# NATIONAL SURVEY ON R&D AND OTHER S&T-RELATED ACTIVITIES IN **AGRICULTURE** IN SOUTH AFRICA, 2010/11

**A report prepared by the Centre for Science, Technology and Innovation Indicators of behalf of the Department of Agriculture, Forestry and Fisheries**

HSRC Human Sciences Research Council
CeSTII Centre for Science, Technology & Innovation Indicators

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# ACRONYMS

| | |
|---|---|
| ARC | Agricultural Research Council |
| ASTI | Agricultural Science and Technology Indicators |
| CeSTII | Centre for Science, Technology and Innovation Indicators |
| DAFF | Department of Agriculture, Forestry and Fisheries |
| DST | Department of Science and Technology |
| FTE | Full-time Equivalent |
| GDP | Gross Domestic Product |
| IP | Intellectual Property |
| HSRC | Human Sciences Research Council |
| PDA | Provincial Department of Agriculture |
| R&D | Research and Experimental Development |
| S&T | Science and Technology |
| UN | United Nations |

# CONCEPTS AND DEFINITIONS

Concepts employed in this project are divided into "general definitions" and "indicator definitions":

**General definitions**

General definitions are provided for each concept, along with the source of the definition at the end (DAFF, CeSTII, the OECD Frascati manual, 2002, or the OECD/Eurostat Oslo manual, 2005).

**Agricultural extension agents:** People who are employed, either permanently or on contract, to extend access to products, services and technologies developed to progress agriculture. Extension agents include extension officers and researchers who perform an extension function but are based at research institutions, higher-education institutions and provincial departments of agriculture. Extension work may include some R&D (usually feedback R&D) but mostly involves applying proven technologies, methods and systems. Extension work bridges the gap between R&D and the application of new knowledge on farms. (DAFF)

**Agricultural research:** Research on crops, livestock, forestry, fisheries, natural resources and the socioeconomic aspects of primary agricultural production. Agricultural research also includes research on pre- and post-farm aspects such as input supply, post-harvest or food-processing research. Ideally, pre-, on- and post-farm research should be itemised separately to facilitate analysis, although the reality is that research at this level of detail is rare. (DAFF)

**Applied research:** Original research directed towards a specific practical aim. (Frascati manual, 2002)

**Basic research:** Experimental or theoretical research undertaken to understand underlying phenomena and observations without a particular application in mind. (Frascati manual, 2002)

**Development:** The application of research findings (or other scientific knowledge) to create new or significantly improved products, processes or services. Development aims to devise or develop an invention, design or computer programme of a scientific or technological nature. (DAFF)

**Experimental development:** Systematic work that draws on existing knowledge to produce or devise new or improved materials, products, devices, processes, systems or services. (Frascati manual, 2002)

**Extension work:** Refers to technology transfer of relevant industrial and agricultural processes and products to parties that apply them in practice (see "Technology transfer") and the provision of science and technology services that farmers cannot perform for themselves, for example, soil testing (see "Science and technology transfer").

**Full-time equivalent (FTE) employment:** Number of full-time employees that could have been employed if the reported number of hours worked by part-time and full-time employees had been worked by full-time employees exclusively. (DAFF)

The number of hours (person years of effort) spent on R&D activities. (CeSTII)

**Gross domestic product:** Sum of the value all producers add to an economic territory during an accounting period. (DAFF)

**Headcount:** The number of people ("physical persons" involved with R&D. (Frascati manual, 2002)

**Impact indicator:** A measure of the effect of a given outcome on society. Also measures general objectives in terms of national development and poverty reduction. (DAFF)

**Imputation:** A procedure for entering a value for a data item where the response is missing or unusable. (CeSTII)

**Indicator:** An instrument to objectively measure progress towards achieving a defined objective. (DAFF)

**In-house/intramural R&D:** R&D done by a unit or entity itself. This includes R&D done in South Africa but using foreign funding. (CeSTII)

**Innovation:** The implementation of a new or significantly improved product (goods or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations (Oslo Manual, 2005).

**Input indicator:** A measure of resources (for example, financial, administrative and regulatory inputs) used or applied, for example, the expenditure budget or employee hours. (DAFF)

**In-scope entities:** Entities that conduct in-house R&D. See also "Out-of-scope entities". (CeSTII)

**Non-response:** Failure to obtain measurements on one or more variable selected for the survey. These include out-of-scope entities (Sarndahl, Swensson and Wretman, 1992).

**New materials:** New materials include multi-functional materials, advanced materials, nanomaterials, nanocomposites and nanotechnology. (CeSTII)

**Outsourced R&D:** R&D done by an independent entity on behalf of, and paid for by, the reporting unit. (CeSTII)

**Outcome indicator:** A measure of results at beneficiary level. (DAFF)

**Other personnel directly supporting R&D:** Skilled and unskilled craftspeople, secretarial and clerical staff participating in, or directly associated with, R&D projects. (CeSTII)

**Out-of-scope entities:** Entities that have not been included in sampling because they did not conduct in-house R&D in the reference period (and so do not belong to the target population). (CeSTII)

**Output indicator:** A measure of immediate and concrete deliverables achieved using inputs. (DAFF)

**Process indicator:** A measure of the ways programme services and goods are provided. (DAFF)

**Process innovation:** The use of new or significantly improved methods for the production or supply of products and services (OECD/Eurostat, 2005).

**Product innovation:** The introduction to the market of a new product or service or a significantly improved product or service with respect to its capabilities, such as improved user-friendliness, components or subsystems (Oslo manual, 2005).

**Reference period:** The length of time for which data are collected. (CeSTII)

**Reporting unit:** A unit that supplies data for a given survey instance. (CeSTII)

**Researchers:** Professionals engaged in conceiving or creating new knowledge, products, processes, methods and systems, including planning and managing the research projects concerned.

**Research and development (R&D):** A term covering three activities: basic research, applied research and experimental development. (DAFF)

**Response:** Response was defined as entities that were not counted as non-response. (CeSTII)

**Science and technology (S&T) services:** Activities that support research and experimental development, and contribute to generating, disseminating or applying scientific and technical knowledge. These include patenting, geological surveys, standards generation, and the operation of libraries and national scientific databases (Department of Science and Technology, DST). S&T services in agriculture cover agricultural national public good assets, and analytical and diagnostic services. (DAFF)

**Sector:** Refers to agriculture, forestry and fisheries sectors. (DAFF)

**Technicians directly supporting R&D:** People doing technical tasks in support of R&D, normally under the direction or supervision of a researcher.

**Technology information dissemination tools:** Any tool that facilitates access to technology generated by research in the agricultural sector. It includes novel ways of delivering technology to farmers.

**Technology transfer:** Making available industrial and agricultural processes, products and enabling technologies to recipients for practical application. This can be done by, for instance, disclosing R&D results; licensing intellectual property rights for such results; education and training; information exchanges; or joint ventures. Technology transfer includes technology dissemination, extension and adaptive research. (DAFF)

**Vacancy rate:** The time taken to fill vacancies in R&D or S&T in publicly funded institutions in the sector. (DAFF)

**<u>Indicator definitions</u>**

These indicator definitions were derived from the DAFF draft document, *Tracking System for Public Investment in Research and Development*, and from discussions between CeSTII and the DAFF.
Availability of standard technological services that support public good assets
Comprises three independently computed indicators: the total number and description of available services, the number of new services developed, and the level of subsidies/funding for these services. Standard technological services include diagnostic and analytical services, advisory services, decision-support services and plant and animal health services, which are necessary to ensure that the research sector helps farmers identify disease, test samples, deal with outbreaks and take appropriate quarantine measures, as an example. Standard technological services can take the form of information repositories such as geo-referenced information systems, websites, biobanks, herbariums or laboratories.

