Agrekon

Agricultural Economics Research, Policy and Practice in Southern Africa

ISSN: 0303-1853 (Print) 2078-0400 (Online) Journal homepage: www.tandfonline.com/journals/ragr20

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To cite this article: Petronella Chaminuka, Nienke Beintema, Kathleen Flaherty & Frikkie Liebenberg (2019) Public agricultural research and development spending in South Africa – update, Agrekon, 58:1, 7-20, DOI: 10.1080/03031853.2018.1550427

To link to this article: https://doi.org/10.1080/03031853.2018.1550427

AGREKON
2019, VOL. 58, NO. 1, 7–20
https://doi.org/10.1080/03031853.2018.1550427

Public agricultural research and development spending in South Africa – update

Petronella Chaminuka [a], Nienke Beintema [b], Kathleen Flaherty [c] and Frikkie Liebenberg [d†]

[a]Economic Analysis Unit, Agricultural Research Council, 1134 Park Street, Hatfield, Pretoria, 0083; [b]Agricultural Science and Technology Indicators (ASTI), International Food Policy Research Institute, 1201 Eye Street, NW, 20005 Washington; [c]Agricultural Science and Technology Indicators (ASTI), International Food Policy Research Institute, 1201 Eye Street, NW, 20005 Washington, DC; [d]Department of Agricultural Economics, Extension and Rural Development, University of Pretoria

ABSTRACT
In developing countries, where few incentives exist for private sector investment in research, public investment in agricultural research and development (R&D) is critical for technological change that stimulates agricultural development, food security and poverty alleviation. This article analyses trends for key indicators in agricultural R&D in South Africa, building on the work of Liebenberg *et al.* (2011). The paper uses data collected from a range of sources including the Agricultural Science and Technology Indicators (ASTI) surveys comprising data for the period 2000–2014. Results show fluctuations in agricultural R&D spending, although there was a general increase in gross spending on R&D at national level, reflecting a continued trend of increased funding for non-agricultural research. Research spending intensity ratios for South Africa remain higher than the recommended 1 per cent. Despite the harsh economic environment and lower than expected economic growth in South Africa since 2011, the government continues to provide the major source of funds for the Agricultural Research Council (ARC). When compared with countries in Africa south of the Sahara, South Africa continues to rank second in agricultural R&D investment, whilst it invests much less than its BRICS (Brazil, Russia, India and China) counterparts, despite having the highest research intensity ratio. The article supports Liebenberg *et al.* (2011)'s recommendations for revisiting policies for long term support of agricultural R&D and explores mechanisms for the ARC to establish sustainable funding streams for agricultural R&D. Recommendations for establishing comparable research spending intensity ratios are also made.

KEYWORDS
public agricultural R&D spending; research intensity ratio; researcher capacity; Agricultural Research Council (ARC)

JEL CLASSIFICATION
Q16; Q18; O32

1. Introduction

Agricultural research and development (R&D) is pivotal to unlocking the potential for agricultural productivity and growth, food security and sustainable development in most developing countries. Increase in agricultural growth and total factor productivity can be realised through use of improved crop and livestock varieties, and diffusion and adoption of new technologies (Perez & Rosegrant, 2015). There is evidence that investment in agricultural R&D can stimulate sufficient agricultural productivity growth to not only pay for the investment itself, but also raise per capita incomes and reduce poverty in developing economies (Thirtle *et al.*, 2003; Alene & Coulibaly, 2009).

CONTACT Petronella Chaminuka Chaminukap@arc.agric.za
†Deceased

Investment in agricultural R&D, whether public or private, is the key to bringing about technological change that stimulates development. The need for public research investment is higher in developing countries, where few incentives exist for private sector investment in research, and for strategic crops that have a bearing on food security and the welfare of smallholder producers. Private sector investment in agricultural research can, amongst other factors, be stifled by the public good nature of research outputs and the long time frame between investment and realisation of returns in agricultural research (Alston *et al.*, 1998). Returns to investment in agricultural R&D on agricultural productivity can sometimes take decades before returns are realised, but once realised the returns are sustained for long periods of time (Alston *et al.*, 2009).

Alston *et al.* (1998) noted that although advances in biotechnology and information technology have significantly reduced the time lag between research investment and realisation of outputs, and enhanced agricultural R&D's contribution to development and poverty alleviation, investments in agricultural research remained limited at the turn of the century in most countries. Evidence that is more recent, however, showed that after decades of stagnation, public sector investment in agricultural research increased in Africa south of the Sahara between 2000 and 2014, although most of the spending was on salary increases and infrastructure revitalisation and development (Beintema & Stads, 2017).

Analysing long-term trends in agricultural R&D spending can provide useful information for policy makers on the impacts of certain policies, and guide adjustment of policy and decision making in response to emerging local and global realities (Liebenberg, 2013). Public spending in agricultural R&D needs to be considered jointly with other broad macro-economic variables such as the country's gross domestic product (GDP), agriculture's contribution to GDP (AgGDP), total budgetary allocation to agriculture, and gross value of agricultural production. The variables influence decisions on investment in public sector agricultural research spending and are, over time, affected by it.

