STATE OF WATER RESEARCH IN SOUTH AFRICA 2015

WATER RESEARCH COMMISSION
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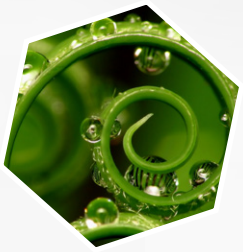

Introduction:

In the last 500 years, science has emerged as a central and transformative force that continues to reshape our everyday life. Science does not only help us to understand the world we are living in, it also teaches us how to adapt and thrive in that world.

Science is also an important basis for sound decision making in many sectors of society. International science and technology cooperation and exchange also play a critical role in narrowing knowledge, information, and technology gaps between countries and societies.

In South Africa, targeted water-related research and resulting scientific discoveries have played a significant role in reducing uncertainties and improving the management of this scarce natural resource. Our improved scientific understanding has also formed the foundation for practical applications that have enhanced the prosperity and security of South African society.

In today's world of threatening climate change and increasing water scarcity, research on water resources has taken on greater importance than ever before.

But how well are we doing in terms of research and innovation? Monitoring and evaluating the various facets of the scientific enterprise is a necessary and integral part of science policy. Rising costs of research and development, coupled with disciplinary claims for financial resources require intelligent allocation of resources, which presuppose knowledge of the activities and performance of the innovation system.

While the National Survey and Experimental Development, undertaken annually by the Department of Science and Technology, provides valuable information on various research and development expenditures in various fields, water research is not part of the report's classification schemes.

This publication offers the first ever glimpse of the state of water research in South Africa. The investigation, for the first time in the country provides an overview of the investment for water-related research and development. The report will also provide a benchmark for future assessments.

The following indicators are reported on as recommended by the OECD:

- Research and development expenditures for water
- Bibliometrics of water research in South Africa as seen in the international context
- Patent analysis of water inventions
- Human resources for water research

It is the expressed hope that the outcomes of this study will go a long way towards guiding research and innovation policy.

Water R&D Expenditure in South Africa

Fostering and supporting high levels of expenditure on research and development (R&D) activity is a critical component in the efforts of countries such as South Africa to enhance their global competitiveness.

Domestic expenditure on R&D as a percentage of the gross domestic product (GDP) is a useful indicator of the extent of support for R&D.

While South Africa has no specific targets for water-related scientific investment, the country has set an overall target of achieving an R&D intensity ratio of 1.5% by 2019. The country currently spends around R24-billion a year on R&D. This translates to 0.76% of GDP, and has remained steady since 2010/2011.

With regards to funding of water-related research, current funding stands at R2.1-billion (2014 figure), up from R1.4-billion in 2000. Government and business are the major funders of research in South Africa.

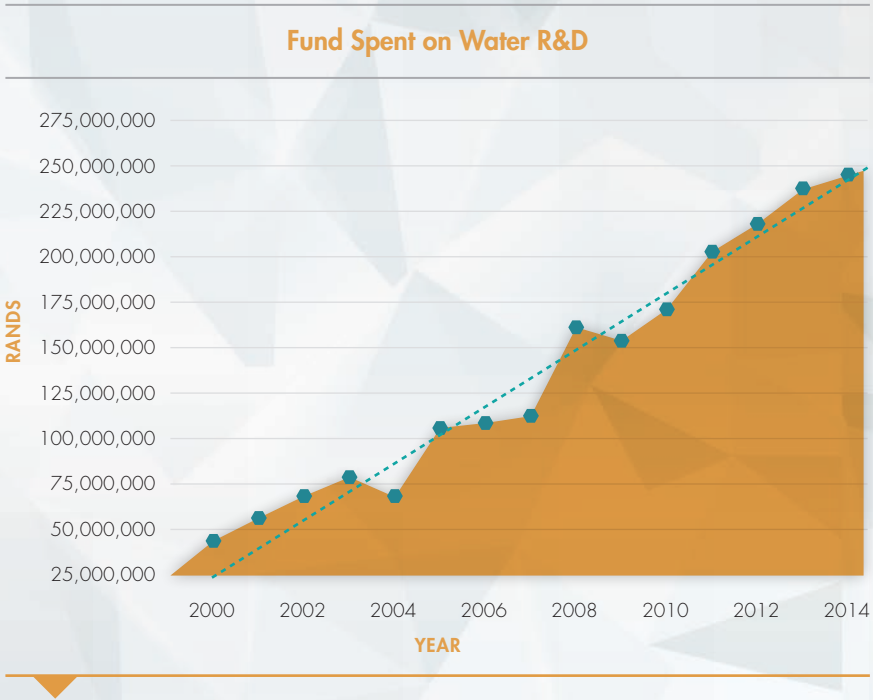

Figure 1: *Funding spent on water R&D (2000-2014).*

Water-related R&D spend, on the other hand, amounted to R240-million in 2014, up from about R50-million in 2000. Despite this progressive increase in expenditure, the total amount translates into a minute percentage of GDP, only 0.0069%.

