The other duality of CSIR's partnerships in Africa relates to its own functional duality of both being a premier research and development house as well as being a provider of specialist and technical consulting services. The CSIR constructs its African R&D cooperation under the umbrella of bilateral cooperation agreements and a Regional Research Alliance.

The **Regional Research Alliance** is a three party agreement between CSIR, Botswana Technology Centre (BOTEC) and Zimbabwe's Scientific and Industrial Research and Development Centre (SIRDC). The projects include:

- Impact of mercury from small-scale mining on water resources
- The development of nutritionally-enhanced and drought-resistant crops for Southern Africa
- Low Carbon Footprint Pavements using local sands
- Establishment of sustainable energy communities

The CSIR - Botswana Technology Centre (BOTEC) MoU

Collaboration includes but is not limited to:

- Manufacturing and Materials Technology
- Renewable Energy and Clean-Energy Technologies
- Environmental and Water Technologies
- Nanotechnology
- Human Resource Strategies and Dynamics

Southern African Network for Biosciences (SANBio). This is flagship project of the African Consolidated Science and Technology Plan of Action. SANBIO together with the Biosciences East and Central Africa (BECA), West African Biosciences Network (WABNet) and North African Biosciences Network (NABNet) form the Biosciences platform of the continental plan. The SANBIO foci are:

- Scientific validation of traditional medicine for the treatment of HIV and opportunistic infections
- Affordable Microbicides for HIV infection control

Bill Gates Foundation

CSIR Biosciences is also part of the Bill gates funded project (Nutritional enhancement of sorghum) involving African countries: Kenya, Burkina Faso.

African Laser Centre (ALC)

The ALC is another AU/NEPAD flagship with the CSIR based National Laser Centre as the coordinating node. The member countries are Lesotho, Algeria, Kenya, Nigeria, Egypt, South Africa, Senegal and two Diaspora representatives (MIT, USA) and (University of Ulster, Ireland). The research collaboration programme typically involves mutually beneficial research collaboration between a South African based research team and their counterpart elsewhere on the African continent. The supported research projects are from wide laser application fields from health, through laser physics to environmental sciences. The training events include introductory laser course (theory and practice), symposia/conferences up to advanced level courses. Limited scholarships are supported for MSc and PhD laser research students.

Information Society Technologies in Africa (IST-Africa)

IST-Africa is a multi-stakeholder initiative between corporations from Ireland, Malta, Mozambique, South Africa and Tanzania focussed on training to reduce the Digital Divide, skills transfer to support research capacity building & awareness, and, community building to support EU-African Research Cooperation

MERAKA is further engaged in the following ICT activities in Africa:

- IDRC Wireless Africa (Consortium) Project, has projects and partners in Angola, Uganda, Tanzania, Zambia, Rwanda, Ghana, Mozambique, Morocco and Nigeria.
- OpenPhone project, the OpenPhone Project (http://www.openphone.org/) has a simple goal—to phone-enable every computer on the planet. If a computer can browse the Web and play audio from Internet radio stations, it should be able to place and receive phone calls, too. The basic technology is available today. The OpenPhone Project aims at fostering the development of the software that can make this a reality.
- EuroAfrica ICT (Consortium) project, has projects and partners in, Uganda, Rwanda, Ghana, Mozambique, Nigeria, Benin, Cameroon, South Africa, Senegal, Kenya and Botswana.
- DigitalWorldForum - SAP-Meraka UTD, Digital World Forum on Accessible and Inclusive ICT ('Digital World Forum') is a FP7 European project focusing on the use of ICT to leverage economic development in Africa and Latin America. Providing minimal services (health, education, business, government, etc.) to rural communities and under-privileged populations is of major importance to improve people lives, and to sustain development.

- MOU with Makarere University (Uganda) in:
    - ICT Development
    - High performance computing
    - Human language technology & human technology interaction
    - Scientific computing and visualisation
    - Wireless and ad-hoc networking
    - Broadband communications
- AfriNIC is a non-governmental and not-for-profit membership based organisation. Its main role is to serve Africa region as Regional Internet Registry
- NEPAD - e-Africa commission, the NEPAD e-Africa Commission is the ICT arm of NEPAD working for long-term solutions for the development of the ICT sector in Africa. It creates partnerships and collaborates with governments, companies and local people to realize positive change in the ICT sector.
- LinkNet collaboration (with signed MoU) in Zambia
    - to create broad awareness on the needs on deployment of Internet in rural Africa, the strive for development and publication of open source solutions for deployment in Africa,
    - to develop the Centre of Experience in rural ICT development and training at Macha,
    - and to develop research projects to gain better understanding of realities in rural Africa.
- EO2HEAVEN EU FP7 (Earth Observation and ENVironmental modelling for the mitigation of HEAlth risks) proposal.

The important observations are the following:

- The CSIR is an important implementing agent for certain intergovernmental agreements at multilateral level and in some cases at bilateral level.
- Beyond some examples, there is no automatic nesting between the government level agreements and the CSIR and its African counterparts.

- In an ideal system there would be both a nesting and congruency when comparing the country level agreements and those of the universities and science councils as the key public R&D institutions.

Scientometrics of Collaboration

One of the most efficient and objective methods of assessing research and innovation performance is through scientometric indicators. An indicator is defined[16] as "statistics of direct normative interest which facilitates concise, comprehensive and balanced judgments about the condition of major aspects of a society. It is in all cases a direct measure of welfare and is subject to the interpretation that, if it changes in the "right" direction, while other things remain equal, things have got better or people better off." Scientometric analysis, the quantitative study of the innovation system, is based mainly on bibliometric and patent indicators. In bibliometrics the number of publications in a field is considered as an indicator of research activity.

