A Scientometric Assessment of the Southern Africa Development Community – Science in the Tip of Africa

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Abstract

This article reports the results of a scientometric assessment of the Southern Africa Development Community countries. The National Science Indicators database of Thomson- Reuters and the online ISI Web of Knowledge are utilized in order to identify the number of publications of the 15 countries over a period of 15 years; the activity and relative impact indicators of 22 scientific disciplines for each country and their collaborative patterns. It is identified that South Africa with 19% of the population in the region is responsible for 60% of the regional GDP and 79% of the regions publications. All countries tend to have the same focus in their disciplinary priorities and underemphasize disciplines such as engineering, materials science and molecular biology. It is expressed concern that the current research infrastructures are inadequate to assist in reaching the objectives developed in the Regional Indicative Strategic Development Plan of the community.

Keywords: scientometrics, assessment, SADC, Southern Africa, research

Introduction

The Southern African Development Community (SADC) has been established in 1992 under Article 2 of the SADC Treaty. The SADC vision is one of a common future, within a regional community that will ensure economic well-being, improvement of the standards of living and quality of life, freedom and social justice; peace and security for the peoples of Southern Africa. The community is currently consists of 15 member countries: Angola, Botswana, the Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.

Table 1: Vital Statistics: SADC 2008

Country	Population	GDP (PPP US$	GDP /per

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		billions)	Capita (US$)
Angola	12,799,293	110.30	8.800
Botswana	1,990,876	27.06	13.900
DC Congo	68,692,542	20.64	300
Lesotho	2,130,819	3.29	1500
Malawi	14,268,711	11.81	800
Mauritius	1,284,264	15.27	12.000
Mozambique	21,669,278	18.94	900
Namibia	2,108,665	13.25	6300
S Africa	49,052,489	491.00	10.100
Swaziland	1,123,913	5.70	5100
Tanzania	41,048,532	54.25	1300
Zambia	11,862,740	17.5	1500
Zimbabwe	11,392,629	1.92	200
Madagascar	20,653,556	20.13	1000
Seychelles	87,476	1.715	19,800

Table 1 shows the vital statistics of the SADC countries. DC Congo has the biggest population (exceeding 68 million) followed by South Africa and Tanzania. In terms of GDP South Africa is the largest economy followed by Angola (less than one fourth in size). Interestingly though Seychelles, Mauritius and Botswana are richer than South Africa in terms of GDP per capita.

The member states aim to achieve regional economic integration and they have established the following milestones: the SADC Free Trade Area was launched on August 17, 2008 at Sandton, South Africa; the Customs Union (CU) is planned to be established by 2010, the Common Market (CM) by 2015, Monetary Union (MU) by 2016 and the Single Currency by 2018.

Science and technology are recognised as important components in achieving the regional objectives (SADC Treaty 5(2)(f)) and they are overseen by the Southern African Minister's Council on Science and Technology.

In 2007 the SADC Ministers of Science and Technology officially adopted the SADC protocol on Science, Technology and Innovation in Pretoria.

The SADC protocol on Science Technology and Innovation is a legally binding document aimed at regulating collaborative initiatives within the SADC region to support the implementation of the SADC Regional Indicative Strategic Development Plan (RISDP) and Africa's Science and Technology Consolidated Plan of Action.

In December 2008 the SADC Ministers endorsed the development of a science, technology and innovation strategic plan. The objectives of the plan (to be completed by the end of 2009) are:

1." Regional and legal institutional mechanisms to strengthen cooperation

2. Promotion of partnerships for investment in R&D and innovation within the region

3. Establishment of collaborative regional R&D programmes in priority areas

4. Promotion of the value and application of IKS & technologies

5. Promotion of technology transfer and innovation

6. Promotion of public awareness of and value in STI

7. Development and promotion of regional STI capacity" (Mpanza 2009)

The identified areas of priority are: energy, water and agriculture technologies; materials science, manufacturing and laser technologies; biotechnology and indigenous knowledge systems and ICT and space science technologies (earth observation)

In the above context this article reports the results of an investigation to assess the state of science in the fifteen SADC countries. The article aims to outline trends in the research outputs of the fifteen countries; to identify their scientific specialisation and to report their collaborative patterns. The results of the investigation could be used as benchmarks for identifying the effectiveness of the Community efforts to promote the field of science.