Established in 1971 to, among others, promote the coordination, cooperation and communication in the area of water R&D, the WRC remains the main funder of water-related research in South Africa. In 2014, the WRC was funding 65% of all water-related research, followed by the Council for Scientific and Industrial Research (CSIR) (16%), Mintek (9%) and the National Research Foundation (8%).

Funders of Water Research

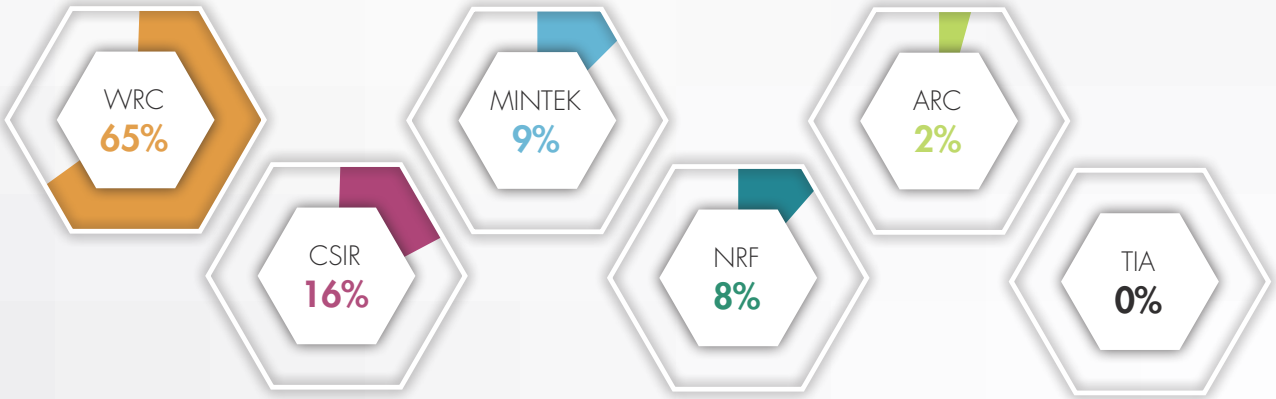

Figure 2: *Funders of water research (2014).*

Water Patent Analysis

Patents play an increasingly important role in innovation and economic performance as they are useful indicators of inventive activity and a country's capacity for innovation. There is an increasing trend among policy-makers, researchers, innovation analysts and technocrats to rely on patent statistics for this reason.

Probably the most important characteristic of patents that makes them valid indicators is the fact that they are going through assessment – proper validation that the content is a contribution to knowledge. As such, patent statistics remain a unique source for the analysis of the process of technical change.

The patents most often utilised internationally for this type of analysis are those granted by the US Patent and Trademark Office (USPTO), even though most countries have their own patent authorities.