**Government subscriptions to R&D donors:** The total donor subscriptions are the total number of subscriptions that national and provincial government pay to international R&D donor organisations. The projects implemented by donor-funded institutions describe the total benefits specifically accrued by Africa, Southern Africa and South Africa in terms of projects implemented.

**Number of new, innovative ways to address the human capital challenge:** The number of new and innovative mentorship, incentive and other programmes introduced to address the scarce skills gaps in the sector.

**Number of new research projects addressing agricultural productivity:** The number of new research projects whose key research areas address agricultural productivity.

**Number of new technologies/products implemented or adopted:** The number of new products released/commercialised/adopted within the category natural resource management.

**Number of research areas linked to strategic priorities:** The number of research areas linked to the DAFF's five national priorities, specifically, economic growth, job creation, rural development, sustainable use of natural resources and food security.

**Number of research projects completed that address production of specific commodities:** The total number of research projects that have an output of/impact on specific commodities. This includes a sub-indicator that assesses the number of new drought- or pest-resistant cultivars/breeds developed.

**Number of technology-transfer events conducted:** A measure of the total effort by researchers and extension officers to train and interact with farmers to ensure access to, and active participation in, agricultural R&D opportunities.

**Percentage increase in research infrastructure to support the sector:** This is calculated in relation to the baseline of total infrastructure in the sector. Research infrastructure includes infrastructure that supports research, technology development, technology transfer and services in the sector and includes equipment with a value equal to, or in excess of, R500 000 but excludes buildings, laboratories, renovations or building of new centres.

**Percentage increase in technology information dissemination tools:** A technology information dissemination tool is any instrument that facilitates access to technology generated by research in the agricultural sector. It includes novel ways of delivering technology to farmers.

**Percentage of famers benefiting from research:** The proportion of the total number of farmers who have tried or introduced a new research product or process innovation.

**Percentage of new products released/commercialised:** The proportion of the total number of agricultural products or services developed from basic research that have been commercialised and introduced to the market.

This indicator is divided into four sub-indicators: the number of new products and services released for the benefit of smallholding and commercial farmers, the number of trademarks registered, the number of patents registered and the number of intellectual property registrations, all of which are expressed as a percentage of the total number of new agricultural products and services developed through basic research.

**Proportion of technological services that comply with standards (in-house, accredited or other):** The proportion of standard technological services that operate within an international accreditation framework or other in-house standards framework.

**Ratio of farmers to extension agents (farmers: extension agents):** The proportion of farmers versus agricultural extension agents. (See also *Agricultural extension agent*)

**Response capacity:** The human capital, infrastructure and funding available to respond to farmers' queries in a timely, efficient and effective manner. The response capacity is a qualitative component that relates directly to the response rate.

**Response rate:** A measure of R&D's response to client needs for technology development and services. It is measured as the number of needs resolved versus queries received, i.e. how often is research able to solve the client's problem or need. The queries vary in scale, from a simple request for information to a request for help in developing a new drought-resistant cultivar. The only requirement is that the research is informed by the need of a farmer.

**Status and quality of infrastructure:** A qualitative indicator of the maintenance condition of infrastructure that supports research, technology development, technology transfer and services in the sector.

**Total agricultural scientists/researchers, engineers and technologists/technicians (agricultural research workers) employed in sector:** The sum total of the FTEs for agricultural researchers, technicians/technologists (agriculture technical research disciplines only) and engineers employed in the sector. The following is also calculated:

- the proportion of agricultural research workers who hold doctorate, master's or honour's/undergraduate degrees (or equivalent) in agriculture and non-agriculture-related degrees;
- the proportion of agricultural research workers who are women;
- the proportion of agricultural research workers who are over the age of 55.

**Total number of collaborative networks:** A measure of the extent of research collaboration between role-players in the sector.

**Total research scientific outputs per year:** The total number of research papers published in peer-reviewed journals, non-peer-reviewed journals, and books (including citations). Also includes the number of patents and royalties received.

**University and graduate enrolment:** The sum of doctorate, master's and honour's (or equivalent) enrolments at universities, and their corresponding demographics (the number of women researchers and researchers over the age of 55). The proportion of these variables, relative to the total number of enrolments, is also calculated.

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# EXECUTIVE SUMMARY

Agriculture plays a crucial role in South Africa's economic and social development. Not only did it contribute R58.6 billion[1] to the gross domestic product (GDP) in the 2010/11 fiscal year, it also provided employment to 624 000[2] and food security to millions of families.

However, the sector faces a number of challenges, including drought, adaptation to climate change and crop production to meet the need of the biofuel industries as well as for food security, biosecurity, *etc.* Although South Africa is considered to be food-secure on a national basis, rural communities are still vulnerable to food insecurity as a result of these and other concerns. Indeed, according to the national Department of Agriculture, Forestry and Fisheries (DAFF), in 2013 as many as 12 million people have insufficient access to food.

New farming techniques, technologies and products have the potential to ameliorate these risks and ensure greater productivity, which would, in turn, improve agriculture's contribution to the economy and minimise food insecurity, especially for the country's vulnerable rural communities. Well-managed, new technologies also have the potential to create more jobs, directly in agriculture and indirectly in supporting industries like food processing.

These new techniques often require months, if not years, of intensive research and development (R&D) by scientists and researchers who are highly skilled in fields ranging from soil science to animal genetics. This investment of time and skills makes research a costly exercise – one that needs to be carefully monitored to ensure that the country is investing enough, and in the right fields of study, to make a difference to agricultural production.

To this end, in 2009 the DAFF devised a system to track the level of investment in agricultural R&D and other scientific services, as well as the resulting outputs. The aim of this system is to monitor performance on human resources, investment levels, collaborations and partnerships, scientific outcomes and technology transfer in the agricultural sector over time. This information can then be used to determine appropriate investment levels in agricultural R&D, spotlight operational areas that may need development and ensure that agricultural R&D aligns with national priorities, specifically food security, reducing inequality, employment creation, and rural and economic development.

This report contains baseline measurements for the DAFF's tracking system. It provides a snapshot of agricultural R&D and other science activities during the year spanning 1 April 2010 to 31 March 2011 (2010/11). Since there are no historical or subsequent data available for comparison at this stage, this report is limited in its ability to comment on trends. Such in-depth analysis will require additional studies for subsequent years.

The survey also acted as a test-bed for the tracking system's indicators, providing an indication of how they can be expanded or refined in future.

[1] Based on Stats SA GDP Report, 3rd Quarter, 2011.
[2] Based on Stats SA Quarterly Labour Force Survey Report, 3rd Quarter, 2011.

# PART 1: INTRODUCTION

## 1.1 Scope of study and indicators

The survey was limited to agriculture as a key subsector of the greater economic sector that includes forestry and fisheries. The following institutions were surveyed:

- the DAFF;
- provincial agricultural departments;
- science councils;
- higher-education institutions;
- not-for-profit institutions.

Most of these institutions were engaged in agricultural R&D and scientific services, and extension work (the act of communicating and transferring these services to the end user – in this case, farmers) and are either state-managed or use public funding to conduct research and extension work. In total, units from one national government department, seven provincial government departments, eight science councils, 24 higher-education institutions and six not-for-profit institutions responded, for a total of 49 respondents (a 92.5 per cent response rate). Representatives from each of these institutions were interviewed in person and asked to complete a questionnaire formulated to gather information on the following indicator categories: human resources; investment levels; collaboration and strategic partnerships; scientific outcomes; and extension work.