The remainder of the article is organised as follows: the methodology section discusses the databases used for the study and the indicators utilised. The section "Results: SADCs Scientific Performance" outlines the results of the investigation and elaborates on the findings and the related policy implications. The article ends with a "conclusions" section.

Methodology and Data

Scientometric analysis is one of the most efficient and objective methods of assessing scientific performance. Scientometric analysis, the quantitative study of the innovation systems, is based mainly on the number of publications and citations. The number of publications in a field is considered an indicator of research activity and the number of citations an indicator of impact. An additional advantage of the use of number of publications is that they can be considered proxies of the scientific manpower available (SCHUBERT ET AL 1986) in a particular region or country. The latter is particularly useful for countries which do not collect research manpower statistics.

The philosophy underlying the use of scientometric indicators as performance measures has been summarized 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." (DE SOLLA PRICE, 1975).

Even though scientometric studies are not without their critics (ROLAND , 2007; LEYDESDORFF, 2008) the field of scientometrics is currently well established internationally. Investigators are using scientometric techniques to undertake cross country comparisons (KING, 2004, POURIS ET AL 2009); in order to assess disciplinary strengths and weakness (MOLATUDI ET AL 2006) ; to confirm theories (SCHUBERT et al forthcoming, LUBANGO ET AL., 2007) and others.

There are limited scientometric studies investigating science in the African continent and even fewer which focus exclusively in the continent. Examples include SHRUM 1997, NARVAEZ-BERTHELEMOT ET AL 2002; INGWERSEN et al 2004; TIJSSEN 2007, POURIS 2009 and others. Most of these studies focus in the prolific producers in the Continent and rarely examine science in the smaller countries in the region.

The most often used databases for such analyses are the citation indices of Thomson Reuters (formerly known as those of the Institute for Scientific Information (ISI)). "These databases currently provide the best source of information to identify the basic research activity across all countries and fields of science" (TIJSSEN 2007). The citation indices (science citation index expanded; social science citation index and arts and humanities citation index) cover the scientific literature in the most important 10 000 journals in the world. The main advantages of the Thomson-Reuters databases are that they provide all the names and addresses of authors so searches can identify all authors from a particular country or institution and they provide citation related information.

For this investigation we are using the National Science Indicators database. In the National Science Indicators database, Thomson- Reuters counts articles, notes, reviews and proceeding papers, but not other types of items and journal marginalia such as editorials, letters, corrections, and abstracts and summarizes a number of papers and citations according to country and scientific discipline per year. A paper is attributed to a country if the paper carries at least one author address of that country. We also utilize the online ISI Web of Knowledge in order to identify collaborative patterns among the SADC countries.

For the assessment of scientific fields we utilize the activity index and the relative citation impact indicator. The activity index has been suggested by Frame (1977) and has been elaborated by Schubert et al (1996). It characterizes the relative research effort a country devotes to a given field. It is defined as the ratio of the country's share in the world's publications output in a given field to the country's share in the world's publication output in all science fields. An activity index equal to one indicates that the country's research effort in the particular field corresponds exactly to the world average. An activity index larger than one reflects higher than average effort dedicated to the field and vice versa. The relative citation impact indicators is defined as the ratio of the citation impact (number of citations received per paper published) for the country in a particular field to the citation impact for the field as a whole worldwide.

Results: SADCs Scientific Performance

Table 2 shows the number of publications in the database from the different SADC countries for three 5 year periods-1994-1998; 1999-2003 and 2004-2008. With the exemptions of Zimbabwe and Democratic Republic of Congo, all countries exhibit a growth in their number of publications from period to period. The war in DRC and the socioeconomic instability in Zimbabwe are reflected in their research output. Mozambique and Seychelles exhibit the highest growth (79% and 78% respectively) among the SADC countries for the period from 1999-03 to 2004-2008 – albeit from a small base. Zimbabwe's research output exhibits a contraction during the period.

Furthermore, the table shows that only South Africa produces an "adequate" number of research publications. Adequacy in this context should be linked to the minimum number of publishing researchers needed in order to support some presence in a scientific speciality.