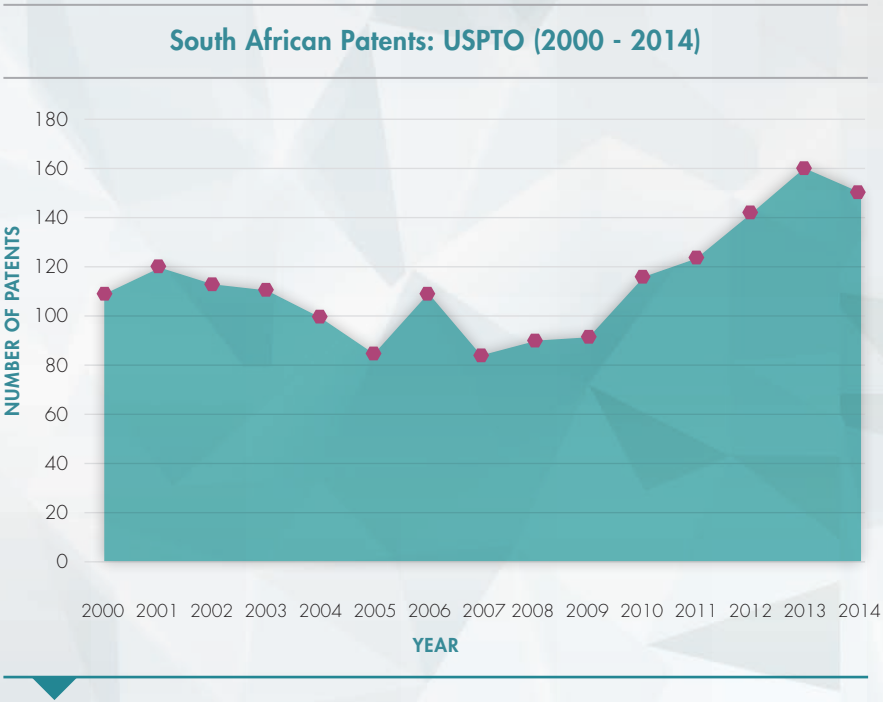

***Figure 3**: Patents granted by South African inventors by the USPTO (2000-2014).*

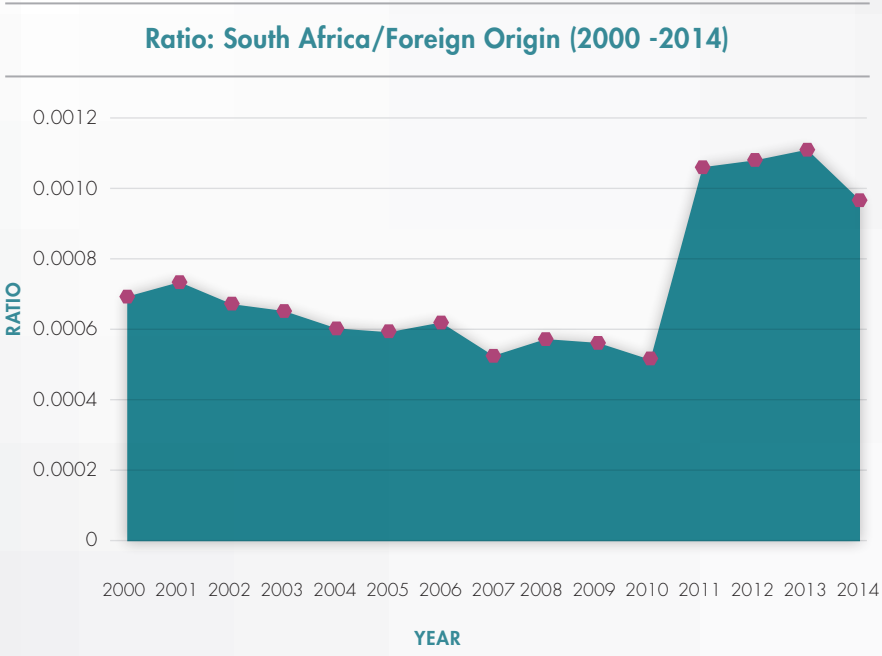

Figure 4: *Ratio of patents granted to South African inventors to Total Foreign Grants by USPTO (2000-2014).*

Figure 3 shows the number of patents awarded to South Africans by the USPTO, while **Figure 4** shows the South African share in the foreign patents (excluding the USA) awarded by the USPTO.

The last two years exhibit an increase in the number of patents awarded to South Africans, and it appears that the long-term decline in the South African share has been stabilised. A definite highlight is the granting of 160 patents to South African inventors in 2013 – an all-time high.

In general, however, South Africa gets very few patents in the USPTO compared to, for example, companies such as IBM, which are granted more than 3,000 patents a year.

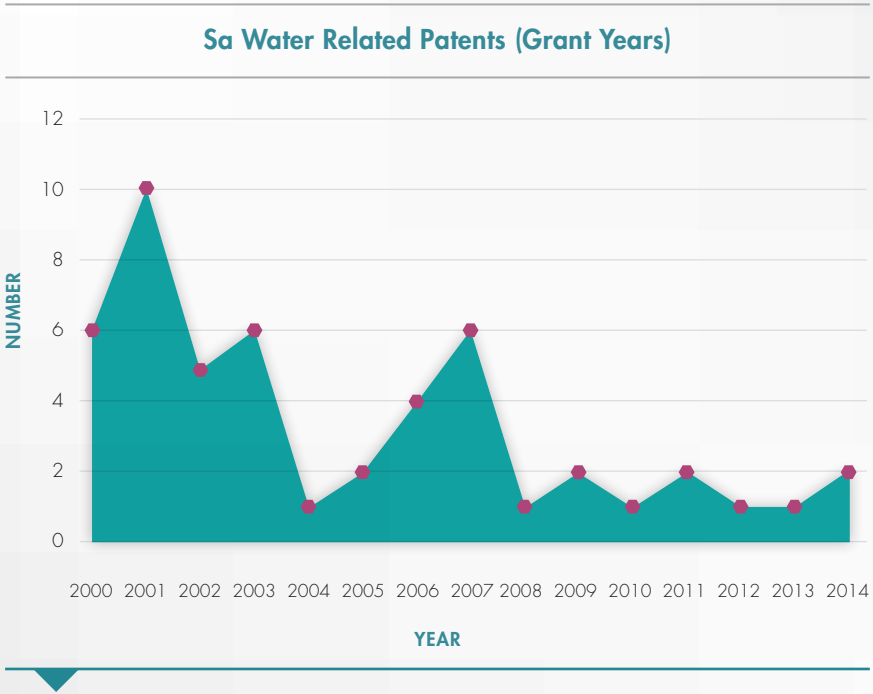

Figure 5: *Water-related South African patents (2000-2014).*

Of all the patents granted to South African inventors between 2000 and 2014, only 46 patents were related to water (see **Figure 5**). This translates to around 3 patents a year.