The philosophy underlying the use of bibliometric indicators as performance measures has been summarised in De Solla Price's statement that "for those who are working at the research front, publication is not just an indicator but, in a very strong sense, the end product of their creative effort"[17].

Of course, there are many trained scientists who are not required to publish. They may perform managerial or administrative functions, they may teach available knowledge or they may apply existing knowledge in making new products and in providing services. The common characteristic of all these scientists is that they are far away from the research front. They provide the infrastructure for the producers of knowledge and they exploit the end results of research and development. In any case, however, they cannot be considered as "knowledge" producers.

Scientometric analysis is used in the science and technology policy arena to determine the knowledge outputs of the national systems of innovation[18] It has been used for cross-country comparisons of overall performance in scientific disciplines[19] as empirical support for policy-making theories[20] to elucidate patterns of knowledge flow and the association between

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16 DHEW. 1970. *Towards a Social Report.* Department of Health, Education and Welfare, University of Michigan Press, Ann Arbor.

17 De Solla Price D. 1975. The Productivity of Research Scientists in *Yearbook of Science and the Future, Encyclopaedia Britannica Inc.*, University of Chicago, Chicago.

18 Leydesdorff L and Gauthier E. 1996. The evaluation of national performance in selected priority areas using scientometric methods, *Research Policy*, **25:** 431-450.

19 King DA. 2004. The scientific impact of nations. *Nature* **430:** 311-316.

20 Smith K. 1994. *Interactions in knowledge systems: Foundations, policy implications and empirical methods*. STEP Report.

science and technology[21] and to assess performance of and collaborations within scientific disciplines[22].

A recent article[23] reports the state of science and technology in the African continent (country by country) on the basis of the number of research publications and number of patents awarded. The article shows that Africa produced 68,945 publications over the 2000–2004 period or 1.8% of the world's research publications. In comparison, India produced 2.4% and Latin America 3.5% of the world's research publications. More detailed analysis reveals that research in Africa is concentrated in just two countries – South Africa and Egypt. These two countries produce just over 50% of the continent's publications and the top eight producing countries over 80% collectively (Table 3). Furthermore, disciplinary analysis reveals that few African countries have the minimum number of scientists required for the functioning of a scientific discipline. For example, in the field of ecology (a discipline necessary for environmentally friendly and sustainable development) only four countries (South Africa, Egypt, Nigeria and Kenya) produce 300 or more publications (the minimum threshold).

Table 3: Number and Share of Publications of the Most Prolific African Countries: 2000–2004

Country	Number of publications	Share in the continent's publications	Cumulative share
South Africa	20 762	30.1%	30.1%
Egypt	13 942	20.2%	50.3%
Morocco	5 463	7.9%	58.2%
Nigeria	4 040	5.9%	64.1%
Tunisia	3 930	5.7%	69.8%
Kenya	3 231	4.7%	74.5%
Algeria	2 766	4.0%	78.5%
Tanzania	1 368	2.0%	80.5%
Ethiopia	1 321	1.9%	82.4%
Cameroon	1 301	1.9%	84.3%

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21 Meyer M. 2002 Tracing knowledge flows in innovation systems – an infometric perspective on future research on science-based innovation, *Economic Systems Research*, 14: 323-344.

22 Frenken K, Holzl W and De Vor F. 2005. The citation impact of research collaborations: the case of European biotechnology and applied microbiology (1988-2002), *Journal of Engineering and Technology Management*, **22:** 9-30.

23 Anastassios Pouris and Anthipi Pouris. 2009. The State of Science and Technology in Africa (2000-2004): A Scientometric Assessment. Special Issue of the *International Journal Scientometrics* **79 (1) and (2)**

South Africa appears to be producing over 70% of the continent's space science and psychology and over 50% of the Continent's research in education, economic sciences and neurosciences. Egypt is producing over 40% of the continent's research in chemistry and materials science and just below 40% of the continent's research in engineering. Nigeria is the main producer of agricultural research in the continent (18.9%).

In the context of the ophelimity model that we advanced in the previous section, these findings indicate that there are limited opportunities for scientific collaboration with African countries (on the basis of mutual scientific benefit). Furthermore in those countries with certain scientific strengths (i.e. Egypt, Morocco and Nigeria) the collaboration should focus on those disciplines (e.g. chemistry and material science in Egypt) if South Africa aims to maximise its scientific benefits.

Another interesting finding is that "land and primary resources" sciences (i.e. agriculture, ecology, geosciences and plant and animal sciences) occupy 26.4% of the research in Africa while the relevant figures for USA and India are 13.5% and 19.5%, respectively.

Examination of the continent's inventive profile, as manifested by patents, indicates that Africa produces less than 1,000 of the world's inventions. Furthermore, 88% of the continent's inventive activity in concentrated in South Africa. Again South Africa will find it almost impossible to identify equal partners for collaboration.

In this context we should emphasise that scientometrics can identify the revealed (actual) research priorities of a country. An indicator used often is the activity index. The activity index is the fraction of the country's research publications in the particular field, relative to the fraction of the world's publications in the field. An activity index above 1 means that the country is producing more publications in the field than expected (given the total number of publications). Pouris[24] estimated that the disciplines emphasised in South Africa are plant and animal sciences (AI=2.98); ecology/environment (AI=2.40); earth sciences (AI=2.35) and space science (AI=1.93). Disciplines that are underemphasised are neurosciences (AI=0.31); computer sciences (0.42); materials sciences (AI=0.62) and engineering (AI=0.67).