Levels of investment in agricultural R&D differ substantially between developing and developed countries and within developing countries themselves (Alston *et al.*, 1998; Beintema *et al.*, 2012). Although there is no rule of thumb on what constitutes an 'acceptable' level of public sector spending on agricultural research for African countries, the United Nations recommended a minimum of 5 per cent growth in developing countries' agricultural research spending during 2015–2025 and an allocation of at least 1 per cent of AgGDP (UNSDSN, 2013). The 2007 Addis Ababa Declaration on Science Technology and Scientific Research for Development also emphasised the need for increased funding for science and technology on the continent (AU, 2007). Under the 2003 Comprehensive Africa Agriculture Development Programme (CAADP), countries committed to spend at least 10 percent of their budgets on agriculture, with the goal of achieving annual growth of 6 per cent in their agricultural sectors. In 2014 in Malabo, Equatorial Guinea, heads of states reaffirmed their support and confirmed that additional investment was needed to meet this target and in many countries substantial progress has been made since (Beintema & Stads, 2017). However, South Africa's budgetary allocation to agriculture has not been greater than 10 per cent of GDP since 1955 and has been steadily declining over the years. Since 1994, the country has not managed to allocate up to 5 per cent of total government expenditure to agriculture (Liebenberg, 2013). This is despite the important role that agriculture plays in the livelihoods of up to 2 million agricultural households in the country (STATS SA, 2016).

Substantial literature on the patterns of investment in agricultural R&D in South Africa emanates from the earlier work of Liebenberg and other scholars (e.g., Thirtle *et al.*, 2003; Liebenberg *et al.*, 2011) and the International Food Policy Research Institute's (IFPRI) Agricultural and Science Technology Indicators (ASTI). Following indications that research investment in Africa south of the Sahara took a turn for the better in the new millennium (Beintema & Stads, 2017), and the dynamic changes in local and international policy contexts, there is value gained from analysis of up-to-date data within the South African context. Comparison of investment trends with other emerging economies within the Brazil, Russia, India, China and South Africa (BRICS) group can also provide useful insights on how the country is performing when compared with other non-Africa countries. Liebenberg and ASTI/IFPRI updated the South African agricultural R&D data series to 2014, which resulted in the production of ASTI country fact sheets for South Africa (Beintema *et al.*, 2017), but the data has not been further explored and recent trends in South African agricultural R&D spending analysed in relation to other indicators of agriculture and economy.

Consequently, this article builds on important earlier work by Liebenberg *et al.* (2011) in which they analysed the changing structure of South Africa's agriculture from 1910 to 2007. Their analysis revealed that agricultural R&D spending had reached a plateau in South Africa, starting in the 1970s (Liebenberg *et al.*, 2011). In this article, we analyse the updated trends in agricultural R&D spending and researcher capacity to the year 2014, using the data collected by Liebenberg, the Agricultural Research Council (ARC) and ASTI/IFPRI. In addition to updating the analysis done by Liebenberg *et al.* (2011), we compare the emerging trends in South Africa with data from the African continent and other emerging economies. We discuss the implications of the findings for the future of agricultural R&D in South Africa, and on wider imperatives of agricultural development.

2. Recent institutional and economic changes affecting South Africa's agricultural research

Public R&D in South Africa has, since 1994, been mainly conducted by the provincial departments of agriculture, ARC and universities. Prior to the establishment of the ARC in 1992, there were a number of specialised research institutes conducting research under the Department of Agriculture (Liebenberg, 2013). The establishment of the ARC brought all the specialised research institutes under one organisation which, until 1997, was funded under a baseline formula and reported directly to Parliament (Liebenberg, 2013). Following some structural changes that applied to all science councils, funding of the ARC became the primary responsibility of the Department of Agriculture Forestry and Fisheries (DAFF). Additional funding for the ARC and other science councils could be secured from the DST through centres of scientific excellence, and from other line departments through contracting of R&D services (Liebenberg and Pardey, 2011). The ARC was also able to access research funding through the commodity levies, part of which was allocated to research funding (Liebenberg, 2013)

According to Liebenberg (2013), the country's agricultural R&D spending increased gradually until 1972, after which it did not grow significantly, but showed upward and downward spiralling. The changes in public agricultural R&D spending coincided with restructuring of public agricultural research agencies, and general changes in science policy. The share of agricultural sciences in total gross expenditure on research and development (GERD) declined from 8.2 per cent to 5.5 per cent between 2001 and 2008. This was in contrast to expenditure in other fields such as Information, Computer and Communication Technologies (ICT), social sciences and humanities, and medical and health sciences, which increased in real terms over the same period (Liebenberg, 2013). Data that is more recent shows that by 2013 the agricultural sciences share of GERD had risen to 8.6 per cent and despite increasing to 9.1 per cent in 2014, it declined to 8.0 per cent in 2015 (CeSTII, 2017). Research expenditure in ICT and medical and health sciences continued to increase during the same period.

Other changes that have taken place from a government restructuring perspective, have had some potential effects on agricultural research spending since the article published by Liebenberg *et al.* (2011). Between 1996 and 2009, DAFF was called Department of Agriculture and Land Affairs. In 2009, the department's responsibilities were divided into two departments; i.e., DAFF and a newly formed Department of Rural Development and Land Reform (DRDLR). One of the effects of this was to create the possibility of an additional funding stream for the ARC, which was subcontracted to implement projects for the DRDLR. Research funding for agricultural R&D could also be secured through the statutory levies implemented by the National Agricultural Marketing Council (NAMC), from an initial seven industries in 1998 to 11 industries in 2007 (Liebenberg *et al.*, 2011). Although the ARC can access the funding from the levies, in recent years, the allocation of funding from the commodity levies to the organisation declined due to increased competition from other research organisations and service providers, reduced ARC competitiveness and changes in allocation of levy income directed towards research (Liebenberg *et al.*, 2011; NAMC, 2015).