Table 1 shows the number of water-related patents awarded to South Africa and a number of selected countries between 2005 and 2014. It is interesting to note that South Africa has one of the highest water patents vs total patents ratio at 3.39.

COUNTRIES	WATER PATENTS	TOTAL PATENTS	RATIO
Japan	2 445	363 233	0.67%
Canada	523	39 020	1.34%
United Kingdom	397	35 877	1.11%
China	270	21 111	1.28%
Australia	181	12 837	1.41%
India	111	9 171	1.21%
Russia	56	2 198	2.55%
Brazil	55	1 332	4.13%
Finland	54	8 587	0.63%
South Africa	34	1 004	3.39%

Table 1: *Water patents as a percentage of total granted patents (2005-2014).*

Human Resources in Water R&D

An important set of indicators monitoring the science, technology and innovation space are those classified under human resources in science and technology. Attracting, developing, and retaining talent in science and technology is a priority of the water science community.

Capacity building in science is critical to meet the demand for scientific advance, and to improve science-based decision-making and problem-solving. In South Africa, transforming the water science sphere to include more individuals from historically disadvantage communities are another focus area.

One way of assessing capacity building in the water research sector is by looking on the production of Masters and PhD degrees by the higher education system. These indicators provide information about the supply of researchers, in particular scientific disciplines and specialities, and the academic institutions producing these researchers and specialities.

With this information important gaps in a research field can be identified; research can be stimulated in neglected areas; networking and collaboration between researchers can be encouraged; while facilitating informed decision-making and strategic management.

Figure 6 shows the number of water-related PhDs awarded per year from South Africa's universities between 2000 and 2014. The number of relevant PhDs awarded annually ranges from 14 to 32.

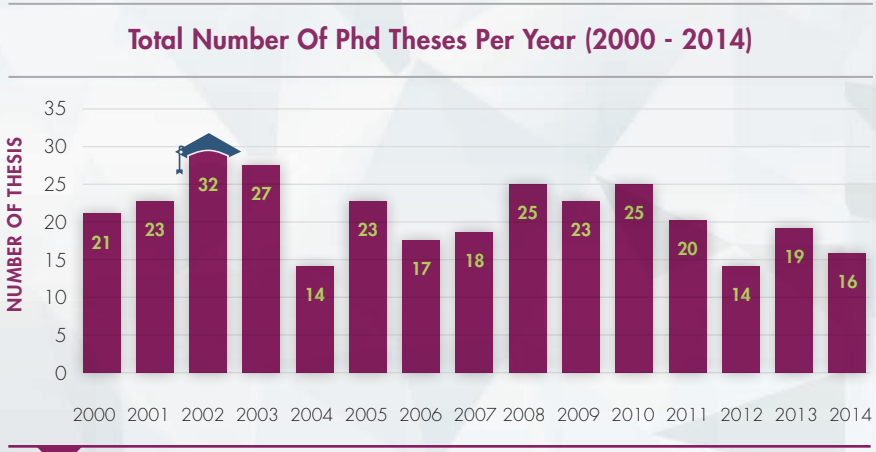

Figure 6: *Number of PhDs awarded per year (2000-2014).*

Evaluating the number of water-related PhDs per research institution proved somewhat problematic as a number of tertiary institutions merged after 2004. Nevertheless, the top five universities in terms of PhDs awarded between were the University of Pretoria (42 PhDs awarded between 2000 and 2014), University of Cape Town (37), Rhodes University (36), University of the Free State (32), and University of the Witwatersrand (30). They are followed by the University of the Western Cape with 26 PhDs awarded between 2000 and 2014, Stellenbosch University (23), North-West University (13) and the University of KwaZulu-Natal (11). All the other institutions have awarded less than 10 water-related PhDs in the last 14 years.

The number of water-related PhDs produced in South Africa remains small, and indicates an apparent lack of focus on water research in South Africa. Researchers and PhD candidates are distributed across the country.