Estimation of the collaborative patterns of South Africa during the period 2004–2005 identifies that out of the 11,318 research articles that South Africa produced during the period, 4,905 had additional international addresses, signifying that they were based on collaborative research. Of those articles, 458 (4%) were with authors from African countries. Table 4 shows the top countries with which South Africa collaborates. USA occupies the top

[24] Pouris A. 2003). South Africa's research publications record: Last Ten Years. *South African Journal of Science* **99:** 425-428

position participating in more than 34% of South Africa's collaborative effort. England and Germany follow participating in 18.6% and 11.4%. Identification of the disciplines emphasised in SA's collaboration show that emphasis is placed on infectious diseases (4.5%); plant sciences (4.3%); ecology (4.2%) and public, environmental and occupational health (4%). It should be noted that plant sciences and ecology are the two most active research disciplines in South Africa (Pouris 2003)

Table 4: Countries Collaborating with SA 2004–2005

Country	Number of articles	Percent of total collaboration
USA	1,678	34.2%
England	911	18.6%
Germany	555	11.4%
Australia	463	9.4%
France	402	8.2%
Canada	379	7.7%

Table 4 shows SA's collaboration with the African countries. The countries with which SA collaborates mostly are Nigeria, Kenya, Namibia and Zimbabwe.

Comparison of the extent of collaboration between countries in Table 4 and the African countries show that SA collaborates relatively little with the African countries. It should be mentioned that the sum of collaborations in Tables 2 and 3 maybe higher than 100% because of multiple collaborations.

Comparing the identified SA-African collaboration with that during the mid 1990s[25], it becomes apparent that there have not been any drastic changes. The SA-Africa collaboration is still 4% to 5% of the country's total collaboration.

Table 5: African Countries Collaborating with SA 2004–2005

Country	Number articles	Percent of total collaboration
Nigeria	71	1.4%
Kenya	70	1.4%
Namibia	69	1.4%
Zimbabwe	64	1.3%

[25] SCE. 1997. *South Africa's Scientific Cooperation: Pattern Analysis.* Input to EU effort to Explore the Prospects for Greater RTD Cooperation between the EU and SA. Science Consultancy Enterprises, Pretoria.

Botswana	43	0.8%
Ethiopia	42	0.8%
Uganda	29	0.6%

In comparison to Table 3 the results of Table 5 indicate that South Africa ignores collaboration with North African countries, which are scientifically stronger than the other African countries. Scientific strength in the collaborative country and geographical proximity appear to affect the patterns of collaboration with the rest of the African countries.

Identification of the scientific disciplines emphasised within the SA-Africa collaboration show that the most emphasised disciplines are tropical medicine (6.7%); public, environmental and occupational health (6.3%); ecology (6.1%); parasitology (5.9%); infectious diseases (5.7%); medicine general and internal (5.2%); environmental sciences (5%); plant sciences (5%); veterinary sciences (5%). Again strengths of SA science and country primary needs (i.e. health) appear to dictate the patterns of collaboration.

SWOT analysis of South Africa's Science and Technology collaboration in Africa.

South Africa's sojourn into Africa at both the bilateral as well as the multilateral level in terms of science and technology collaboration has been quite active. In this section we examine these collaboration efforts though a Strengths, Weaknesses, Opportunities and Threats perspective.

Figure 4: SWOT of Africa-South Africa Collaboration

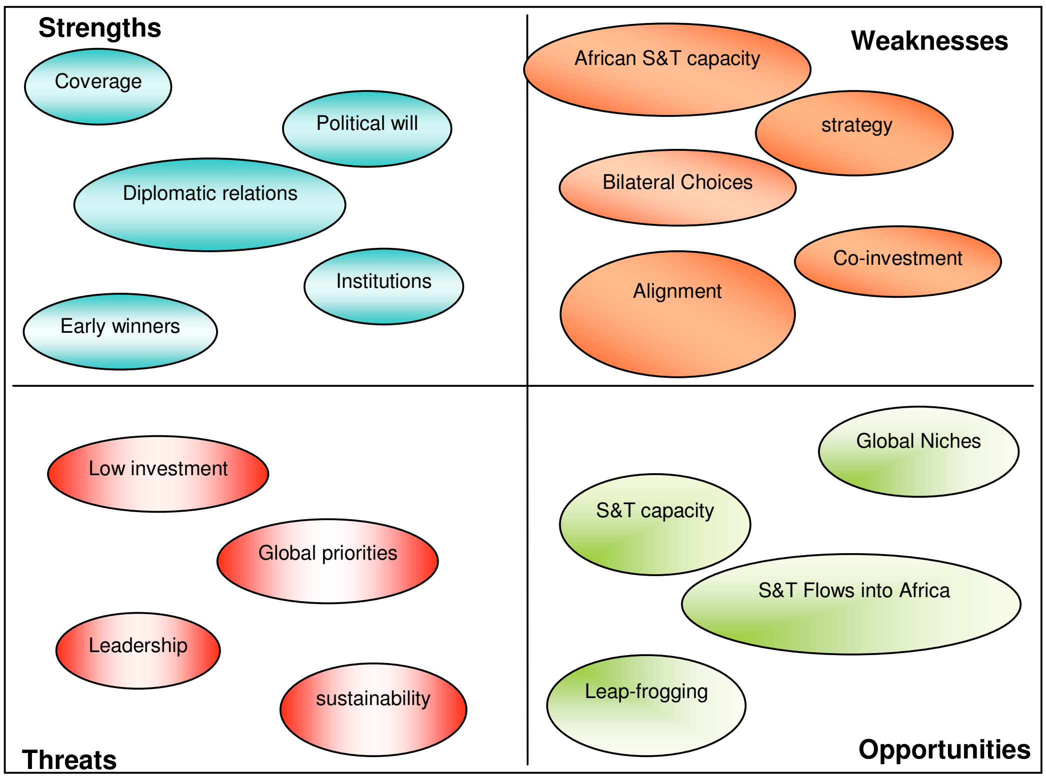

Figure 4 provides a summary of the SWOT discussed below.