## 1.2 Key findings

### 1.2.1 Human resources

Table 1: Key indicators for human resources in agricultural R&D and extension

| Key indicator | Value | |
|---|---|---|
| | R&D | Extension |
| Total full-time equivalents[1] for agricultural researchers | 781.7 | 45.8 |
| Total number of technicians/technologists | 613 | 149 |
| Total number of engineers | 50 | |
| Proportion with doctorates | 12.8% | 11.3% |
| Proportion with master's, honours, bachelor's or equivalent | 24% | 53% |
| Proportion of researchers over age 55 | 14.3% | 12.3% |
| Proportion of woman researchers over age 55 | 2% | 0.6% |
| Total number of vacancies and scarce-skill areas | 154 | |
| Number of vacancies filled in 2010/11 | 89 | |
| Average time (in years) taken to fill vacancies | 6.4 (>12 months) | |
| University enrolment: postdoctoral | 29 | |
| University enrolment: doctorate | 478 | |
| University graduates: doctorate | 58 | |
| University enrolment: master's | 944 | |
| University graduates: master's | 185 | |

The survey confirmed that agricultural R&D and extension work require highly skilled staff. Indeed, in 2010/11, a substantial proportion of them – 24 per cent of researchers and 53 per cent of extension workers – held at least a bachelor's degree. Presumably, given the large number of students and fellows still enrolled in university (no less than 478 doctorate candidates and 944 master's students), this will continue to be the case in future.

During 2010/11, there were substantially more male than female agricultural researchers for most age cohorts, indicating that some work may be needed to improve this indicator in future. The most concerning finding, however, was the significant drop-off in researchers and extension workers under the age of 30: among researchers, for example, there were 167 workers between the ages of 31 and 35 (the largest age cohort) but only 74 workers under the age of 30. The large population of students still in the human-resources pipeline may fill the future skills gap that this disproportion may create, but only if there is an understanding of why there was a decline in this age group in the first place.

Additional monitoring and careful management of the future skills pool is therefore recommended. Also worth noting was that only 57.8 per cent of jobs in scarce-skills areas were filled in 2010/11 and, on average, it took more than 12 months to fill vacancies. This, too, should be closely monitored and corrective action taken if this finding proves to be a trend.

### 1.2.2 Investment levels

Agricultural R&D expenditure by the surveyed entities amounted to R1.216 billion in 2010/11. Most of this – 42.9 per cent – was funded by the government, followed by science councils (36.2 per cent) and higher education (20.8 per cent).

Most expenditure – R733.5 million, or 60.3 per cent of total investment – went to labour, while only R179.9 million (14.8 per cent) went to capital expenditure, which includes maintenance of existing facilities.

The latter figure would have been substantially higher had facilities received their full maintenance-budget request of R159.2 million for the year. As it was, they received only R30.4 million – a significant under-expenditure that could hobble future R&D and extension work, should the condition of facilities, which was rated as being only slightly better than average during the period under review, deteriorate or become outdated due to insufficient maintenance and upgrading.

### 1.2.3 Collaborations and strategic partnerships

The number of linkages between various R&D-performing facilities is a measure of how well a sector leverages its R&D infrastructure and investment. The survey assessed the number of collaborations between the types of organisation surveyed (provincial government departments, national government departments, higher-education institutions, science councils and not-for-profit organisations) and potential partners (farmers, other universities, industry, state-owned enterprises, other provincial departments and other state entities), both local and international.

In general, most of the institutions collaborated primarily with farmers, and most of these collaborations were on technology transfer. Higher-education institutions and science councils reported the most collaborations (also primarily with farmers). Universities in particular had strong ties to international partners on R&D.

Provincial departments of agriculture had a substantial number of partnerships with higher-education institutions, industry, state-owned entities and other provincial agriculture departments.

The DAFF reported very few partnerships (19 in total), most of which were with higher-education institutions and farmers. This is to be expected, given that the role of a national department is primarily to provide guidance and strategic direction to provincial and local government. However, the fact that the DAFF only reported one partnership with a provincial department of agriculture is noteworthy. It would be informative to closely monitor this indicator in future surveys for possible intervention.

### 1.2.4 Scientific outcomes

Scientific outcomes refer to the results of basic research that were regarded as viable and of use to farmers during 2010/11.

Of the 246 new agricultural products developed, 121 (48.2 per cent) were regarded as viable and of benefit to farmers. Of this, a total of 85 products (33.9 per cent of all new products and processes) went on to be commercialised. Furthermore, of the 135 new processes developed, only 32 (23.7 per cent) were regarded as viable.

The viability of new agricultural products and processes should be closely monitored to determine whether these relatively low rates are a trend. If so, steps to further incorporate farmers' input during the R&D process may help increase the success rate.

Of the new technologies that were regarded as viable, the survey found that it was mostly smallholding farmers who implemented them. Further study is required to determine whether implementing them actually resulted in production benefits for farmers.

The survey found that a total of 208 new R&D projects addressing agricultural productivity – a key focus area for agriculture – were introduced in 2010/11.

### 1.2.5 Extension work

Extension work refers to the process of transferring new technologies to farmers and of responding to farmers' requests for agricultural R&D, technological services and information. Most of the queries received were for technology services (9 995 queries), followed by technology transfer (8 933 queries). There were relatively few requests from farmers for R&D (1 807 queries).
Overall, the rate at which these requests were successfully was high – 86.6 per cent.

Extension workers were asked to identify possible areas where tight resources may be affecting response performance. Constrained funding and staff numbers and insufficient training and skills were identified as the three areas most in need of additional resources in 2010/11. These indicators should be closely monitored in future surveys to determine whether these constraints are indeed a general trend. An audit of human-resource numbers and skills may be required to determine the optimal numbers of each to provide effective, sustainable R&D and extension work in agriculture.

Scientific research outputs in the form of articles, books and presentations are important tools for disseminating the results of R&D to farmers and other interested stakeholders. Local agricultural researchers were prolific in their output. They produced:

- 896 articles in journals;
- 112 academic books or chapters in books (including citations);
- 903 papers and posters for presentation conferences;
- 484 popular publications.

The majority of the above (65.8 per cent of all products) were peer-reviewed, and a substantial amount (34.2 per cent) was for an international audience, indicating that local research is well respected around the world. Extension work was mostly carried out in KwaZulu-Natal, the Western Cape and the Eastern Cape. Most extension work was done through personal interactions with farmers (through workshops, presentations, study groups and the like). The survey also showed that electronic communications through TV broadcasts, video presentations and SMS services are also being explored. This is promising since these technologies are often also available in remote rural areas, possibly extending the reach of extension workers. Future surveys may provide a clue as to whether these technologies are being fully utilised.

**Note:** Unless otherwise indicated, all data presented in tables and analyses are for the 2010/11 period and are limited to the agricultural sector.

## 1.3 Agricultural R&D and other S&T in South Africa

This report presents the results of the first national survey on R&D, S&T and related aspects such as infrastructure, technology transfer and extension work in agriculture in South Africa in 2010/11. This survey also serves as a pilot to:

- evaluate the indicators identified by the DAFF in its tracking system for public investment in R&D in the sector;
- provide baseline measurements for each indicator; and
- assess the tracking system toolkit's efficacy as a national survey.

The survey only covers the public sector and excludes forestry and fisheries, which also falls under the DAFF's mandate. These sectors will be covered in subsequent surveys.

This chapter provides a brief overview of the role of agriculture, agricultural R&D and other S&T activities in South Africa, and developments in the measurement of agricultural R&D/S&T indicators. It also provides a background to the survey and outlines the survey's aims, objectives and scope. Finally, it summarises how this report is structured.