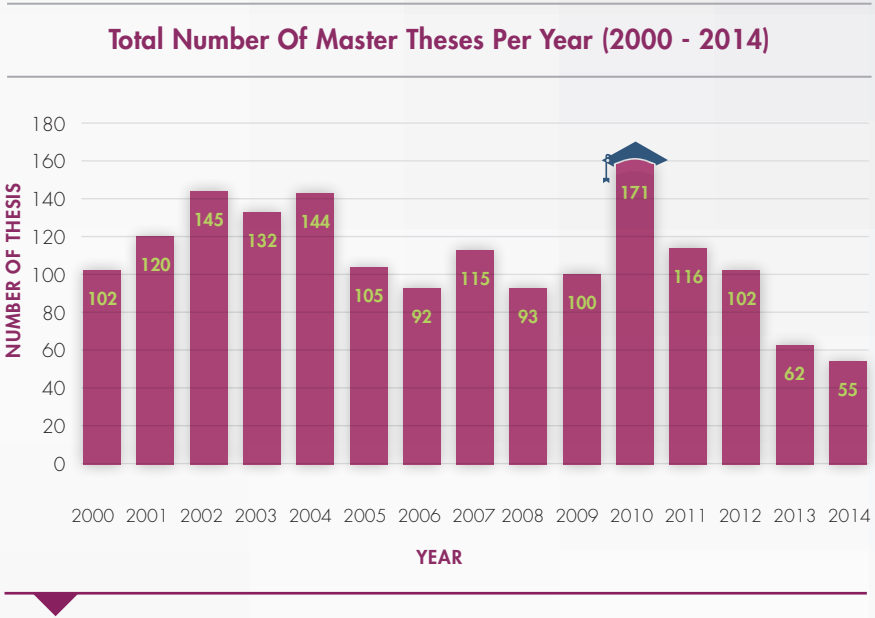

Figure 7: *The number of Masters degrees awarded per year (2000-2014).*

Figure 7 indicates the number of Masters degrees awarded annually by the country's university between 2000 and 2014. In this period, around 100 Masters degrees were awarded. The top universities in the production of Masters degrees are Stellenbosch University (181 Masters degrees awarded between 2000 and 2014), the University of the Witwatersrand (180), North-West University (147), University of Pretoria (135) and the University of the Western Cape (123).

This study also attempted to identify the WRC's involvement in human resources development. The WRC does not provide bursaries, but encourages researchers to involve post-graduate students in their studies. Between 2007 and 2014 the WRC supported, on average, 500 post-graduate students a year (**Figure 9**).

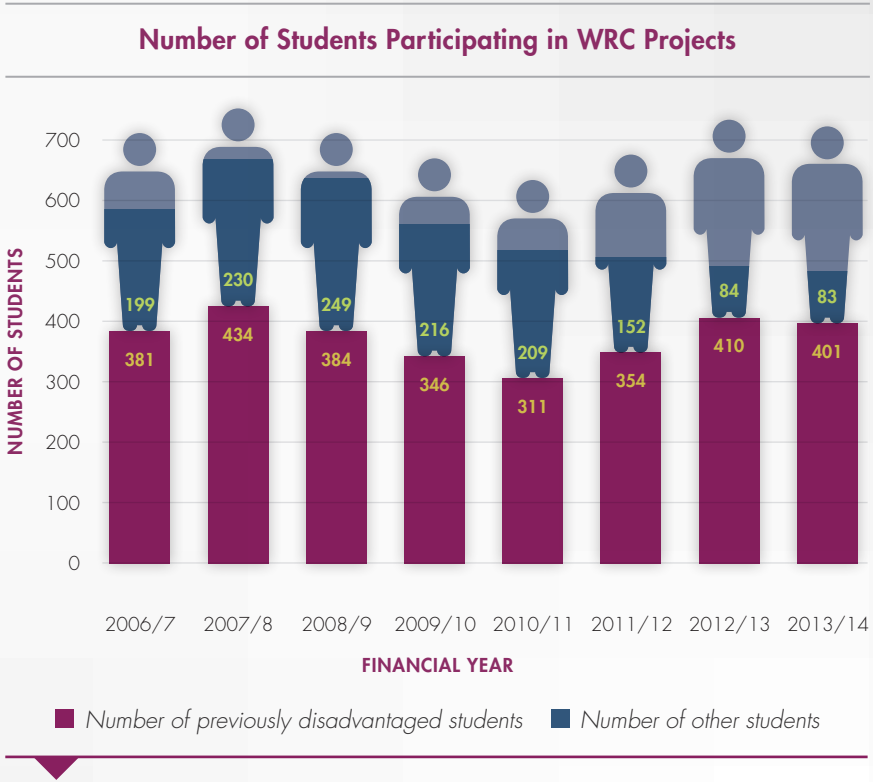

Figure 9: *Number of students participating in WRC projects (2007-2014).*

Figure 10 shows the distribution of WRC-supported PhD candidates across various universities in the 2013/14 financial year. The University of KwaZulu-Natal (23%) appears on top of the list, followed by the University of Pretoria (14%), and the University of Cape Town (13%).

Number of WRC-supported PhDs per Institution (2013 - 2014)