Strengths

In 15 years South Africa has organised an intensive penetration of the African continent with respect to relations in science and technology. In those 15 years we see the conclusion of 47 bilateral co-operation agreements in which science and technology is a significant component, with 16 being exclusively science and technology.

This extensive coverage has been built on the back of good diplomatic relations and the prioritisation of Africa in South Africa's Foreign Affairs strategy and agenda. This in turn has been led from the top, firstly through President Mandela and then even more intensely by President Mbeki. All indications are that the focus and energy from a political leadership perspective will continue with President Zuma.

The rapid development of institutions like the Office of the African Union Human Resources, Science and Technology Commissioner, the Science and Technology Office of NEPAD, the S&T desk of SADC secretariat as well as the development of an African Co-operation Directorate in the DST are strong points for the African collaboration platform.

The early successes including AIMS, SANBio and the African Laser Centre also present encouraging platforms on which to build future collaborations.

Last but not least, South Africa has a substantially stronger S&T capacity than the other African countries and hence it can provide leadership and support.

Weaknesses

An important challenge is the limited science and technology capacity on the continent. This is in terms of the size of the science and technology community, the number and interconnectedness of institutions as well as the existence and availability of infrastructure and equipment. This is further exacerbated by the limited access to information and information technology compared to any other region of the world. All of these factors represent difficult hurdles for African S&T collaboration at both bilateral and multilateral levels.

While South Africa has achieved wide coverage in its outreach into Africa, the lack of a stratified engagement, the notion of 'different strokes for different folk', has been a limiting factor. A further challenging factor has been the choice of bilateral partners on the continent. While South Africa has chosen to formalise bilateral relations with 16 out of Africa's 54 countries, in the absence of a published strategy, it is not entirely clear how the choice of these 16 countries has been made. In fact there may be some important omissions when considering the pockets of scientific strength on the continent.

An important factor assisting collaboration is stimulus funding. South Africa's own experiences with the AU/NEPAD platform and the early harvests in biotechnology, mathematics and laser technology demonstrates this. This is further confirmed at the bilateral level in South Africa's broader international portfolio. In the latter a key factor is co-investment by both parties. This is sadly absent on the African bilateral agreements. While it is encouraging to see plans to change this weakness with the Mozambican and Kenyan bilateral agreements, lack of resources for S&T capacity development will remain probably the most important obstacle in the continent.

Opportunities

In the wake of increasing globalisation, Africa's connectivity to the rest of the world is improving. With its own leapfrogging of traditional telephony connection to the cell phone revolution, intra-African connectivity is also encouraging. Collaboration in this climate is much more viable.

Africa's scientific capacity is small and embryonic, but has particular strengths (e.g. biodiversity, health, geographic position, etc). This enables Africa to develop multilateral science projects that occupy important global niches. Recent examples include the development of an institute to examine the important nexus between tuberculosis and AIDS. In general Africa is a useful platform to engage with 'neglected diseases' that have re-emerged globally, diseases like malaria and tuberculosis.

The continent is also the best laboratory to consider the expansion of the global food security options through the further development of such indigenous crops as cassava.

In addition, Africa's need to leapfrog in terms of technological advancement provides a very useful impetus for further and more intense science and technology collaboration on the continent. The often-quoted example of this is connectivity in Africa. Africa has leapfrogged the traditional landline telephony connection modality and has very successfully embraced cell phone technology as the connection technology of choice.

Threats

Some key threats for both bilateral and multilateral agreements are associated with the global economic downturn. The global economic crisis has dire implications for Africa in the way it affects the donor strategies of many of the OECD partners. This represents an important threat to the potential donor investments in several of the flagships in the implementation of the Consolidated Plan of Action.

The challenge at national level is similar. South Africa faces its first recession since 1992. The availability of new funds from the National Treasury to support the country's science and technology in general, and collaboration in particular, is limited. Any possibility of leveraging significant partner funding could alleviate this weakness.

The 21st century as the African century was a dominant dialogue in multi-lateral forums initially, but it is a dialogue that has rapidly lost momentum in the last nine years. Global priorities and focus has moved elsewhere in the wake of the oil crisis, the global war on terror and now the economic downturn. The references to Africa in the context of the MDGs and climate change vulnerability are diminishing.

A further threat at the multilateral level is that of leadership. The AMCOST was launched at a high level with great promise in 2003. It had achieved phenomenally in the first years, even securing S&T as the special focus of the January 2007 Ordinary Summit of the African Union. The change of leadership to Senegal in 2005 was smooth and this was repeated with Kenya taking over the reins in 2007. While from a governance perspective this is encouraging, the platform has lost significant momentum. In parallel, the continued power struggle between the NEPAD Secretariat and the AU Commission has also not helped. An important threat to the AU/NEPAD Science and Technology platform is leadership and sustainability.

The adaptation of the NSI to the African collaboration

South Africa's resolve to deepen and broaden research, science and technology collaboration in Africa since 1994 has had certain consequences for the national system of innovation. In order to develop sufficient capacity to enable this intensified collaboration, the DST developed a discrete Directorate for African collaboration in the branch International Collaboration and Resources in 2003. The DST developed an African portfolio in the STAF (S&T Agreements Fund) in the NRF. This includes funding support for the bilateral agreements as well as the South African based flagship activities of the African Consolidated Plan of Action.

The DST then initiated the 'African Forum', a partnership dialogue in the form of workshops on South Africa's African engagement, involving the science councils and universities. Some institutions responded by replicating this modality intra-institutionally. The CSIR is a case in point. Similarly the country's universities have signed a substantial number of MoUs with similar institutions in the African continent.