Table 2: Number of SADC publications: three 5-year periods

Countries	**94-98**	**99-03**	**04-08**
Angola	26	56	69
Botswana	319	596	816
DR Congo	208	96	118
Lesotho	31	38	58
Madagascar	260	388	652
Malawi	405	538	759
Mauritius	99	211	251
Mozambique	115	185	331
Namibia	179	225	360
Seychelles	46	49	87
South Africa	18,099	19,785	27,008
Swaziland	54	72	83
Tanzania	1,041	1,200	1,943
Zambia	338	398	583
Zimbabwe	1,128	1,165	1,027

South Africa is producing almost 14 times more publications than the second country in the list-Tanzania. The small output of the SADC countries becomes profound if we take into account that the University of Pretoria in South Africa is producing approximately 1000 publications per year.

In this context, probably the most important issue that should be emphasised is that it is doubtful that the SADC countries will be able to meet the "Millennium Development Goals" (MDG) with the existing research infrastructure. The MDGs set development targets that are to be met by individual countries and the international community within specific time-frames. The targets include halving poverty and hunger, halting and reversing HIV/AIDS and incidence of malaria, halving the proportion of people without safe water, and reversing environmental degradation. In addition to these, the MDGs have targets aimed at promoting global partnership for development. Two of these targets deal with science and technology cooperation for development: target 17 is about promoting public cooperation with pharmaceutical companies to provide access to affordable, essential drugs in development, and target 18 focuses on public-private cooperation to ensure that benefits of new technologies are available to all, particularly in developing countries. It is apparent that the achievement of MDG requires substantial scientific inputs and the SADC countries (with the exception of South Africa) are lacking the relevant infrastructure. (United Nations, 2004)

Table 3: Country contribution (% of world papers)			
Country	**94-98**	**99-03**	**04-08**
Angola	0.00%	0.00%	0.00%
Botswana	0.01%	0.01%	0.02%
DC Congo	0.01%	0.00%	0.00%
Lesotho	0.00%	0.00%	0.00%
Madagascar	0.01%	0.01%	0.01%
Malawi	0.01%	0.01%	0.02%
Mauritius	0.00%	0.01%	0.01%
Mozambique	0.00%	0.00%	0.01%
Namibia	0.00%	0.01%	0.01%
Seychelles	0.00%	0.00%	0.00%
South Africa	0.50%	0.49%	0.55%
Swaziland	0.00%	0.00%	0.00%
Tanzania	0.03%	0.03%	0.04%
Zambia	0.01%	0.01%	0.01%
Zimbabwe	0.03%	0.03%	0.02%
World Papers	3,622,178	4,025,074	4,953,725

Table 3 shows the contribution that each country makes in the world literature. The figures show that only South Africa is producing 0.55% of the world literature. Tanzania is producing 0,04% and all other countries are in the region of 0,02% or less. In this context it should be mentioned that the Latin American countries produced 4.13% and India 2.94% of the research literature during the period.

Table 4 shows the relative impact of the publications of each country. The figures should be used only tentatively as in small numbers one or two highly cites papers can provide misleading figures for the whole population.

Table 4: Impact relative to world			
Countries	**94-98**	**99-03**	**04-08**
Angola	0.20	0.73	0.18
Botswana	0.20	0.41	0.71
DC Congo	0.99	1.29	0.69
Lesotho	0.30	0.47	0.48
Madagascar	0.45	0.68	0.62
Malawi	0.80	1.05	1.01
Mauritius	0.33	0.51	0.55
Mozambique	0.40	0.70	1.01
Namibia	0.45	0.51	1.50
Seychelles	1.45	0.93	1.34
South Africa	0.58	0.67	0.82
Swaziland	0.22	0.38	0.30
Tanzania	0.88	0.67	0.92
Zambia	0.63	0.76	0.96
Zimbabwe	0.51	0.56	0.75

Table 5 shows the activity indices of the 22 scientific disciplines covered in the database for the 12 most prolific SADC countries. The table shows the “revealed” research priorities of the various countries. They are revealed in the sense that they are indicated by the actual emphasis of the research outputs of the particular countries. Often, priorities indicated in political rhetoric are not implemented and they remain just rhetoric priorities while the research system moves on following its own inertia and non governmental influences. For example, in South Africa the Department of Science and Technology recognises the importance of information infrastructure and it sets the target for the country to be among the top countries in the world in the field of pharmaceuticals by 2018 (DST, 2008). However, the activity indices (table 5) show that South Africa’s emphasis is well below the world average in the fields of computer science (0.45) and molecular biology (0.38) and biology and biochemistry (0.87) – fields required to achieve the objectives set in the Ten Years Plan.