### 1.3.1 The role of agriculture and agricultural R&D/S&T

Agriculture plays an important role in low-income countries, especially those in the Sub-Saharan Africa. It is the source of livelihood for 80 per cent of the population of Africa, while about 60 per cent of the economically active population gain employment in this sector (African Development Bank, 2010). Growth in agriculture therefore has the potential to improve food security, help develop rural areas and reduce poverty by creating employment.

South Africa's farming community consists of a well-developed commercial sector, smallholder farming and subsistence farming, which the rural community still depends on (Baiphethi and Jacobs, 2009). The country is regarded as nationally food secure but, according to several literature reports, rural communities are susceptible to food insecurities (Leroy et al, 2001; Drimie and McLachlan, 2013; De Cock et al, 2013; Altman et al, 2009). The DAFF's recent statement that 12 million people have insufficient access to food attests to this (DAFF, 2013).

Agricultural R&D in most low-income and developing countries is carried out by the government. It is imperative that other sectors – higher-education institutions, the private sector, not-for-profit and farmers' organisations – be supported in carrying out agricultural research, whether privately or publicly funded, without crowding out each other's efforts.

The DAFF is aware of the issues impeding production, development and growth in agriculture. In response, it has developed several strategies and policies that prioritise food security, inequality, unemployment and rural and economic development. The DAFF is also well aware of the importance of R&D in generating and adapting technological, sociological and economic innovations for use by farmers and others involved in the agriculture sector.

The setting of priorities should rely on credible information based on accurate, reliable and timely data. Agricultural R&D indicators are used to accurately describe specific, measurable characteristics of R&D in the country. They provide the government with the basis for reliable analysis that can be used to develop policies and interventions that will ensure performance and accountability.

### 1.3.2 Developments in measuring agricultural R&D (and other S&T) indicators

Internationally, attempts have been made to collect information on agricultural R&D and S&T indicators. Of particular interest is Agricultural Science and Technology Indicators (ASTI) programme, an initiative led by the International Food Policy Research Institute that gathers quantitative and qualitative data on investment, capacity and institutional trends in low- and middle-income countries. These countries are grouped into three regions, namely, Asia and the Pacific, West and North Africa, and Sub-Saharan Africa.

The ASTI survey instruments gather data on a range of relevant indicators, including research staff qualifications and training, investment trends (including sources of funding), and the full-time equivalent (FTE) for researchers working on enhancing the production of specific commodities – an important focus area given that the allocation of resources to different lines of research is a significant policy decision. According to ASTI' data, in 2008 South Africa spent R1 billion (or 272 purchasing power parity dollars, both in 2005 constant prices) on agricultural R&D and employed 784 FTE research staff, positioning it second after Nigeria in terms of agricultural R&D investment. By 2010, it had still not met its investment target of 3 per cent of agricultural GDP. Traditionally, most agricultural research is conducted by the Agricultural Research Council (ARC), which is still heavily funded by the government through fluctuating parliamentary grants. The council also sells goods and services, and receives support from producer organisations. Funding from sales has declined through the years, while donor contributions have increased.

In 2009, the DAFF, guided by the National Agricultural Research and Development Strategy (2008), launched a tracking system that uses a suite of indicators to monitor R&D (and other S&T activities) as part of an initiative to close information and developmental gaps within the sector. The tracking system describes indicators that are likely to inform strategies for the development of the sector.

## 1.4 About this survey

### 1.4.1 Background

The National Agricultural Research and Development Strategy was developed with the priorities outlined in the 2001 Agricultural Sector Plan in mind, that is, equity, enhanced natural-resource management and sustained competitiveness within the agricultural sector. The strategy identifies various challenges facing the sector, as well as key areas where baseline data (and tracking of subsequent variations) would contribute to understanding the sector's performance.

The strategy calls for stronger collaboration, together with improved efficiency, efficacy, transparency, accountability and participation in agricultural research. To this end, the DAFF is developing a national agricultural research agenda, drawing on input from a wide range of stakeholders, including the National Agricultural Research Forum.

R&D within the DAFF is guided by, among other plans, policies and strategies:

- the Forestry Research Strategy;
- the Integrated Growth and Development Plan;
- the DAFF's contributions to the government's outcomes;
- the National Aquaculture Strategic Framework for South Africa;
- the Marine Aquaculture Research and Technology Development Implementation Plan.

A tracking system has been developed to gather data on a suite of strategically identified indicators that reflects the performance of R&D/S&T, technology transfer and extension in agriculture, forestry and fisheries, taking into consideration relevant inputs (including investment and human resources), outputs and impacts. Each indicator has been defined and substantiated, and its assessment/calculation method, scope and data sources have been outlined.

This tracking system is an integral component of a results-based accountability system. As such, the indicators were developed taking cognisance of the government's strategic goals, the Medium Term Strategic Framework outcomes that form part of the DAFF's mandate, and the sector's defined targets. It will support decision-making processes when formulating policies by providing quantitative and qualitative data on the constraints and capabilities of R&D/S&T in the sector.
The tracking system requires regular data-sourcing to improve the availability and quality of information, and to build referral systems to streamline R&D efforts. To obtain baseline measurements for future tracking, the DAFF commissioned CeSTII to conduct a survey of R&D activities in agriculture. CeSTII designed a measuring instrument that captures the following:

- the level of collaboration between public agricultural research institutions;
- the level of coordination between public agricultural research institutions and industry/international research organisations;
- the level of funding required to ensure the viability of agricultural research systems.

This instrument will help with policy-making and assessing the impact of policies after implementation.

### 1.4.2 Objectives

This survey aims to:

- evaluate the indicators identified by the DAFF's tracking system;
- recommend database options to manage data for long-term analysis; and
- conduct a pilot survey to establish the effectiveness of the tracking system as a monitoring and evaluation tool.

### 1.4.3 Scope

The study is limited to public-sector and state-owned organisations that conduct agricultural research, innovation, development or transfer. It excludes private entities. CeSTII identified entities to be interviewed in collaboration with the DAFF.

### 1.4.4 Report structure

This report is organised as follows:

- **Part 1** (this section) provides an introduction to this document and to R&D/S&T in South Africa today. It also provides a background of research into R&D/S&T in agriculture in South Africa and internationally, and details the objectives and scope of this survey.
- **Part 2** presents the methodology used for the survey.
- **Part 3** presents the key findings, divided as follows:
    - Summary of key findings
    - Detailed results on human resources in agricultural R&D and extension
    - Detailed results on investments in agricultural R&D and extension, including infrastructure and facilities
    - Detailed results on collaborations and strategic partnerships
    - Detailed results on scientific outcomes of research and other S&T activities
    - Detailed results on technology transfer.
- **Part 4** concludes the report by presenting the general discussion and recommendations.

# PART 2: METHODOLOGY

## 2.1 Introduction

The design and conduct for this survey was guided by the 10 United Nations principles of international statistical activities (United Nations Statistical Division, 2013), which promote the production of statistics that are impartial and transparent. As far as possible, international concepts, classifications and methods have been used. Scientific principles and professional ethics have informed the methods and procedures for collecting, processing, storing and presenting statistical data.

Procedures that protect respondent confidentiality and minimise respondent burden were followed. Data was drawn from various sources, chosen to maximise quality, and minimise cost and respondent burden.

Statistical organisations collected data in a coordinated manner. Statistical agencies are entitled to comment on erroneous interpretation and misuse of statistics. They are to present information according to scientific standards on their sources, methods and procedures.

This survey presented certain methodological challenges, most notably:

- constructing a suitable representation of the units of interest;
- developing a survey instrument capable of producing the desired indicators that also integrates with local and international concepts of science, technology and innovation.

Establishing a network of contacts that could help extract data from respondents who had their own busy schedules also presented some operational challenges.