Apart from structural changes that affected agriculture directly, the broader South African economy faced considerable economic challenges in recent years. Between 2011 and 2016, per capita income barely increased with more than 30 million poor South Africans living on less than R1131 per month (about US$2.9 a day) (World Bank, 2017). In the five-year period from 2010 to 2014, average economic growth was 2.4 per cent, compared with 3.6 per cent in the 10 years prior to 2010 (SARB, 2015). Growth further slowed down to 1.3 per cent in 2015, which was regarded as the lowest rate since 2009. The poor growth can be attributed to the severe drought experienced in 2015/16, which led to AgGDP contracting by 8.4 per cent, regarded as the worst performance in 20 years (IDC 2016). However, South Africa emerged from recession in the second quarter of 2017 (World Bank, 2017), leading to a GDP growth of 1.3 per cent in 2017 with agriculture, finance and mining contributing to this effect. Other domestic factors such as electricity shortages also contributed to poor growth performance in recent years.

Insufficient economic growth is pushing South Africa into a vicious circle, with insufficient tax revenue raising the risk of public debt distress, which has also played an important role in the downgrade of South Africa's sovereign credit rating in early 2017. This reduced investors' confidence for South Africa, where such investments would support the much-needed growth. South Africa is today much less productive than it was before the 2008 financial crisis. For instance, with the same amount of economic resources (i.e., natural resources, capital, and labour), South Africa produced 6 per cent less in 2016 than in 2007 (World Bank, 2017). A critical contributing factor to this deterioration is the insufficient innovation efforts. The drop in private R&D expenditures, which by some estimates is about 40 per cent lower than in 2009, suggests a growing innovation gap relative to other countries (World Bank, 2017). Hence, from a productivity standpoint, South Africa has fallen behind leading countries in technology.

3. Methods

The data used in this article were derived from ASTI (2018), a 1971–2014 data series based on data from the ASTI surveys, complemented by databases from the Centre for Science, Technology and Innovation Indicators (CeSTII) of the Human Sciences Research Council (HSRC), and Higher Education Management Information System (HEMIS) of the Department of Higher Education and Training (DHET). The ASTI data was collected and synthesised through collaboration between IFPRI, the University of Pretoria, and the ARC, which was initiated in 2000 and focussed on public sector agencies. These include government, public and private higher education agencies, and non-profit institutions but exclude the private-for-profit sector. Four survey rounds were implemented in South Africa with a fifth one currently ongoing. Survey data for the ARC institutes and central office were of high quality in all four survey rounds. The survey rounds during 2000–2002 and 2008–2010 were reasonable successful, generating sufficient institutional coverage to prepare detailed financial and researcher capacity indicators for South Africa for the 2000 to 2008 period. Unfortunately, the survey round that was implemented during 2011–2013, covering the years 2009 to 2011, was unsuccessful. Many agencies failed to return the survey forms, which led to the exclusion of South Africa in the series of country fact sheets. For the latest survey round that was completed in early 2017, covering the years 2012–2014, detailed survey data for the ARC were combined with detailed human resource data for higher education agencies from HEMIS and aggregated spending and researcher data for the other government and non-profit agencies and spending data for the higher education from CeSTII. The data collected from the ARC institutes, include:

(i) human resource numbers by degree, age, position, gender, discipline, and research focus;
(ii) spending per cost category;
(iii) funding sources; and
(iv) research outputs.

Human resource and financial data are calculated in full-time equivalents (FTEs) taking into account the proportion of time researchers spend on research and, therefore, excluding that spent on non-research activities. Financial data are adjusted for inflation and expressed in 2011 rand. For the comparisons with other countries, the financial data are presented in 2011 purchasing power parity (PPP) dollars. PPPs reflect the relative purchasing power of currencies more effectively than standard exchange rates because they compare prices of a broader range of local – as opposed to internationally traded goods and services. For further details on ASTI data collection procedures see www.asti.cgiar.org (the South Africa data can be downloaded from https://www.asti.cgiar.org/data?country=ZAF).

4. Results

This section presents the updated trends in agricultural research spending, research spending intensity ratios, analysis of research focus areas and trends in human capacity in public agricultural research in South Africa (largely based on data from the ARC).

4.1 South Africa's public agricultural research spending trends

South Africa's total public agricultural research spending almost doubled since the early 1970s, in inflation-adjusted prices, from an estimated R1.3 billion in 1971 to R1.9 billion in 2014 (both in 2011 prices) (Figure 1). Although spending on agricultural research increased on average by a moderate rate of 1.1 per cent per year, yearly spending levels varied considerably. After a period of slow growth during the 1980s and the 1990s, agricultural research spending began to decline in 1998 to R1.2 billion (in 2011 prices) in 2003. The reason was the shift in government contributions to the science councils from core funding dispensation to competitive parliamentary grants (Flaherty *et al.* 2010). Under the competitive system, the ARC experienced a severe cut in the parliamentary grant of 15 per cent in 1998–1999, in nominal prices. Although the magnitudes of the cuts declined in the following years, they continued until 2001–2002 (Liebenberg & Pardey, 2011). Thereafter, spending increased substantially from 2003 to 2005 and, again, from 2010 to 2013. The latter growth period was a combined result of the increased income generated by the ARC from implementing projects for the DRDLR and increased capacity of the higher education sector.