As part of the African engagement strategy, government supports the development of continental structures to promote and develop science and technology in Africa. This included activities like seconding government officials to serve in African and SADC structures. It also included support for the development of the ICSU Regional Office for Africa – the first regional office of its kind in the world.

This type of activity has spread further with South Africa's intensified participation in such structures as the Association of African Universities (AAU), the Southern African Regional Universities Association (SARUA), and the expanded activities of the Academy of Sciences of South Africa (ASSAf) on the continent with its national counterparts, the African Academy of Science and the inter-academy panels.

In summary, South Africa has adapted and supported certain structures in the NSI in order to enhance South Africa's capacity to increase research, science and technology collaboration in Africa.

Discussion and Recommendations

This document set the objective to investigate the processes affecting S&T collaboration on the African continent and to develop recommendations on how the South African government could effectively interact with its African counterparts in S&T initiatives.

Scientific collaboration has become an important component of science, technology and innovation policy internationally. The recognition of the importance of international collaboration, coupled with the increasing fiscal requirements for the activity, has drawn the attention of policy makers who have expressed concerns. In a number of countries fears have been expressed that the spending in international collaboration is not always to the benefit of the paying country. Others worry that critical technologies and key knowledge for competitiveness are given away to competitors. Additional concerns have been voiced that collaborative agreements subordinate the interests of science and technology to strategic or political ends. Last but not least, researchers have argued that collaboration may be an endogenous self-perpetuating outcome of science[26] with substantial costs and no commensurate benefits.

S&T collaboration is expanding its applicability to different policy domains. A recent article in the reputable journal Science[27] quotes Hani Mulki, at that time secretary-general of the Jordan Higher Council for Science and Technology and subsequently foreign minister and Jordanian ambassador to Egypt, arguing that "scientific co-operation should not be a by-product of the peace process; it should be a driving force for peace. When the situation is most critical, scientists and engineers must make the greatest effort to work together." The article reports that Mulki's resolution was accepted by acclamation.

The expressed concerns of the role of scientific collaboration gave rise to a number of investigations in the field and policy authorities started developing strategies for targeting research alliances and managing scientific and technological collaboration.

We initiate this analysis by introducing the "ophelimity" framework and by discussing international collaboration in the context of science and technology policy. It is emphasised that under this formulation, collaboration is a policy instrument aimed at achieving particular policy objectives.

The most often mentioned objectives are to:

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26 Jones FB, Wuchty S and Uzzi B. 2008. Multi-University Research Teams: Shifting Impact, Geography and Stratification in Science. *Science* **322**: 1259-1262.

27 Greene M. 2008. A Force for Peace in the Middle East. *Science* **321:** 1192.

- Gain access to knowledge unavailable locally;
- Share costs and risks;
- Gain access to partners' markets;
- Achieve standardisation; and
- Fulfil political considerations.

"Gaining access to knowledge" and "sharing costs and risks" are objectives internal to S&T policy. The other objectives should be seen as external to science and technology and as achieving objectives in other spheres of governance. For example, collaboration efforts may be based on developing the attractiveness of the country for inward investment in R&D and foreign direct investments in general. Collaboration between countries can create trust and personal friendships between researchers, which can sometimes help diffuse tension and conflicts between the respective countries. Collaborative research provides a useful mechanism for engaging the talents of émigré researchers who have joined the brain drain, but still wish to stay in touch with their country of origin and lastly scientific collaboration between developing countries may be necessary in order to help solve regional and global problems.

As far as South Africa is concerned there are a number of non S&T reasons favouring collaboration. For example, South Africa exports a variety of products to the African continent. Exports to Africa during 2007 were valued at R68 billion which was equal to exports to the Americas. The major target countries were: Zambia (with exports R10 billion;) Zimbabwe (R8.5 billion) and Mozambique (R 9 billion). The South African universities benefit from African students studying in the country and others

We suggest that in the context of S&T collaboration for the benefit of science and technology, the knowledge of the partner's capabilities and the clear understanding of the objectives of the collaboration is the determining factors of success.

On the chapter "Foreign Influences" we elaborate on ODA, the World Bank, certain GTZ programmes and NEPAD. We pay particular emphasis on the World Bank's effort to identify and disseminate good practice. World Bank publications are widely circulated in developing countries where access to academic literature may be limited. World Development Reports, produced annually by the WB, are often regarded as textbooks and the World Bank Research Observer claims to be the most widely read economic journal. Hence, the influence of the World Bank should not be underestimated.

The decision of the World Bank to undermine higher education for almost 30 years has unknown consequences for the developing countries. Public support for higher education and the national innovation system are currently considered the cornerstones of development. Without support for higher education, there will not be enough highly qualified technicians, engineers, communicators, social workers, designers and scientific researchers – all of whom contribute to the ongoing education and development of a nation. It becomes apparent that developing countries need to have their own expertise in order to decide priorities and developmental paths.

The above are in accordance to the development experts and policymakers who suggest that developing countries need "ownership" of their development strategy and implementation. This means bringing knowledge and skills into dialogue with development partners (e.g., donor governments, international development agencies and multinational corporations) and stakeholders. Countries must be able to participate in international forums, which define scientific standards for international trade, public health, education, telecommunications, etc. Thus, in the best of scenarios, building S&T capacity in developing countries may help them define and choose development options, acquire indigenous capacity to create human capital and appropriate institutions and infrastructure for development, and to have a more equitable voice in international affairs.

The examples of ODA and GTZ make apparent the multiplicity of entry points that foreign governments/organisations have in the South African society. Even though their activities have direct influence to science and technology, the Department of Science and Technology does not have a direct role to play. South Africa could benefit by the establishment of a monitoring mechanism in order to prevent direction of resources to non-priority areas and to maximise benefits through collaboration.