Comparing the priorities shown in table 5 we identify that the SADC countries have the tendency to focus on the same scientific disciplines. Immunology, environment/ecology; plant and animal sciences and agriculture appear to be among the disciplines which are emphasised in the SADC countries. It has been argued (SCHUBERT forthcoming) that the identified priorities are the result of the South African influence in the region. In turn the South African research priorities are affected by the natural wealth of the country (biodiversity, geosciences and so on) and the relevant health challenges.

It is interesting to notice that with the exceptions of South Africa and Namibia all other countries have a minimal presence in space science. Space science is a priority research area in South Africa. The country has a number of relevant research facilities such as the South African Astronomical Observatory (SAAO); the South African Large Telescope (SALT); the Hartebeesthoek Radio Astronomy Observatory and the Hermanus Magnetic Observatory. Namibia has only one such facility the High Energy Stereoscopic System (HESS) — a system of telescopes set up near Gamsberg Pass to investigate cosmic gamma rays. Astronomy and astrophysics is the discipline in which the two countries compete most. Twenty six percent of the collaborative articles of South Africa and Namibia are in the field of astronomy and astrophysics.

South Africa is currently competing with Australia for hosting the Square Kilometer Array Telescope - which would be by far the biggest radio telescope in the world.

Table 5: Activity Indices of SADC countries (2004-2008)

Discipline	SA	Tanzania	Zimbabwe	Botswana	Malawi	Madagascar	Zambia	Namibia	Mozambique	Mauritius	DR Congo	Seychelles
Agricultural Science	1.32	3.52	5.22	2.50	3.28	1.30	2.22	1.12	3.17	2.97	0.42	1.14
Biology & Biochemistry	0.87	0.55	0.45	0.57	0.46	1.46	0.28	0.41	0.55	1.59	0.31	0.84
Chemistry	0.66	0.11	0.06	1.02	0.04	0.35	0.04	0.17	0.15	1.08	0.14	0.00
Clinical Medicine	0.79	1.59	1.11	0.40	2.29	0.95	1.65	0.11	1.79	0.31	2.37	0.90
Computer Science	0.45	0.00	0.03	0.37	0.04	0.15	0.00	0.09	0.30	0.79	0.00	0.00
Economics & Business	1.31	0.80	0.74	0.68	0.72	0.31	0.70	0.19	1.03	3.77	0.57	0.00
Engineering	0.66	0.22	0.35	0.68	0.15	0.46	0.15	0.14	0.08	1.00	0.00	0.29
Environment / Ecology	2.46	4.01	3.84	3.97	1.19	5.34	2.13	6.58	1.71	4.34	2.55	6.05
Geosciences	2.13	1.92	3.67	5.62	0.86	1.06	1.44	4.83	2.65	0.00	2.15	1.67
Immunology	1.63	4.69	6.84	2.91	9.67	1.14	10.47	0.23	4.26	0.00	6.98	0.95
Materials Science	0.43	0.08	0.21	0.11	0.00	0.26	0.11	0.18	0.06	0.34	0.00	0.00
Mathematics	0.99	0.12	0.44	0.80	0.10	0.67	0.00	0.11	0.24	1.26	0.00	0.00
Microbiology	1.24	1.73	0.79	0.68	1.53	1.50	3.24	0.00	2.59	0.73	2.58	0.70
Molecular Biology	0.38	0.26	0.21	0.23	0.24	0.16	0.06	0.20	0.11	1.14	0.30	0.00
Multidisciplinary	4.74	1.74	2.00	4.47	2.36	1.71	0.38	1.89	0.00	0.89	1.89	0.00
Neuroscience	0.40	0.21	0.07	0.00	0.27	0.11	0.18	0.00	0.00	0.00	0.29	0.39

Pharmacology	0.78	0.68	0.71	0.34	0.00	1.26	0.00	0.15	0.50	1.96	0.92	0.00
Physics	0.48	0.02	0.06	0.24	0.01	0.20	0.06	0.18	0.03	0.17	0.09	0.24
Plant & Animal Science	2.93	2.68	3.05	1.59	1.45	5.35	2.90	6.42	3.18	2.85	1.71	6.95
Psychiatry / Psychology	1.05	0.17	0.58	0.57	0.49	0.00	1.07	0.00	0.25	0.17	0.35	0.00
Social Sciences	2.01	2.31	1.52	3.85	2.37	0.62	2.40	1.13	1.89	1.89	1.48	2.01
Space Science	1.77	0.17	0.00	0.00	0.00	0.00	0.14	11.96	0.00	0.33	0.00	0.00