The trends in South African public agricultural research spending are highly influenced by ARC spending, which has accounted for more than 50 per cent of the country's total public agricultural R&D spending in 2014 (Figure 2). The ARC comprises 11 research institutes, seven of which focus on crop research, and two on livestock research, accounting for 42 per cent and 31 per cent of the ARC's total spending respectively during 2010–2014 (Table 1). The remaining two are the

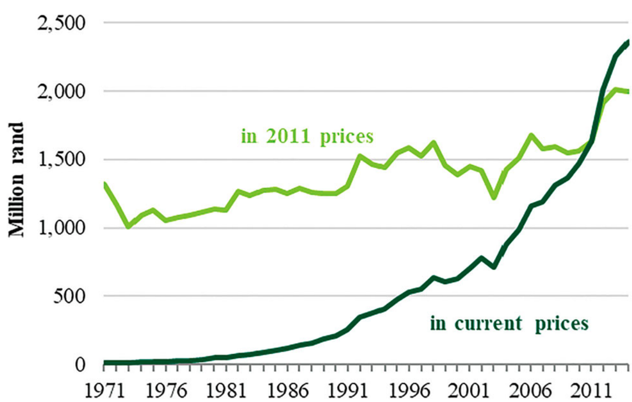

Figure 1. Public agricultural research spending in South Africa, 2014.
Source: Calculated by authors based on ASTI, 2018.

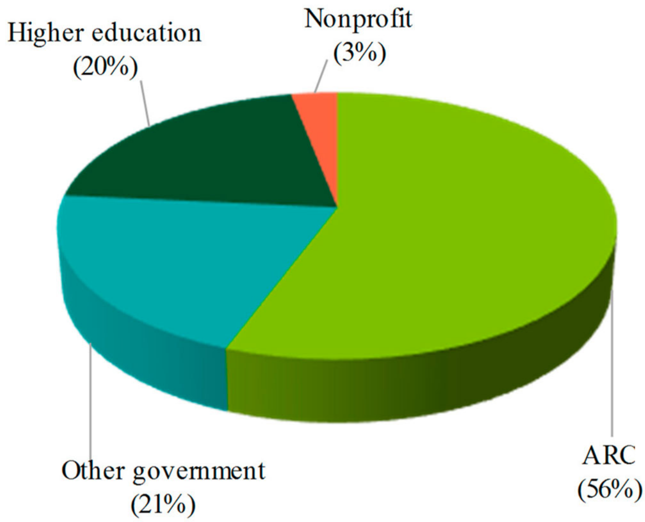

Figure 2. Public agricultural research spending by institutional category, 2010–2014.
Source: Calculated by authors based on ASTI, 2018.

Agricultural Engineering and the Soil, Climate and Water Institutes. Other business units are the Central Office (which is the Council's overall administrative function), and two recently established crosscutting structures in research: the Biotechnology Platform and the Agricultural Economics and Capacity Development (AECD) division.

A few other government agencies are also involved in agricultural research, accounting for 21 per cent of the country's total public agricultural research spending in 2014. The provincial departments of agriculture were established in 1994 following the merger of former agro-ecological agricultural

Table 1. Agricultural research spending by the ARC institutes, 1992–2014.

	Million constant 2011 rand (period averages)			Percentage shares (period averages)		
	1992–2000	2000–2010	2010–2014	1992–2000	2000–2010	2010–2014
Crops						
Grain Crops Institute (GCI)	84.4	66.3	54.1	8.1	6.9	5.5
Institute for Industrial Crops (IIC)	40.5	31.7	30.6	3.9	3.3	3.1
Small Grains Institute (SGI)	44.5	46.4	42.8	4.2	4.8	4.3
Institute for Tropical and Subtropical Crops (ITSC)	72.4	53.4	56.9	6.9	5.6	5.8
Infruitec-Nietvoorbij (INFR)	86.9	107.1	98.2	8.3	11.2	9.9
Vegetable and Ornamental Plant Institute (VOPI)	79.9	56.3	73.9	7.6	5.9	7.5
Plant Protection Research Institute (PPRI)	85.1	73.3	61.0	8.1	7.7	6.2
Subtotal	493.7	434.5	417.4	47.1	45.4	42.3
Animal Sciences						
Animal Production Institute (API)	188.1	169.3	157.1	18.0	17.7	15.9
Onderstepoort Veterinary Institute (OVI)	128.4	134.4	146.3	12.3	14.0	14.8
Subtotal	316.5	303.7	303.4	30.2	31.7	30.7
Other						
Institute for Soil Climate and Water (ISCW)	64.8	73.7	64.7	6.2	7.7	6.6
Institute for Agricultural Engineering (IAE)	26.4	27.1	21.0	2.5	2.8	2.1
Agricultural Economics and Capacity Development (AECD)	–	–	22.4	–	–	2.2
Biotech	–	–	18.2	–	–	1.8
Subtotal	91.2	100.8	108.1	8.7	10.5	10.9
Central Office	145.7	118.4	160.9	13.9	12.4	16.3
Total	**1047.1**	**957.4**	**987.8**	**100.0**	**100.0**	**100.0**

Note: 1992 reflects financial year 1992–1993, and so on.
Source: Calculated by authors based on ARC, various years.