South Africa has in the last 15 years demonstrated a prolific penetration of the continent with regards to science and technology collaboration, both at a multilateral level and a bilateral level, given that it started from virtually a zero base.

At the continental level, there is a science- and technology-led multilateral platform in the form of AMCOST and its related African Consolidated Science and Technology Plan of Action. This is complemented by the African multilaterals in the areas of Health, Agriculture, Environmental and Education under the auspices of the African Union and supported by the NEPAD Secretariat. This is replicated at SADC level in the form of SADC sectoral ministerial platforms, sectoral protocols and a SADC level priority plan based on the continental plans.

South Africa's own bilateral co-operation agreements coverage of the continent, from a numbers perspective, appears to be quite wide. South Africa has concluded and signed 16 science and technology bilateral co-operation agreements on the continent with countries from all five of Africa's regions. If one considers the other bilateral agreements with a significant science and technology content, this number increases to 47. This represents 13% of all South Africa's African bilateral co-operation agreements to date. Many would argue that these represent significant achievements for such a short period of time, if the signing of agreements is a political objective in itself.

The field prioritisation associated with the 16 S&T bilateral agreements cover a total of 13 discipline areas. The order of popularity, as defined by the representation in the different agreements and their programmes of co-operation, is: biotechnology followed by agricultural sciences and indigenous knowledge as the top three areas of collaboration. In addition, all the agreements include clauses on collaboration in development of policy and institutions, capacity building and the public understanding of science, engineering and technology.

Table 1 indicates that 13% of the South Africa's bilateral agreements in Africa have a significant science and technology content. The non-DST led bilateral agreements in this category come primarily from three other sectors. These are health, agriculture (and livestock) and education. There are also a limited number of agreements related to mining and minerals and others related to energy. The latter have very little research content and are largely in the space of using scientific and technological tools as opposed to developing new ones or advancing the development of knowledge.

The health, agriculture and education bilateral agreements make provision for the development of joint research projects, inter-institutional collaboration on S&T developments and development of high level human capital.

In the chapter "Scientometrics of Collaboration" we investigate collaborative efforts as they are manifested in co-authorship patterns. We identify that Africa produced 68 945 publications over the 2000-2004 period or 1.8% of the world's research publications. In comparison, India produced 2.4% and Latin America 3.5% of the world's research publications. More detailed analysis reveals that research in Africa is concentrated in just two countries – South Africa and Egypt. These two countries produced just above 50% of the continent's publications and the top eight producing countries over 80% collectively. Furthermore, disciplinary analysis reveals that few African countries have the minimum number of scientists required for the functioning of a scientific discipline. For example, in the field of ecology (a discipline necessary for environmentally friendly and sustainable development) only four countries (South Africa, Egypt, Nigeria and Kenya) produce 300 or more publications (the minimum threshold).

Co-authorship analysis identifies the countries with which South Africa collaborates. USA occupies the top position participating in more than 34% of South Africa's collaborative effort. England and Germany follow, participating in 18.6% and 11.4%, respectively. Only 4% of the country's collaborative effort was with authors from other African countries. This intensity has remained the same since the mid 1990s. The countries with which SA collaborates mostly are Nigeria, Kenya, Namibia and Zimbabwe. Furthermore, South Africa appears to ignore collaboration with North African countries which are scientifically stronger than the other African countries. Disciplinary analysis of the SA-Africa collaborative effort identifies that the emphasis is in health disciplines (disciplines in which SA can make a contribution).

The SWOT analysis indicates that South Africa's African collaboration can rely on significant strengths including strong political desire and will, some important institutional strengths and some early successes. There are also opportunities for international participation and leadership in certain areas like using indigenous crops for nutritional security, and research into the so-called neglected diseases as well as disease interfaces like HIV/AIDS and TB. In spite of the very important weaknesses and potential threats, these strengths can be very instrumental in an innovative strategy toward realising the opportunities and facilitating beneficially collaborative activity.

South Africa has made important investments to facilitate good collaboration at both the bilateral and multilateral levels in Africa. This includes developing dedicated capacity in DST to dedicated funding through the NRF's STAF mechanism as well as direct investment supporting the business plans of the AU/NEPAD nodes.

Based on the above we suggest the following recommendations.

1. *Co-ordination through monitoring of South Africa's research, science and technology engagement in Africa*

The study reveals that there has been an increased quantum of engagement and collaboration with African partners by a range of South African institutions and individuals since 1994, as indicated by the agreements concluded and the activities associated with those agreements. Government alone has concluded 47 bilateral co-operation agreements that include significant research, science and technology components. Sixteen of these were led by the DST, while the others were concluded by other government departments independent of any substantive input by the DST. Various institutions in the South African public research sector, in particular universities, science councils and research institutions have concluded international agreements with partner institutions on the African continent. This picture is replicated at the multilateral level with several NEPAD- and African Union-led continental action plans having substantive research, science and technology components, again with limited input from the DST outside the African Consolidated Science and Technology Plan of Action. Similarly there are a number of MoUs between universities, and a large number of African students study in the country's universities.

There is the need for a relevant macro-monitoring mechanism with the objective of assessing the degree of current collaboration with the rest of the world, and the capacity of the local scientific community to expand its international collaborative activities. There should be a 'Team South Africa' approach for the various interactions between South African and institutions and their counterparts.

> *We suggest that NACI considers recommending that the DST plays a co-ordinating and expert advisory role through monitoring in the implementation of the research, science and technology components of all of South Africa's existing African bilateral co-operation and multilateral agreements. There should be a 'Team South Africa' approach for the various interactions between South African and institutions and their counterparts.*

The following specific actions should be considered:

1. The development of an intergovernmental co-ordination forum for South Africa's research, science and technology collaboration in Africa to ensure that the efforts of individual government departments are overlapped in a value-added manner that derives a larger benefit for the South African NSI as a whole.