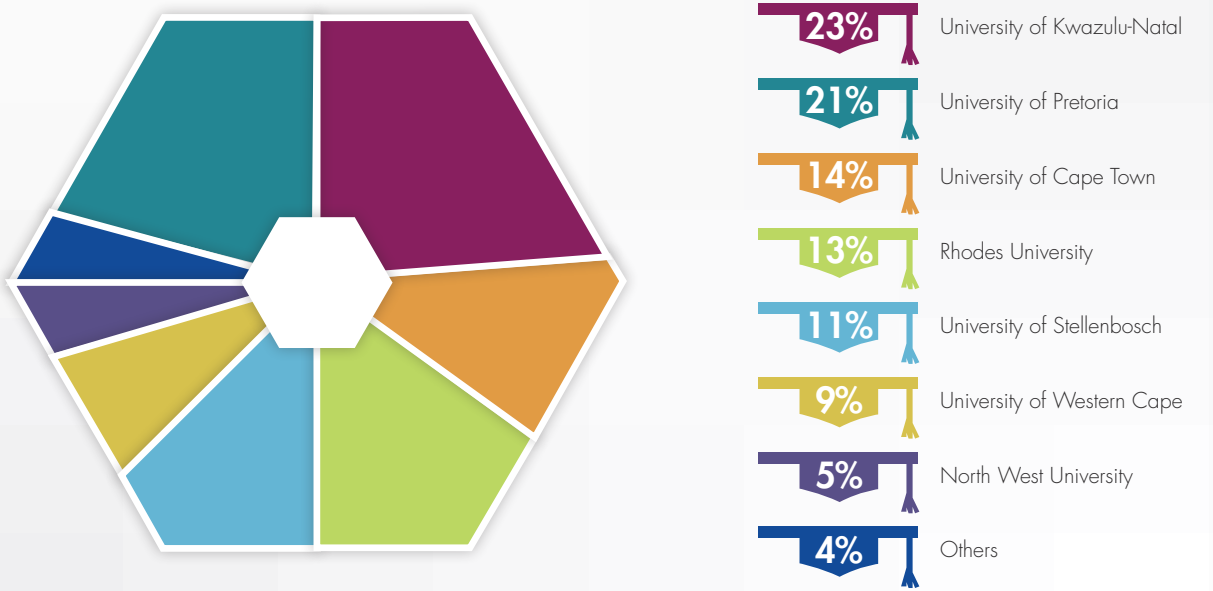

Figure 10: *Distribution of PhD students participating in WRC projects per university (2013-2014).*

Publishing one's work in a journal is an integral part of being a scientist. Journal articles act as a permanent record of what has been discovered, when and by. It shows the quality of the scientist's work – through the peer review system other experts have rated it as valid, significant, and original.

Since communication in science is realised through publications, they are considered an extremely suitable source of data to investigate the growth rates of science. Bibliometric analysis, the quantitative study of the research system, is based mainly on publication indicators.

Bibliometric assessments, apart from being repeatable & verifiable exercises, have the benefit of allowing comparisons among different scientific disciplines and different countries.

Figure 11 illustrates the number of water research publications with at least one

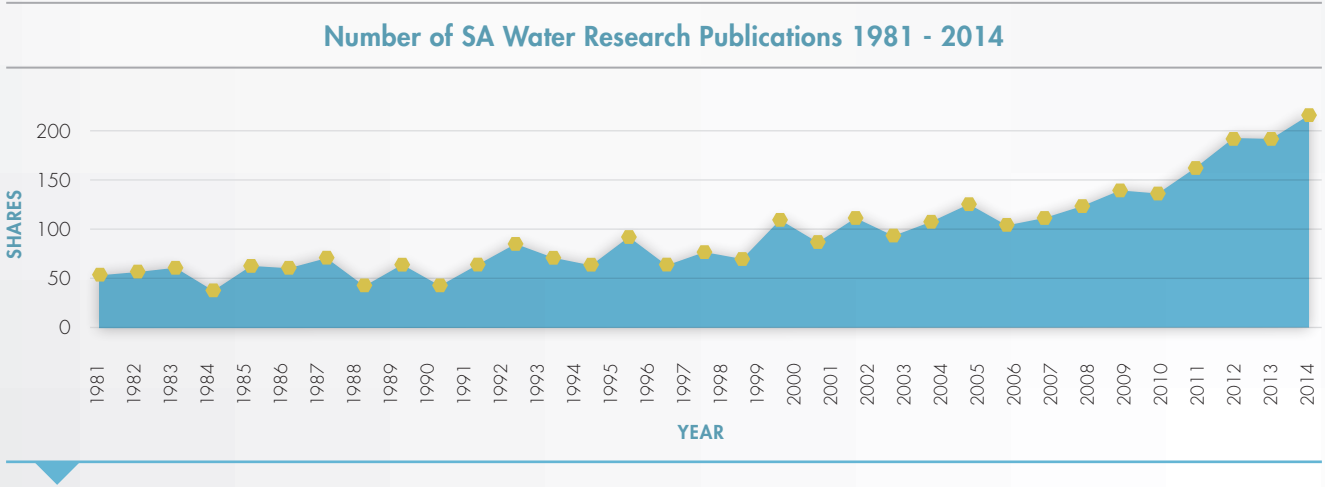

Figure 11: *Number of South African water research publications (1981-2014).*

author with a South African address for the period 1981 to 2014. It is apparent that South African researchers were producing around 60 publications per year in the beginning of the period. During the 2000s this number increased to around 100 publications per year. By 2014, the number jumped to 200 publications. While a number of factors have contributed to this growth, increases in research funding and emphasis in publishing by funding institutions such as the WRC, were undoubtedly of critical importance.