## 2.2 Key concepts

### 2.2.1 Reference period

The reference period for the survey was 1 April 2010 to 31 March 2011, or the nearest complete financial year of the reporting institute. (See "Concepts and definitions" for a definition of "reference period".)

### 2.2.2 Scope

The survey included the relevant units of all public-sector, state-owned and academic organisations that were likely to conduct agricultural R&D or extension activities, including science councils.

### 2.2.3 Register

The survey register (that is, all possible participants in the survey) was compiled from a comprehensive list of units that HSRC-CeSTII had identified using available information from the National Surveys of Research and Experimental Development survey series, and complemented by CeSTII and DAFF specialists.

### 2.2.4 Frame

A frame is a list, map or other specification that defines the population to be sampled. The frame should have enough information so that a unit in the sample may be located and taken up for inquiry.

The survey frame was established by examining the register for units that were likely to perform agricultural R&D/S&T. If a unit was not a likely R&D performer, it was assumed that it also did not conduct significant technology-transfer activities either.

The following auxiliary information was gathered through preliminary investigation or desktop research:

- sectors;
- contact details;
- status as being in- or out-of-scope.

## 2.3 Questionnaire design and piloting

The survey ran from December 2011 to January 2013. A questionnaire was designed based on the indicators that the DAFF required for its tracking system for public investment in R&D and HSRC-CeSTII's recommendations regarding practicalities and alignment with concepts in national R&D and innovation surveys in South Africa. The information requirements were amended so that the questionnaire could, as far as possible, be integrated with International Food Policy Research Institute questionnaires.

A pilot survey of 18 units was run to test survey procedures and evaluate the survey instrument. The data collected were processed and analysed to ensure relevance, but were not included in the final survey results. Based on the pilot survey, production systems were finalised, including the development of a survey database. This was done using purposive, consensus-based sampling that drew on the combined experience of HSRC-CeSTII and DAFF experts.

## 2.4 Data collection, capturing and processing

Fieldworkers were employed to collect data from the selected units. Experienced HSRC-CeSTII staff trained these workers in survey-collection techniques in science, technology and innovation before assigning them to the field. The strategy was to phone respondents to set up face-to-face interviews, with follow-ups to secure full response. Most respondents reacted favourably, although some units refused to participate despite attempts by HSRC-CeSTII agents to obtain their cooperation. Even intervention by the DAFF was not enough to secure a response from two higher-education institutions.

Non-response may be of two types: "unit non-response" and "item non-response". Unit non-response occurred when a unit failed to respond to the request for information. Unit non-response included out-of-scope entities, which are those units that should not have been included in the sampling frame because they did not belong to the target population in the reference period (Sarndahl, Swensson and Wretman, 1992). Item non-response was when the unit responded partially, resulting in incomplete responses for some questionnaire items. Incomplete responses necessitate imputation procedures (entering a data value where the response is missing or unusable). Good practice dictated that these potential sources of error were kept to a minimum.

"Response" was defined as entities that were not non-responsive.

Double-capturing and internal-consistency checks were used to endure valid results during data-capturing and -editing. Cross-checking against unpublished estimates obtained for use in the *National Survey of Research and Experimental Development* for 2010/11 ensured consistency with externally available statistics. All data and metadata will be kept on record, in line with HSRC institutional policy.

The compilation of data for statistics was done to represent, as closely as possible, the measurable features of the target population. This representation may be adversely affected by insufficient modelling of the true population during the frame-construction process, and by the number of completed responses received by fieldwork.

Table 1 presents the units selected for the survey from the register as being likely to be in-scope, as well as the survey response and imputation rates.

The survey covered the public sector which included government and quasi-governmental organisaions and the higher education sector. This included public enterprises and not-for-profit organisations that undertake R&D and/or extension activities Appendix B). The original list had 253 target units, of which 210 were in-scope (see. Due to changes in reporting arrangements[3], the total number of questionnaires expected back was 49, of which 37 responses were received (a 92.5 per cent response rate). No units were imputed.

Table 2: Survey size and responses by sector of performance

| Sector | Target entities | | Reporting units | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Number on register | Number in-scope | Number surveyed | Non-response | Out-of-scope | Responses | Questionnaire response rate (%) | Unit imputation rate (%) |
| Government | 56 | 36 | 8 | 2 | 1 | 6 | 85.7 | 0 |
| Science councils | 20 | 16 | 8 | 0 | 0 | 8 | 100 | 0 |
| Higher education | 161 | 149 | 27 | 6 | 4 | 21 | 91.3 | 0 |
| Other | 16 | 9 | 6 | 4 | 4 | 2 | 100 | 0 |
| **Total** | 253 | 210 | 49 | 12 | 9 | 37 | 92.5 | 0 |

A reporting unit is a unit that supplies the data for a given survey instance. The questionnaire response rate was calculated using the following formula:

$$\frac{\textbf{Response}}{\textbf{(Response + non-response) - (out-of-scope)}}$$

Imputation is a procedure for entering a value for a specific data item where the response is missing or unusable. The unit imputation rate was calculated using the following formula:

$$\frac{\textbf{Number of unit imputations}}{\textbf{(Response + non-response) - (out-of-scope)}}$$

Appendix B contains a detailed description of the methodology followed for each phase of the project.

[3] Some of the units preferred to collate data from all subunits into a single questionnaire

# PART 3: SURVEY FINDINGS

## 3.1 Summary of key findings

This chapter presents the survey's results in a way that facilitates evaluation of South Africa in 2010/11 in terms of the indicators in the tracking system for investments and performance in agricultural R&D and other S&T activities.

The tracking system was designed to manage and monitor the performance of investments while assessing the outputs and benefits of research and technology development in agriculture, forestry and fisheries. This document groups the information gathered by populating these indicators using data from the agriculture subsector into the following themes:

- human resources;
- investments;
- collaborations and strategic partnerships;
- scientific outcomes; and
- technology transfer.

### 3.1.1 Human resources

Table 3 summarises human resources data in agricultural R&D and extension. The total FTE for agricultural researchers was 781.7 for R&D and 45.8 for extension. The headcount stood at 3 726 for R&D and 345 for extension. Men were predominant in both groups. The total number of technicians/ technologists was 613 for R&D and 149 for extension. Fifty agricultural engineers were active. The total number of doctorate holders was 478 (12.8 per cent of total R&D personnel) for R&D and 39 (11.3 per cent of total extension personnel) for extension. However, the proportion with master's, honour's or bachelor's (or equivalent) degrees was lower for R&D (24.0 per cent of total R&D personnel) compared to extension (53.0 per cent of total extension personnel).

There was a large pool of students feeding into the human-resource pipeline, with 58 doctorate graduates, 185 master's graduates and 734 graduates with bachelor's/honour's (or equivalent) degrees. During the review period, there were an additional 478 doctorate enrolees and 944 master's enrolees (the Frascati Manual does not include undergraduate or master's enrolees, so this figure is not provided).

The proportion of researchers over the age of 55 years was 14.3 per cent for R&D (as a percentage of all R&D researchers) and 12.3 per cent for extension (as a percentage of all extension researchers). The number of women researchers over 55 years was 18 for R&D (2.0 per cent, expressed as a percentage of all R&D researchers) and 1 for extension agents (0.6 per cent, expressed as a percentage of all extension researchers).

The total number of vacancies in scarce-skills areas was 154 during the review period, of which 89 were filled during the year. On average, it took more than 12 months to fill vacancies.