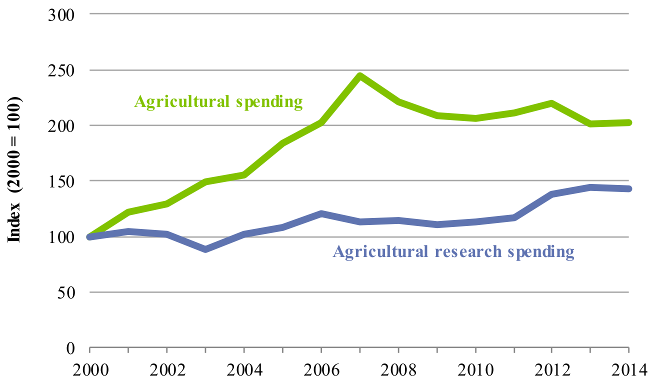

Figure 3. Public spending on agriculture and agricultural research, 2000–2014.

Note: Agricultural spending only includes funds derived from national governments; agricultural research spending includes funds derived from governments, donors, development banks, producer organizations, and revenues generated internally by research agencies.
Sources: Calculated by authors based on ASTI, 2018 and IFPRI, 2015.

development institutes and agricultural administrations of the former homeland and independent states. The research conducted by the provincial departments focus on issues in their respective provinces. Other government agencies involved in agriculture-related research are the research units under the Forestry and Natural Resources Management Branch and the Fisheries Management Branches of DAFF and the Council of Scientific and Industrial Research (CSIR), which conducts agricultural-related research in the areas of forestry, natural resources and biosciences.

Agricultural research capacity in the higher education sector has increased since the early 1990s and in 2014 the sector accounted for 20 per cent of the country's total agricultural research spending (Figure 2). The non-profit sector accounted for only 3 per cent of the country's total. Information on private sector spending on agricultural R&D is limited because many private companies are reluctant to share data on their financial and human resources. Kirsten *et al.* (2011) found that private companies increased their involvement in agricultural R&D from 2001 to 2008, mostly the result of an increase in partnerships with foreign multinational corporations.

Many African countries have increased their public-sector investments in agriculture as part of the 10 per cent commitment under CAADP. This has also been the case for South Africa, however, in inflation-adjusted terms spending levels have decreased somewhat since 2006 (Figure 3). Although spending on agricultural research increased during the same period, it fell behind that of government contributions to the agricultural sector as a whole.

Figure 4 shows that South Africa's total R&D spending, in inflation-adjusted terms, increased at a high rate from R7.7 billion in 2003 to R13.6 billion rand in 2014 (in 2011 prices). Agricultural research spending grew from R1.2 billion to R1.9 billion in the same time. Because spending in the non-agricultural research sectors grew stronger, the share of agriculture in total R&D spending declined slightly from 16 per cent in 2003 to 15 per cent in 2014. Liebenberg *et al.* (2011) also noted the growth in total R&D spending in the country between 1966 and 2006. The observed growth in total research spending could be attributed to South Africa's investment efforts in R&D through the establishment of the National System of Innovation (NSI); an enabling framework for science and technology, central to the country's prospects for continued economic growth and socio-economic development (HSRC, 2014). Through the NSI, the 1996 White Paper on Science and Technology, the 2002 National Research and Development Strategy, and the Ten-Year Innovation Plan for South Africa (2008–2018) were developed. These strategic frameworks guided the government in steadily increasing total funding for R&D over time.

The ARC's funding sources changed substantially between 1992 and 2014 (Figure 5). Whereas the parliamentary grant constituted more than 90 per cent of the organisation's source of funding in 1992, by 2014 the figure had declined to 68 per cent. From 2014 to 2016, the ARC experienced

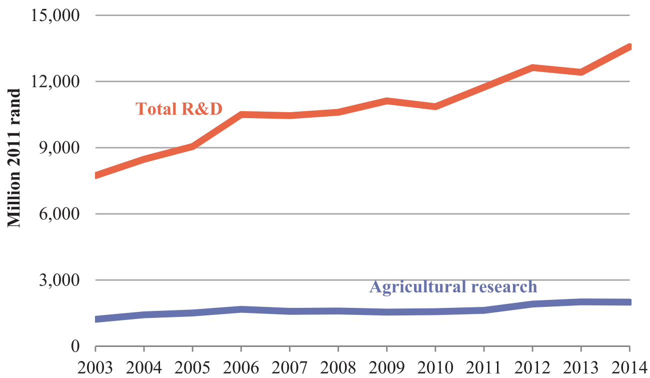

Figure 4. Total public R&D and public agricultural research spending, 2000–2014.
Sources: Calculated by authors based on ASTI, 2018 and OECD, 2018.

another period of severe cuts in the parliamentary grant (ARC, 2016). The share of income from research services has also been steadily declining since 2000, whereas other income (mainly external research funds) showed an upward trend in terms of contribution to total income since 2012. Analysis of the average sources of income for the different ARC institutes in 2014 shows some significant differences (Figure 6). As expected, the support business units such as Central Office and AECD were mainly funded through the parliamentary grant. The Biotechnology Platform derived most of income from research and advisory services and diagnostic services. Across the board, most of the organisation's business units derived most of their funding from the parliamentary grant. Liebenberg *et al.* (2011) noted the potential for crop related institutes to source a large share of non-core income from provision of research services. This trend generally continues, although the Biotechnology Platform seems to present new opportunities.