Table 6 shows the collaborative patterns of the SADC countries**.** The table shows the top five countries in the world producing collaborative research with the particular SADC countries and the percent of total collaborative research that it is produced. The figures below the name of the countries, show the percentage of collaborative research of the SADC country which is attributed to the particular partner. England appears among the top collaborating countries in all SADC countries while the USA is not one of the top collaborating countries only for Namibia. South Africa does not appear in the lists of top collaborating countries for Tanzania, Seychelles, Malawi, DRC and Angola. On the other hand South Africa is the primary partner for Swaziland and Lesotho (both countries are enclosed by South Africa) and for Namibia.

Language appears to be a facilitating factor for scientific collaboration. Portugal appears twice in the list, in collaboration with Angola and Mozambique. Both countries speak predominantly Portuguese.

It should be emphasised that the major collaboration between Germany and South Africa and Germany and Namibia is in the field of space science. The underlying reason for this German preference is the South African Large Telescope (SALT). Germany is a member of the consortium funding the telescope and hence, has an interest to promote the utilization of the facility.

Table 6: Main collaborating countries: SADC 2004-2008

Angola	Portugal	England	France	USA	Italy
	21.9%	19.5%	14.6%	14.6%	13.4%

Botswana	USA	SA	England	Australia	Germany
	19.3%	14.7%	7.8%	5.1%	4.9%

DRC	France	Belgium	USA	England	Cameroon
	25.6%	18.6%	17.0%	8.8%	7.2%

Lesotho	SA	USA	England	Malawi	Swaziland
	39.4%	21.1%	8.4%	8.4%	8.4%

Madagascar	USA	France	England	Germany	SA
	32.0%	31.2%	12.0%	7.6%	4.4%

Malawi	England	USA	SA	Netherlands	Tanzania
	35.0%	33.7%	9.5%	6.4%	5.4%

Mauritius	England	USA	Australia	Brazil	Finland
	22.7%	13.7%	9.3%	5.0%	4.3%

Mozambique	USA	Spain	SA	England	Portugal
	22.1%	17.1%	14.5%	11.5%	8.8%

Namibia	SA	Germany	England	France	Czech Rep
	43.5%	23.0%	22.2%	16.3%	14.6%

SA	USA	England	Germany	Australia	France
	14.7%	9.1%	5.1%	4.0%	3.5%

Seychelles	Switzerland	USA	England	France	Australia
	34.7%	30.4%	16.5%	16.5%	6.9%

Swaziland	SA	USA	England	Zimbabwe	Botswana
	30.3%	26.9%	12.3%	10.1%	6.7%

Tanzania	USA	England	Switzerland	Netherlands	Denmark
	27.70%	25.00%	8.90%	7.60%	7.20%

Zambia	USA	England	SA	Belgium	Malawi
	41.5%	15.6%	9.8%	8.0%	6.0%

Zimbabwe	USA	SA	England	Netherlands	France
	20.3%	16.3%	13.8%	7.4%	4.9%

Conclusion

The objective of this article is to assess the state of science in the fifteen Southern Africa Development Community countries. Science and technology are recognised in SADC's Regional Indicative Strategic Development Plan to be key drivers of socioeconomic development and that "most of the challenges facing regional integration as identified in the RISDP such as food security; energy; water; transport; communications infrastructure and human resources development will require scientific and technological solution" (SADC 2003)

The investigation identifies that South Africa with 19% of the population in the region is responsible for 60% of the regions GDP and 79% of the regions publications. However, South Africa produces only 0.55% of the world's scientific literature. In comparison India produces 2.94% of the world's literature.

Identification of the research emphasis of the Community shows an emphasis on traditional research areas (agriculture, plant and animal sciences etc). There is an under-emphasis in scientific areas promising to support innovation such as engineering, material sciences and molecular biology. It is suggested that it is doubtful that the existing research infrastructure will be able to contribute to the Community's objectives.

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