2. There should be a much closer cooperation between the government players and the key research and higher education institutions wrt African collaboration. Government through the intergovernmental agreements and support measures, like the S&T Agreements Fund (STAF) which NRF administers on behalf of the DST should facilitate and enable more prolific cooperation between the South African institutions and its partners in other African countries. These interactions in turn give effect to the objectives of the intergovernmental agreements – both bilateral and multilateral.

3. The DST should be charged with the task of compiling and maintaining a real time listing of South Africa's research, science and technology collaborations in Africa. All institutions should be informed by this list in their decisions around further and future collaboration. This should be extended to a monitoring and assessment document that annually outlines the performance of S&T collaboration in the continent, including the activities of the various donors in the country. The document could also assist the newly established Planning Commission in the Presidency as well as the Department of International Cooperation.

2. Constructing a stratified African collaboration strategy

South Africa has to date signed 16 science and technology African bilateral agreements. These relationships have been driven by a variety of drivers.

The collaboration activities on the continent can be distinguished into different categories. This stratification has at least three pools or categories. The first would be the classical 'strength-to-strength' category that typifies most bilateral co-operation, where countries or institutions seek to collaborate with other partners with similar or greater strengths. The African pool in this category should contain the top African countries in terms of number and share of publications. Table 1 indicates who these countries were in the period 2000-2004. The top 10 countries accounted for 84.3% of the publications output of the continent. South Africa currently has bilateral agreements with all but two of them, the two being Tanzania at number 8 and the Cameroon at number 10 on the list. Table 3 illustrates the productivity ranking of South Africa's African bilateral collaborations in the period 2004-2005. The first observation is that only two countries on the list are in the African Top Ten. The second observation is that even for those two countries the articles co-authored with South African partners, as a percentage of the total articles, is low (1.75% with Nigeria and 2.1% with Kenya). The third observation is that these two countries collectively accounted for 2.8% of South Africa's total collaborative output in that period.

> *We suggest that NACI should recommend that South Africa should consider prioritising support for collaboration in those African institutions and countries that fall into this category of strength-to-strength partnerships. This would include considering an intensification of S&T collaboration activities with partners institutions in countries that fall in Africa's top ten list with respect to research output. This category has the highest potential of direct science benefit to the South African NSI, both in terms of one-to-one collaboration as well as one-to-many collaboration These partnerships also organise for South Africa to be well placed to take advantage of international funding opportunities e.g. the EU-ACP Fund for S&T..*

The second category is that of the hegemonic relationships. Here South Africa's vanguard role with respect to the contribution to regional and continental science and technology development should continue to be prominent. There is a proliferation of opportunities in this regard and South Africa already has a track record of success in this area, e.g. the Lesotho-DFID-South Africa project on building tissue culture capacity for potato farming in the mountain kingdom.

> *We suggest that NACI considers recommending that these interactions should make use of third party and donor funding, through such mechanisms as trilateral relationships with donor countries or international funding institutions that have prioritised the African partner for donor aid or investment. In some instances these collaborations form a core component of South Africa's contribution to an international effort. An example is South Africa's contribution to post-conflict reconstruction in countries like the DRC, Rwanda and Burundi. Here South Africa*

makes the higher contribution, with the expectation of limited science benefit. The political capital gained through such interactions is important to South Africa's foreign policy in Africa.

The third category is where investment in the bilateral relationship lends weight to a larger objective, usually 'big science' projects. The two examples where South Africa has successfully used this strategy is in the successful bid to host the African Component of the International Centre for Genetic Engineering and Biotechnology (ICGEB) and the ongoing bid to host the Square Kilometre Array telescope. In addition to the traditional bilateral collaboration benefits, parties in this type of activities have the opportunity for further bilateral benefits associated with the multilateral project. In the case of the ICGEB and the SKA, for example, further related student exchange and research collaboration in biotechnology and astronomy took place.

We suggest that NACI considers recommending that South Africa increases opportunistically its portfolio of projects that lend themselves to this modality, of potential 'big science' regional projects, according to needs.

It becomes apparent that the stratification of South Africa's African collaboration portfolio has implications for allocation of resources and implementation modalities.

We suggest that NACI considers recommending that the DST develops an African Collaboration Strategy Document to guide the collaboration activities of the different players in the National System of Innovation. The strategy paper must clearly describe the different categories of African partners and the engagement modalities (including funding sources) associated with each category.

3. *Planning for multi-dimensional benefit*

South Africa's science and technology collaboration in Africa at both bilateral and multilateral levels have set the seeds for contributions to the African developmental agenda as enunciated in the various declarations of the African Union, as well as in South Africa's political agenda of expanding its relations on the continent. Science and Technology as a foreign policy tool has been used successfully to assist the Presidency and the Department of International Collaboration to consolidate South Africa's relations across the continent. Many a state visit and African Union Summit have cited Africa's science and technology collaboration and the collaborative achievements as a marker for the progress of the African Renaissance. In addition, South Africa's lead in discussions on the development of National Systems of Innovation has encouraged an important economic development dialogue on the continent.

The opportunity space provided by the development of the African Union/NEPAD science and technology platform was successfully used by South Africa to gain this multi-dimensional benefit on the political and developmental fronts.

We suggest that NACI considers recommending that DST develops the African Collaboration Strategy, which actively plans and organises for a multi-dimensional benefit profile. It should contain the development of a priority list of countries for maximising the collaborative benefits from a research, science and technology perspective, followed by an exploration of the potential benefits to the developmental and political agendas as part of the stratification strategy.