4.2 South African agricultural investment trends in a global context

At a regional level, considering countries of Africa south of the Sahara, South Africa's agricultural research spending trend appears quite level in comparison to the substantial increases in spending by Nigeria and Ghana (Figure 7). The latest available data as of 2014 indicated that South Africa ranks

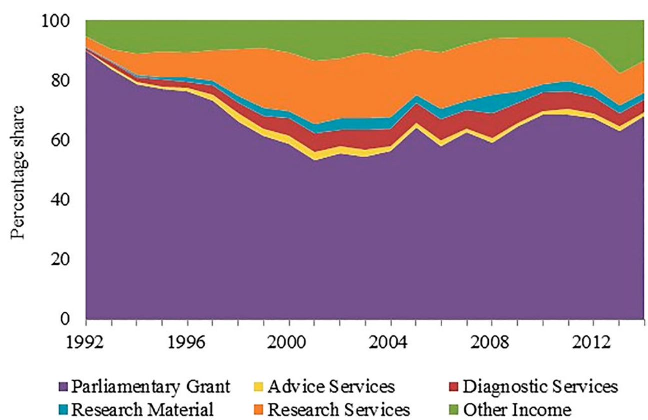

Figure 5. Share of income from the ARC funding sources 1992–2014.
Note: 1992 reflects financial year 1992–1993, and so on.
Source: Calculated by authors based on ARC, various years.

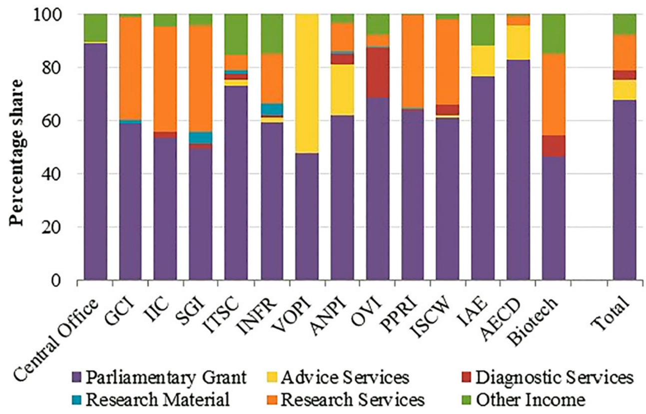

Figure 6. Average share of income sources for the ARC institutes 2014.
Source: Calculated by authors based on ARC, various years.

second in agricultural research investment in real terms after Nigeria, followed by Kenya and Ghana. These four countries accounted for more than half of all spending in the region. South Africa's research spending was significantly less volatile than that of the other countries in the region (Beintema & Stads 2017).

Despite faring considerably well on the African continent in terms of agricultural research spending, when compared with the other emerging economies of Brazil, Russia, China and India, South Africa's spending was considerably lower than the others as of 1981 (Figure 8). Brazil started the decade as the largest spender, but was quickly overtaken by exponential growth of China's agricultural R&D spending. Since 2009 China's agricultural research spending has become larger than even the United States of America (USA). India also began to outspend Brazil as of the 2000s. South Africa's spending from 1981 to 2014 appears practically level by comparison, whereas the other emerging economies witnessed varied levels of growth.

It is noteworthy to mention that following the 5th BRICS Science, Technology and Innovation (STI) Ministerial Meeting held in China in July 2017, the partner countries re-stated a commitment to jointly fund multilateral R&D projects. Agriculture is not explicitly stated as an area of cooperation in the STI Framework Programme, but falls within a number of thematic areas, which include prevention, and monitoring of natural disasters and water resources and pollution treatment. Whether South Africa will follow the trend of a substantial increase in agricultural R&D spending by other BRICS countries remains to be seen in the future.

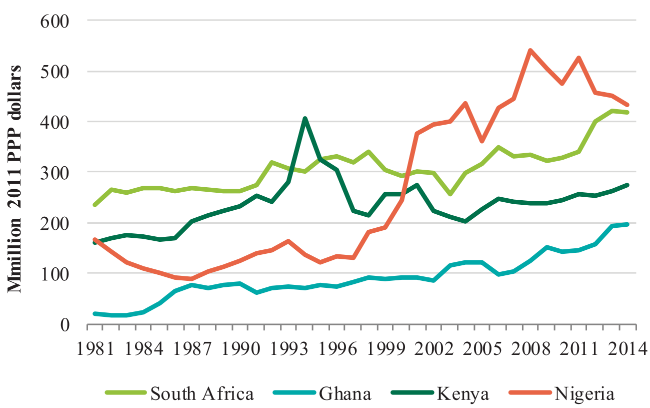

Figure 7. Agricultural research spending in Africa south of the Sahara, 1981–2014.
Source: Calculated by authors based on ASTI, 2018.

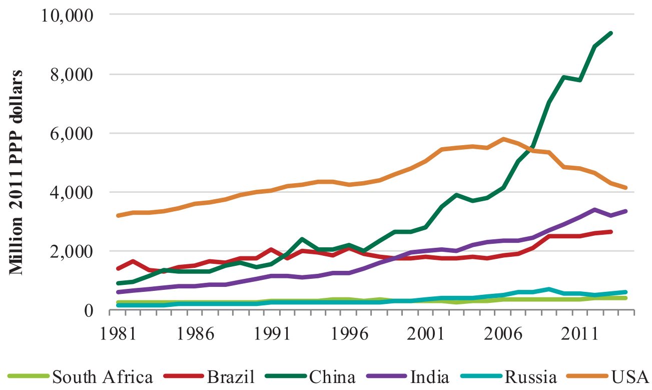

Figure 8. Agricultural research spending in selected countries, 1981–2014.