Table 3: Key indicators for human resources in agricultural R&D and extension

| Key indicator | Value | |
|---|---|---|
| | R&D | Extension |
| Total FTE for agricultural researchers | 781.7 | 45.8 |
| Total number of technicians/technologists | 613 | 149 |
| Total number of engineers | 50 | |
| Proportion with doctorate | 12.8% | 11.3% |
| Proportion with master's, honour's, bachelor's or equivalent | 24.0 % | 53.0 % |
| Proportion of researchers over age 55 | 14.3% | 12.3% |
| Proportion of women researchers over age 55 | 2.0% | 0.6% |
| Total number of vacancies and scarce-skills areas | 154 | |
| Number of vacancies filled in 2010/11 | 89 | |
| Average time (in years) taken to fill vacancies | 6.4 (>12 months) | |
| University enrolment: postdoctoral | 29 | |
| University enrolment: doctorate | 478 | |
| University graduates: doctorate | 58 | |
| University enrolment: master's | 944 | |
| University graduates: master's | 185 | |
| University graduates: bachelor's/honour's (or equivalent) | 734 | |

## 3.1.2 Investments

Expenditure by public institutions for 2010/11 was R1.217 billion for agricultural R&D and R0.179 billion for extension. Expenditure on R&D represented only 0.074 per cent of the total value added, which is low considering the importance of the sector in the economy.

Table 4 provides the proportionate breakdown of sources of funding for R&D and extension in 2010/11. The figures indicate a higher proportion of contracts and grants from within South Africa for R&D, and a higher proportion of own funds used for extension.

Table 4: Key indicators for investments in R&D and extension

| Key indicator | | Value | |
|---|---|---|---|
| **R&D and extension** | | **R&D** | **Extension** |
| Total expenditure on agricultural R&D (public) (R 000 excluding VAT) | | 1 216 532 | 179 392 |
| Total value added at basic prices R'000 | | 1 646 664 000 | |
| R&D as percentage of total value added at basic prices | | 0.074% | 0.011% |
| ***Sources of funds*** | | | |
| | Own funds (R 000 excluding VAT) | 348 949 | 159 000 |
| | Contracts from within South Africa (R 000 excluding VAT) | 535 274 | 5 566 |
| | Grants from within South Africa ((R 000 excluding VAT) | 308 311 | 12 976 |
| | Contracts and grants from abroad (R 000 excluding VAT) | 23 998 | 1 850 |

[1] Data being sourced from the DAFF and Stats SA
[2] Third quarter 2011 Stats SA value (includes Forestry and Fisheries)

On the maintenance of infrastructure, the results indicated that 143 infrastructure and facilities were maintained and that, on average, the condition and quality of infrastructure were just better than moderate.

### 3.1.3 Collaborations and strategic partnerships

Table 5 shows that higher-education facilities' key collaborations were with farmers (53.8 per cent of higher-education facilities' collaborations), while provincial departments of agriculture mainly collaborated with state-owned entities (10.7 per cent of provincial departments' collaborations). Public-sector institutions involved in agricultural R&D and/or extension work mainly collaborated with farmers on technology transfer. Provincial departments of agriculture reported a moderate number of partnerships with each other, but only one reported having a partnership with the DAFF. International R&D partnerships were mainly with other universities.

Table 5: Proportion of key strategic partnerships in agricultural R&D and extension

| Key indicator | Per cent |
|---|---|
| Proportion of higher-education institution and farmer collaborations | 53.8 |
| Proportion of provincial departments of agriculture and state-owned entities collaborations | 10.7 |

### 3.1.4 Scientific outcomes

Table 6 sets out the key indicators for scientific outcomes of R&D and S&T. The total number of agricultural products developed was 246. Of these, 33.7 per cent were released or commercialised and 48.4 per cent were viable, benefiting smallholder and commercial farmers. A total of 135 agricultural processes were developed, 23.7 per cent of which were viable and in use.

Table 6: Key indicators for scientific outcomes of research and S&T in agriculture

| Key indicator | Value |
|---|---|
| Number of commercial famers benefiting from research[1] | 35 126 |
| Number of smallholding famers benefiting from research[1] | 104 856 |
| Number of farmers with income from on-farm activities[1] | 84 953 |
| Ratio of R&D personnel to farmers (number)[1] | 3 726 |
| Number of farmers who have tried/adopted new research product or process | 11 899 |
| Number of new products/processes implemented by farmers | 5 430 |
| Number of farmers who have tried/adopted new natural-resource management technique | 3 074 |
| Number of new research projects addressing agricultural productivity | 208 |
| Number of commercial farmers who benefited from new research projects addressing agricultural productivity | 26 285 |
| Number of smallholding farmers who benefited from new research projects addressing agricultural productivity | 72 272 |
| Number of new mentorship programmes | 203 |
| Number of new incentive programmes introduced | 10 |
| Number of new agricultural products developed | 246 |
| Percentage of new products released/commercialised | 33.7% |
| Percentage of viable products in use by smallholder and commercial farmers | 48.4% |
| Number of new agricultural processes developed | 135 |
| Percentage of viable agricultural processes in use by smallholder and commercial farmers | 23.7% |

[1] Data being sourced from the DAFF and Stats SA

### 3.1.5 Technology transfer

Table 7 indicates the rate of response to farmer queries, calculated as the total number of queries received (for R&D, technology transfer and extension services combined) divided by the number of needs resolved. This proportion was high, at 86.6 per cent.

Broken down by type of query, the response rates were as follows:

- 77.6 per cent of requests for R&D were resolved;
- 79.4 per cent of requests for technology transfer were resolved;
- 94.7 per cent of requests for extension services were resolved.

These figures indicate high to very high levels of response.

Locally, there were 917 publications in peer-reviewed journals/books and 794 publications in non-peer-reviewed journals/books. Internationally, a substantial 751 publications were published in peer-reviewed journals/books, while 92 publications appeared in non-peer-reviewed journals/books. New incubation models and decision-support tools for extension stood at 359, new information packs at 99 and new methods of transferring technologies to farmers at 796.

Table 7: Key indicators for technology transfer in agriculture

| Key indicator | Value |
|---|---|
| Response rate (needs resolved ÷ queries received) | 86.6% |
| Number of research publications in local peer-reviewed journals, books (including citations) | 917 |
| Number of research publications in local non-peer-reviewed journals, books (including citations) | 794 |
| Number of research publications in international peer-reviewed journals, books (including citations) | 751 |
| Number of research publications in international non-peer-reviewed journals, books (including citations) | 92 |
| New incubation models and decision-support tools (extension) | 359 |
| New information packs | 99 |
| New methods of transferring technologies to farmers | 796 |
| Number of farmer training sessions | 7 629 |
| Number of farm demonstration trials | 835 |
| Number of farmers trained | 20 234 |
| Extension officers trained on new technologies | 628 |
| Total number of available services | 247 280 |
| Number of new services undertaken | 114 |
| Level of subsidies/funding for services (total) (R 000) | 164 113 |
| Total internationally accredited services | 1 747 |
| Total nationally accredited services | 3 078 |
| Total in-house standards services | 2 083 |

## 3.2 Human resources

### 3.2.1 Introduction

Human resource is the most valuable R&D resource in South Africa. In a country facing many developmental challenges, advancement in S&T is crucial for building national resources, economic freedom and social development. South Africa, with the support of the government and business, has set a course towards building the continent's strongest knowledge economy. Agribusiness and agri-research require appropriately skilled, qualified and resourced research personnel to address the developmental hurdles the country is facing. This section documents the headcounts and FTEs of research and extension personnel within this sector, as well as the number of graduating students and the rate at which vacancies are filled in agricultural research.