4. Implementation of Collaborative Efforts

The current approach used by NRF to support collaboration with the African countries (one approach fits all) and approved by DST does not appear to be able to bring apparent results. The collaborative patterns of SA-Africa have remained at the same levels for the last 10 years even though the resources devoted to African collaboration have been increasing. We suggest that NACI should recommend that countries and disciplines should be prioritised, and differentiated funding/incentives should be offered for top priorities and for new collaborative partnerships.

Our investigation failed to identify any mechanisms to regularly monitor the effects and impacts of the instruments promoting scientific collaboration. International best practice requires the existence of continuous monitoring-evaluation mechanisms. Key elements of such mechanisms include "systematic" use of assessments and continuous collection of data. Systematic assessments are initiated in the beginning of each project and continue well after the termination of the project, in order to capture socio-economic impacts of the activities. Similarly data collection is a continuous activity and is extended beyond the life of the project. NACI should recommend that all programmes are preceded by status studies and are accompanied by monitoring and assessment mechanisms.

5. Creating the Future

Multilateral organisations and donors have the potential to have a substantial impact on issues of policy and development in the developing countries. Developing countries need expertise in the field of policy in order to assess and take ownership, as appropriate, of third party recommendations. South Africa and the rest of the African continent have limited such expertise. NACI should recommend the establishment of a funding mode for the " Science, Technology and Innovation Policy Support Programme". The programme could be managed by NRF with guidelines from DST and could support knowledge and human resource capacity development in the field of relevant policy, including policy analysis for science, technology and innovation collaboration.

Acknowledgements

The authors wish to thank the following stakeholders for their comments and for providing information. All regular caveats apply.

Rob Drennan – Executive Director, NRF

Rocky Skeef – Executive Director, NRF

Robert Kriger – Executive Director, NRF

John Mugabe – Institute for Technological Innovation, University of Pretoria

Lindiwe Lusenga – CD, DST

Mmampei Mabusela – Director, DST

Kamy Chetty – DDG, Department of Health

Yogan Pillay – DDG, Department of Health

Moeketsi Modisenyane – Director, Department of Health

Galiep Jeppe – CD, Department of Education

Iqbal Sharma – DDG, DTI

Noncedo Vutula – CD, Department of Agriculture

Rivka Kafir – CEO, WRC

Heidi Snyman – Executive Director, WRC

Judy Beaumont – CD, DEAT

Paul Jordaan – former CEO, Mintek

Abbreviations

AI	Activity Index
AIDS	Acquired immunodeficiency syndrome
AIMS	African Institute of Mathematical Sciences
ALC	African Laser Centre
AMCEN	African Ministerial Conference on the Environment
AMCOST	Ministers Council on Science and Technology
ASSAf	Academy of Sciences of South Africa
ASTII	African Science, Technology and Innovation Indicators Initiative
AU	African Union
BECA	Biosciences East and Central Africa
BECCAP	Basic Energy and Climate Change Adaptation Programme
BEST	Basic Energy Services and Technologies
BMU	German Ministry of Environmental Affairs
BMZ	Bundes Ministerium für Zusammenarbeit
BoTEC	Botswana Technology Centre
CAADP	Comprehensive Africa Agriculture Development Programme
CD	Chief Director
CEF	Central Energy Fund
CEO	Chief Executive Officer
COMENA	Atomic Energy Commission of Algeria
CSIR	Council for Scientific and Industrial Research
CSTPoA	Consolidated Science and Technology Plan of Action
DACST	Department of Arts, Culture, Science and Technology
DDG	Deputy Director General
DEAT	Department of Environmental Affairs and Tourism
DG	Director General
DHEW	Department of Health, Education and Welfare
DST	Department of Science and Technology
EU	European Union
GMO	Genetically modified organisms
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HESS	HESS Gamma Ray Telescope in Namibia
HIV	Human immunodeficiency virus
HSRC	Human Sciences Research Council
ICSU	International Council for Science
ICT	Information and Computer Technologies
IKS	Indigenous Knowledge Systems
IMF	International Monetary Fund
IST	Information Society Technologies in Africa
LDC	Less Developed Countries
MAP	Millennium African Plan
MIT	Massachusetts Institute of Technology
MoRST	Ministry of Research, Science and Technology
MoU	Memorandum of Understanding
NABNet	North African Biosciences Network
NACI	National Advisory Council on Innovation
NAI	New Africa Initiative
NAS	National Academy of Sciences
NEPAD	New Partnership for Africa's Development
NGO	Non-government Organisation
NIS	New Independent States
NRC	National Research Council

NRF	National Research Foundation
NSI	National System of Innovation
OAU	Organisation of African Unity
OBP	Onderstepoort Biological Products
ODA	Overseas Development Assistance
ODA	Official Development Assistance (OECD)
OECD	Organisation for Economic Co-operation and Development
OVI	Onderstepoort Veterinary Institute
ProBEC	Programme for Biomass Energy and Conservation
PUSET	Public Understanding of Science, Engineering and Technology (PUSET
R&D	Research and Development
S&T	Science and Technology
SADC	Southern African Development Community
SAMCOST	SADC Ministers Council on Science and Technology
SANBio	Southern African biotechnology network
SARUA	Southern African Regional Universities Association
SCE	Science Consultancy Enterprises
SCI	Science Citation Index
SIRDC	Zimbabwe's Scientific and Industrial Research and Development Centre
SKA	Square Kilometre Array
SMME	Small Scale and Medium Enterprises
STAF	Science and Technology Agreements Fund
STAP	Short term action plan for African infrastructure
STOA	Scientific and Technological Options Assessment
SWOT	Strengths, weaknesses, opportunities and threats
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US(A)	United States (of America)
WABNet	West African Biosciences Network
WB	World Bank