Note: 2014 data for Brazil and China were unavailable.
Sources: Calculated by authors based on ASTI, 2018, OECD, 2017, NBS and MOST, various years, and USDA-ERS, 2017.

4.3 Research spending intensity ratios

Total public spending as a percentage of AgGDP is a common research investment indicator that helps to place a country's agricultural R&D spending in an internationally comparable context. Agricultural research investment can be compared with levels of AgGDP, resulting in a measure of intensity. The United Nations and African Union recommend developing countries to spend at least 1 per cent of AgGDP on research; a level South Africa has consistently exceeded (Figure 9). Liebenberg *et al.* (2011) noted that since the 1970s the research intensity ratio relative to AgGDP has been higher than 1 per cent. The country's intensity ratio has also remained significantly higher than the average ratio of Africa south of the Sahara (0.46 in 2014). Furthermore, South Africa's intensity ratio is higher than the corresponding ratios of the other BRICS, but falls below the USA.

Liebenberg *et al.* (2011) estimated agricultural research and extension intensity ratios relative to farm value added, total population and total farm area for South Africa. The results showed that between 1910 and 1930 there was growth in all the intensity ratios, but from about 1990, the growth stalled. Although intensity ratios provide insights to relative levels of agricultural research investments across countries, they should be interpreted with caution, as they do not take into account contextual factors. In South Africa's case, the change in intensity ratio reflects considerable fluctuations in AgGDP as much as changes in investment levels. In addition, the ratios do not take into account policy and institutional environments surrounding agricultural research, the overall size and

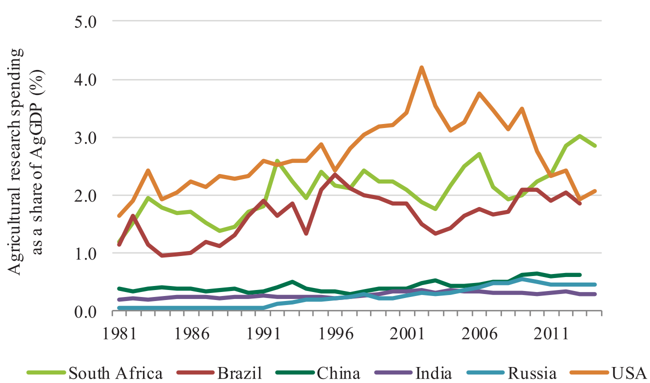

Figure 9. South Africa's agricultural research spending intensity compared with BRICS and USA, 1981–2014.
Sources: Calculated by authors based on ASTI, 2018, OECD, 2017, NBS and MOST, various years, USDA-ERS, 2017, and World Bank, 2018.

structure of the agricultural sector and economy or qualitative differences in research performance across countries (Beintema & Stads 2017). As more data becomes available, it will be necessary to estimate the research intensity ratio using weighted criteria such as the size of the economy, income levels and the state of technology and structure of the agricultural sector (Nin Pratt, 2016).

4.4 Researcher capacity

The quality of human resource capacity is critical in translating research investment into outputs. Scientists with a PhD qualification are generally more able to conceptualise, implement and manage research projects of a high standard. Over the years, there have been notable increases in human resource capacity of both the ARC and higher education institutions. Apart from conducting research, the ARC also funds postgraduate training of its own researchers, as well as other young aspiring scientists through its Professional Development Programme (ARC, 2016). The postgraduate training is done in collaboration with local universities and the Department of Science and Technology (DST), which provides some of the funding through the National Research Foundation (NRF).

Figures 10 and 11 show that the staff compliment of the ARC in terms of FTE researchers is much higher than that of all the higher education institutions put together. This observation holds for all

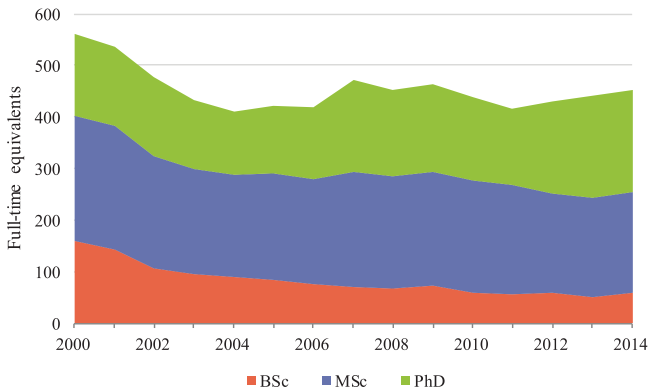

Figure 10. Staff qualifications of the ARC researchers, 2000–2014.

Notes: Full-time equivalent (FTE) measurements take into account the proportion of time that researchers spend on research activities. 2000 reflects financial year 2000–2001, and so on.
Sources: Calculated by authors based on ASTI, 2018.

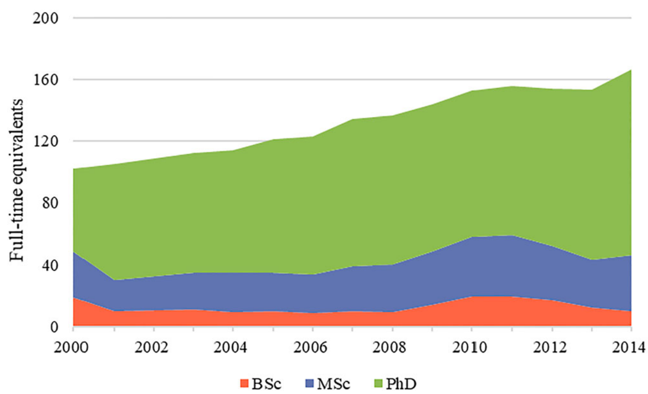

Figure 11. Staff qualifications of higher education institutions, researchers, 2000–2014.