### 3.2.2 Headcount and FTE

Highly qualified and competent human resources are necessary for R&D initiatives to succeed. It is no wonder that human resources for R&D accounts for a major portion of expenditure associated with S&T projects. The FTE for agricultural R&D in 2010/11 was 3 226.22, with a combined FTE (for R&D and extension) of 3 397.45. This implies that 95.0 % of human resources in this category work on R&D, while the remaining 5.0 % work on extension (Table 8).

## Table 8: Headcount and FTE of R&D and extension personnel in agriculture

| Personnel categories and highest qualification | Total R&D headcount | Total FTE for R&D | Total extension headcount | Total FTE for extension |
|---|---|---|---|---|
| **Researchers (including research executives and research managers)** | | | | |
| Doctorates | 470 | 326.94 | 38 | 7.9 |
| Master's/honour's/bachelor's or equivalent | 522 | 433.9 | 82 | 25.6 |
| Diplomas, senior certificate and other qualifications | 22 | 20.9 | 13 | 12.3 |
| **Researchers total** | 1 014 | 781.74 | 133 | 45.8 |
| **Technicians /technologists** | | | | |
| Doctorates | 6 | 5.5 | 1 | 1 |
| Master's/honour's/bachelor's or equivalent | 271 | 210.08 | 91 | 63.13 |
| Diplomas, senior certificate and other qualifications | 336 | 317.1 | 57 | 40.9 |
| **Technicians total** | 613 | 532.68 | 149 | 105.03 |
| **Other directly supporting personnel** | | | | |
| Doctorates | 2 | 1 | 0 | 0 |
| Master's/honour's/bachelor's or equivalent | 103 | 71.7 | 10 | 5.2 |
| Diplomas, senior certificate and other qualifications | 1 994 | 1 839.1 | 53 | 15.2 |
| **Other support total** | 2 099 | 1 911.8 | 63 | 20.4 |
| **Total human resources** | **3 726** | **3 226.22** | **345** | **171.23** |

Table 9 provides more detail about the human resources involved in agricultural R&D. The total researcher headcount was 3 726, of which 68.4 per cent were men and 31.6 per cent were women. Analysis by qualification and gender indicated that 12.8 per cent of R&D staff held doctorates, with twice as many male doctorate-holders as female doctorate-holders. The bulk of human resources held diplomas, senior certificates and/or other qualifications (63.1 per cent). Of this group, 74.8 per cent were men.

## Table 9: Headcount and FTE of R&D personnel in agriculture

| Highest qualification | R&D personnel headcount | | | FTE for R&D | | |
|---|---|---|---|---|---|---|
| | Men | Women | Total | Men | Women | Total |
| Doctorates | 322 | 156 | 478 | 221.21 | 112.23 | 333.44 |
| Master's/honour's/bachelor's (or equivalent) degrees | 468 | 428 | 896 | 363.8 | 351.88 | 715.68 |
| Diplomas, senior certificate and other qualifications | 1 759 | 593 | 2 352 | 1 635.1 | 542 | 2 177.1 |
| **Total** | 2 549 | 1 177 | 3 726 | 2 220.11 | 1 006.11 | 3 226.22 |

Table 10 shows that a considerably smaller cohort of S&T personnel was devoted primarily to extension work. This may be because, in most of the entities surveyed, the same R&D personnel members were also involved in extension work. Staff members who held doctorates accounted for 44.9 per cent of total extension staff, of which 23.9 per cent were women. The majority of extension staff held a higher qualification, with 71.4 per cent holding a master's degree or a doctorate, going up to 83.9 per cent (469 workers) when bachelor's or equivalent degrees were added. Of these, 30.7 per cent were women.

Table 10: Headcount of extension personnel in agriculture, by gender and highest qualification

| | | | |
|---|---|---|---|
| **Doctorate** | Men | 191 | **251** |
| | Women | 60 | |
| **Master's** | Men | 87 | **148** |
| | Women | 61 | |
| **Bachelor's** | Men | 47 | **70** |
| | Women | 23 | |
| **Diploma** | Men | 55 | **68** |
| | Women | 13 | |
| **Other** | Men | 12 | **22** |
| | Women | 10 | |
| **Total extension personnel** | | | **559** |

Agricultural engineers are trained engineers working in agricultural research. Table 11 shows that there were 50 agricultural engineers active within the sector, the majority of which (78.0 per cent) did not have a doctorate. However, of those that reported holding a doctorate, 55.0 per cent were women.

Table 11: Agricultural engineers, by qualification and gender

| **Agricultural engineers** | **Men** | **Women** |
|---|---|---|
| Doctoral | 5 | 6 |
| Non-doctoral | 22 | 17 |
| **Total** | **50** | |

Table 12 shows the age and gender profile of R&D personnel. Researchers between the ages of 31 and 35 are the largest age cohort, of which 53.3 per cent are men. Women between the ages of 51 and 55 reflect a majority of 80.3 per cent within researcher personnel while male technicians represent 56.0 per cent of R&D personnel. The age and gender profile illustrates a gradual increase in number from the age of 30 to 55, which decreases from 56 onwards. There is a general trend of more male than female personnel in all age cohorts.

Table 12: R&D personnel by age and gender*

| R&D personnel | Gender | Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <25 | 26–30 | 31–35 | 36–40 | 41–45 | 46–50 | 51–55 | 56–60 | 61–65 | >65 |
| Researchers | Male | 8 | 5 | 89 | 78 | 73 | 74 | 114 | 67 | 34 | 10 |
| | Female | 13 | 48 | 78 | 70 | 53 | 39 | 28 | 10 | 6 | 2 |
| Technicians | Male | 10 | 57 | 64 | 59 | 64 | 59 | 42 | 20 | 20 | 0 |
| | Female | 7 | 39 | 50 | 38 | 34 | 37 | 21 | 12 | 6 | 0 |
| Other | Male | 35 | 134 | 155 | 177 | 217 | 230 | 182 | 138 | 82 | 0 |
| | Female | 24 | 67 | 53 | 77 | 83 | 77 | 77 | 39 | 30 | 1 |

*Not all personnel age profiles are recorded above.

Table 13 groups the younger age cohorts to focus on the gender profile of personnel over the age of 55. There are not many women over the age of 55 working in agricultural R&D, possibly due to an historic gender bias in this sector, which is being addressed.

Table 13: R&D personnel by age and gender

| R&D personnel | Gender | 26–55 | | 56+ | % |
|---|---|---|---|---|---|
| Researchers | Male | 433 | 49.32% (of total | 111 | 12.64 (of total |
| | Female | 316 | 35.99% (of total | 18 | 2.05 (of total |
| Technicians | Male | 345 | 55.47% (of total technicians) | 40 | 6.43 (of total |
| | Female | 219 | 35.21% (of total technicians) | 18 | 2.89 (of total |
| Other | Male | 1 095 | 60.2% (of total "other") | 220 | 12.09 (of total "other") |
| | Female | 434 | 23.86% (of total "other") | 70 | 3.85 (of total "other") |
| | **Total** | **2 842** | | **477** | |

Extension refers to a range of activities that includes technology transfer and technology services. Technology transfer is the act of making available industrial and agricultural processes and products. Table 14 groups extension workers according to area of specialisation, qualification and gender. The figures indicate that 44.9 per cent of agricultural extension workers held doctorates, of which 76.0 per cent were men and 24.0 per cent were women. There were relatively few master's, honours and bachelor's degree-holders involved with agricultural extension work by comparison. This may have implications for extension work going forward: as older, more experienced personnel retire or leave the sector, there may be relatively few qualified experts available to replace them. There are also a greater number of men working in agricultural extension, with 70.1 per cent of all extension staff being male.