Figure 12 illustrates the South African share of water research publications in the field. The share appears to have declined from above 3% of world publications in the beginning of the period to around 1.5% during the most recent period. It is speculated that the South African decline is as a result of the increase in coverage of water-related research of the ISI Thomson Reuters database as well as the increase in the number of publications in other countries.

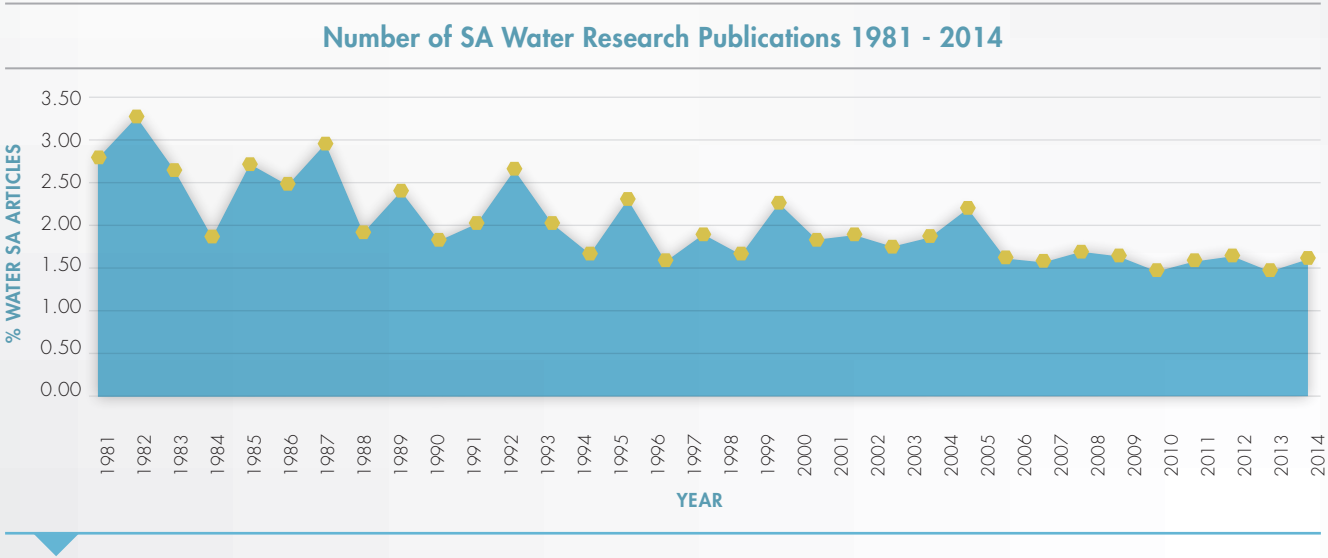

Figure 12: *South African water articles as percentage of world literature (1981-2014).*

Between 2005 and 2014, journal articles were published on a range of subjects, most notably water resources, environmental science, engineering and geology (Table 2).

These research categories are the same across all articles in water resources internationally. The water resources emphasis in South Africa is in accordance to international trends.

Countries	Number of Articles
Water Resources	1 573
Environmental Sciences (Ecology)	332
Engineering	315
Geology	309
Meteorology (Atmospheric Sciences)	206
Agriculture	90
Marine/Freshwater Biology	56
Public Environmental (Occupational) Health	17
Public Administration	15
Oceanography	13
Business Economics	12
Microbiology	12
Chemistry	11
Science Technology (Other Topics)	7
Toxicology	5
Biodiversity Conservation	3
Mathematics	2

Table : *Sub-classification of water resources articles (2005-2014).*

Table 3 indicates the most prolific South African organisations in terms of the publication of water research between 2005 and 2014. The University of KwaZulu-Natal tops the list with 246 articles, followed by the universities of Pretoria and Johannesburg with 166 and 151 articles respectively.

Organisation	Number of Articles
University of KwaZulu-Natal	246
University of Pretoria	166
University of Johannesburg	151
University of Cape Town	137
CSIR	131
Rhodes University	125
University of the Witwatersrand	117
University of the Free State	102
Stellenbosch University	101
North West University	86
Tshwane University of Technology	62

Table 3: *Most prolific South African institutions i.t.o. publishing articles (2005-2014).*