Note: Full-time equivalent (FTE) measurements take into account the proportion of time that researchers spend on research activities.
Source: Calculated by authors based on ASTI, 2018.

qualification levels. What seems apparent is that the ARC is lagging behind higher education institutions in terms of growth for staff members with PhD degrees. This is a common trend across most countries in Africa south of the Sahara where government agencies and national agricultural research organisations employ a lower share of PhD-qualified staff than universities (Beintema & Stads, 2017). It is also possible that the ARC has been losing PhD-qualified staff to universities and other competing local and international organisations. Liebenberg *et al.* (2011) also observed by 2007 the decline in the number of researchers holding PhD degrees in the ARC, although at that time, the BSc-qualified researchers declined at a much faster rate.

5. Conclusion

This article aimed at providing an updated analysis of some of the investment trends in South African agricultural R&D, complementing the article published by Liebenberg *et al.* (2011). Due to challenges in data availability, particularly for higher education institutions and provincial departments of agriculture, this could only be done until 2014. After 2007, agricultural R&D spending in South Africa continued to experience mixed periods of decline and growth in real terms. Although agricultural R&D spending generally increased between 2003 and 2014, its share of spending in total public R&D declined in the same period. The ARC accounted for the greatest percentage in public agricultural R&D spending. The share of ARC funding derived from the parliamentary grant generally declined, although it still accounted for more than 50 per cent of total funding for most ARC institutes.

Despite the harsh economic environment, and lower than expected economic growth in South Africa since 2011, the government continues to play an important role in financing public agricultural R&D, providing the major source of funds for ARC. Apart from the parliamentary grant, additional sources of revenue from the line departments accessed through competitive grants and contract for research and advisory services contributed towards ARC funding. The ARC's 2015/2016 annual report (ARC, 2016) indicates that decline of the parliamentary grant funding to ARC, which in absolute terms translated to R233 million between 2014 and 2016, impacted performance of the organisation, including failure to invest in capital infrastructure. The annual report also noted the declining funding from commodity specific statutory levies. This is likely to decline even further, following an interdict filled by Grain SA stopping DAFF from allocating the entire wheat levy to the ARC (Grain SA, 2018). In the long term, the declining growth of spending on public agricultural R&D will likely affect the sector and the country as whole.

Agricultural R&D in South Africa and the ARC in particular needs to be better resourced to address contemporary challenges facing the sector. Given that the 2015/2016 drought affected the performance of the country's economy, failure to generate new technologies that mitigate the impacts of climate change will compound problems of the economy in the long term. Due to the lag in agricultural research, it is highly likely that effects of the reduction in investment in agricultural R&D will continue to be felt for some years to come. Based on the increasing share of income obtained from diagnostic and advisory services in the last few years, scope exists within the ARC to generate additional income. The biotechnology platform is research and service-driven for the development of agricultural biotechnology in the country, and its work includes application of advanced genomics, molecular breeding, and bioinformatics. Clients include ARC research programmes, the private sector, and other research agencies throughout Africa. Apart from the potential to generate further income for the organisation, opportunity exists for capacity development of skilled young researchers locally and for the African continent through the Biotechnology Platform.

Despite having a high intensity ratio of agricultural research spending, South Africa remains well below most of its BRICS partners in terms of spending on agricultural R&D in absolute terms. The BRICS platform presents an opportunity for the country to leverage funding for R&D, but priority must be placed on agriculture as a focus area of R&D partnerships. When compared with other countries in Africa south of the Sahara, South Africa has less volatile spending compared with other countries, and ranks second in terms of absolute figures for agricultural R&D spending in the region.

Comparisons of intensity ratios across countries, however, need to be considered in relation to other factors such as the size and structure of the agricultural sector in the country, and attainment of country specific goals such as food security, poverty alleviation and increased total factor productivity.

Liebenberg *et al.* (2011) raised some concerns regarding the stagnant research intensity ratio for South Africa and the loss of qualified scientists. It seems from the analysis of recent data that the trends have continued, particularly for the ARC in terms of human resource capacity. Although the ARC in recent years benefitted from additional funding secured from DST and DRDLR, it is not clear whether this will continue, given the land reform policy shift towards expropriation of land without compensation. Despite the renewed optimism following a change in leadership in the country in 2018, South Africa faces challenges such as funding higher education, reversing rating downgrades and reduced economic growth (Business Report, 2018) that could lead to reduced available funding for R&D in general, and more specifically for agricultural R&D. If not curtailed, reduced spending in agricultural R&D will in the long term impact other national imperatives such as food security, climate change adaptation and mitigation and rural development. The problems experienced in getting data for an up-to-date analysis of trends in R&D investment illustrate the importance of establishing a data hub through which such data can be collated, processed, stored and made available to other stakeholders. This was the late Dr Liebenberg's dream and should be pursued for facilitating such types of analysis in future, and for evaluating the returns to agricultural investment and tracking agricultural productivity in the country. This will not only aid decision making for investment in agricultural R&D, but will also contribute towards contemporary national debates such as land expropriation and financing models for higher education.

ORCID

Petronella Chaminuka http://orcid.org/0000-0001-8644-4611

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