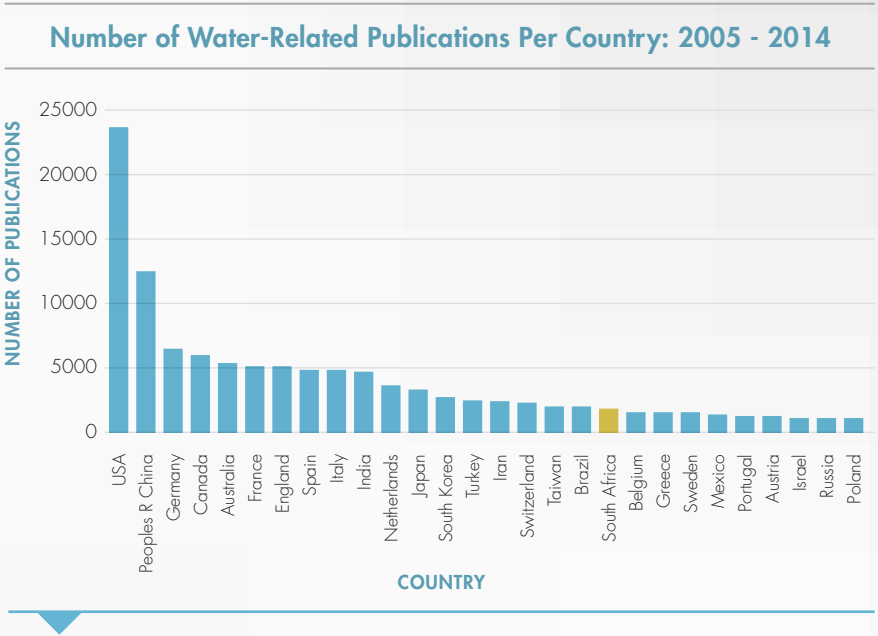

Figure 13: *Number of water-related publications per country (2005-2014).*

Figure 13 indicates the number of water publications of the most prolific countries in the world for the period 2005 to 2014. The USA tops the list followed by the People's Republic of China. It is noteworthy that countries with small populations, such as Canada and Australia, as well countries with small GDPs per capita, such as India and Brazil, are nevertheless managing to produce more water-related research than South Africa.

It must be pointed out, however, that South Africa ranks 19th in the world in the field of water research (the only African country among the top 20). This compares to the country's world ranking of 33rd for the total number of publications in all fields.

Collaboration in science and technology is an international phenomenon. Substantial resources are spent for that purpose internationally. Different stakeholders have differing motivations to collaborate across borders. Governments, for example, participate in order to achieve foreign policy goals, to address global scientific problems, to enhance basic scientific research and to leverage investment in science and technology.

Independently of the type of collaboration, research collaborations manifest themselves into collaborative outputs (publications, patents, and post-graduate students). These outputs are used to identify the size and impact or success of collaboration.

Figure 14 showed the share of South African articles co-authored with international researchers in the field of water and in all scientific disciplines. In the field of water, 35% of the articles produced had international co-authors during 2014. This compares to all South African scientific articles, for which 56% had international co-authors. It should be noted, however, that different scientific disciplines have different collaboration norms. The countries with which South African water researchers collaborate the most are the USA, England, Australia, and the Netherlands.

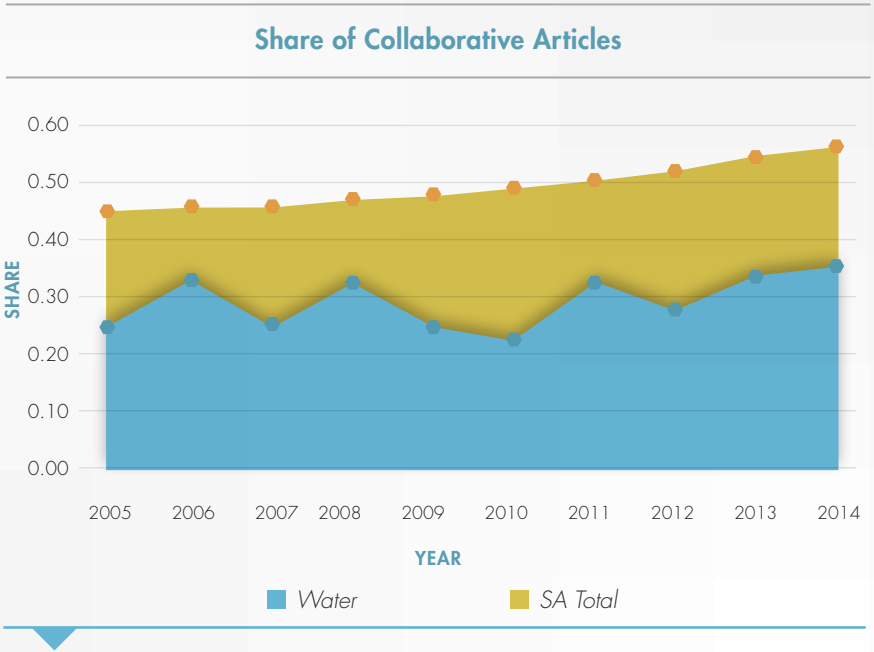

Figure 14: *Share of South African articles and water-related articles with international co-authors (2005-2014).*

ABBREVIATIONS

CSIR	Council for Scientific & Industrial Research
NRF	National Research Foundation
GDP	Gross Domestic Product
R&D	Research and Development
USA	United States of America
WRC	Water Research Commission

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