Table 14: Extension personnel by area of specialisation, gender and qualification

| Area of specialisation | Qualification and gender | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Doctorate | | Master's | | Bachelor's | | Diploma | | Other | |
| | Men | Women | Men | Wome | Men | Women | Men | Women | Men | Women |
| Crop genetic improvement | 89 | 1 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agronomic | 6 | 0 | 1 | 1 | 6 | 1 | 10 | 0 | 0 | 0 |
| Crop pests and diseases | 7 | 7 | 2 | 7 | 0 | 1 | 1 | 1 | 0 | 2 |
| Other crop-related | 1 | 4 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Animal genetic | 23 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Animal management | 4 | 0 | 18 | 0 | 1 | 0 | 19 | 2 | 1 | 0 |
| Pastures | 15 | 24 | 13 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Animal pest and disease | 3 | 0 | 3 | 3 | 1 | 2 | 0 | 0 | 0 | 1 |
| Other livestock | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Soil | 7 | 3 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Water | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other natural resources | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| On-farm storage | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| On-farm post-harvest | 5 | 5 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agricultural engineering | 1 | 0 | 5 | 3 | 0 | 0 | 6 | 0 | 0 | 0 |
| Food safety | 2 | 4 | 3 | 4 | 2 | 3 | 0 | 4 | 0 | 0 |
| Farming systems | 9 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 0 |
| Socioeconomics | 5 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Training | 3 | 7 | 4 | 6 | 3 | 3 | 0 | 4 | 0 | 1 |
| Other | 2 | 0 | 4 | 5 | 0 | 1 | 1 | 0 | 0 | 2 |
| Total | 191 | 60 | 82 | 55 | 16 | 13 | 39 | 11 | 1 | 6 |

The specialisation areas with the greatest number of extension workers are also the areas with the highest-qualified workers. Crop genetic improvement, animal genetics, pastures, crop pests and diseases, farming systems, soil, post-harvest and training account for 37.2 per cent of all extension workers (headcount) and 82.9 per cent of all doctorate holders involved in extension work.

### 3.2.3 Scarce skills

An advanced skills base is imperative to agriculture as only the most skilled scientists, researchers and technicians are able to deliver the outcomes required of agricultural science and technology projects. However, as in all sectors, some skills sets are considered scarce and are valued above others.

Table 15 identifies key areas where skills are scarce in agricultural S&T, the number of vacancies in these areas and the time taken to fill these vacancies.

Within these areas, 68.18 per cent of all vacancies in agricultural S&T were in the livestock, soil, crop-related, pastures, disease prevention and "other" areas of specialisation. There were 154 reported vacancies in 2010/11, of which, 89 vacancies were filled and 65 remained open, resulting in a scarce-skills employment rate of 57.8 per cent.

Table 15: Scarce-skills vacancies in agriculture

| Scarce-skills area | Number of vacancies | Number of vacancies filled | Average time taken to fill vacancies (months) |
|---|---|---|---|
| Crop genetic improvement | 9 | 6 | 14 |
| Agronomic | 9 | 8 | 20 |
| Crop pest and disease | 10 | 11 | 11 |
| Other crop-related | 14 | 0 | 0 |
| Animal genetic | 3 | 2 | 7 |
| Animal management | 3 | 1 | 3 |
| Pastures | 10 | 0 | 0 |
| Animal pest and disease | 5 | 3 | 4 |
| Other livestock | 24 | 24 | 2 |
| Soil | 17 | 4 | 10 |
| Water | 2 | 0 | 4 |
| Other natural resources | 2 | 0 | 0 |
| On-farm storage | 1 | 0 | 0 |
| Off-farm post-harvest | 3 | 2 | 2 |
| Agricultural engineering | 6 | 4 | 16 |
| Food safety | 1 | 1 | 4 |
| Farming systems | 1 | 6 | 2 |
| Socioeconomics | 15 | 7 | 9 |
| Training | 4 | 4 | 6 |
| Climate change | 0 | 0 | 0 |
| Other | 15 | 6 | 21 |
| **Total** | **154** | **89** | **6.4** |

The average time taken to fill scarce-skills posts was six months. However, some posts were harder to fill than others, taking as long as 21 months to be filled.

### 3.2.4 Mentorship and incentive programmes

Mentorship and incentive programmes are some of the ways the agricultural sector strives to address the gap in scarce skills. During 2010/11, 203 new mentorship programmes and 10 incentive programmes were put in place. Mentorship programmes are more readily available than incentive programmes. Creating more incentive programmes may be a good starting point for increasing the number of research projects, products and processes developed. This could, in turn, lead to commercialisation of products and processes developed.

### 3.2.5 Contribution and cost of postgraduate students and fellows

Graduates are a vital source of human resources in any sector and, as such, should be directed and nurtured. Table 16 shows the headcounts and FTE for various categories of postgraduate students and fellows.

An adequate number of students/fellows were enrolled at all levels of higher education. Of particular importance are the doctoral candidates and master's students, which together totalled 1 422 students, representing 44.7 per cent of all students in the sector. More encouraging was the large number of undergraduates studying agricultural sciences. Students with an honour's (or equivalent) and lower accounted for 1 731 (54.4 per cent) of the total 3 182 agricultural students recorded, addressing some concerns regarding the human-resource pipeline. The total cost of these students was R26.517 million, with most of that funding devoted to master's students, followed by doctoral candidates and post-doctoral fellows.

Table 16: Headcount, FTE and cost of undergraduate and postgraduate students and fellows

| Postgraduate categories | Headcount | | FTE | | Total value of salaries, stipends and bursaries |
|---|---|---|---|---|---|
| | Men | Women | Men | Women | |
| Post-doctoral fellows | 20 | 9 | 0 | 4 | **5 180** |
| Doctoral students | 277 | 201 | 148 | 23 | **9 621** |
| Master's students[1] | 469 | 475 | 207 | 214 | **10 506** |
| Honour's student | 498 | 487 | 270 | 242 | **1 210** |
| Diploma/certificates holders | 364 | 382 | 0 | 0 | **0** |
| **Total** | **1 628** | **1 554** | **625** | **483** | **26 517** |

[1] Only those with at least a 40 per cent research component in their master's degree.

### 3.2.6 Graduates entering workforce

Table 17 sets out the number of agricultural-sciences graduates entering the workforce in 2010/11. Of the 1 345 graduates, 749 (55.7 per cent) were men and 596 (44.3 per cent) were women. Most graduates (734 students, or 54.6 per cent) obtained bachelor's/honour's degrees. Fifty-eight doctorates and 368 diplomas (or equivalent) were awarded.

Table 17: Headcount of graduates

| Postgraduate categories | Number of students (headcount) | |
|---|---|---|
| | Men | Women |
| Doctorates | 35 | 23 |
| Master's degrees | 92 | 93 |
| Bachelor's/honour's (or equivalent) degrees | 450 | 284 |
| Diplomas/certificate-holders | 172 | 196 |
| **Total** | 749 | 596 |

## 3.2 Conclusion: Human resources

The majority of workers in agricultural R&D and extension work are aged between 31 and 55. There is a noticeable decline in numbers among younger age cohorts, which may present a human-resource challenge in future if not managed correctly.

The headcounts and FTEs indicate that a greater number of men are active in this sector than women, despite there being 156 female doctorate-holders active in the sector. More work is required to achieve gender equity in this sector.

In terms of scarce skills, there appears to be strong expertise in crop genetics, pasture animal and field management sciences, with many doctorate-holders devoted to these specific areas of specialisation. That said, only 89 of the 154 vacancies identified in scarce skills were filled in 2010/11.
Feeding the human-resources pipeline is a large number of agricultural S&T students and graduates. The total student headcount was 3 182, 51.2 per cent of which were men while 48.8 per cent were women. The number of graduates was 1 345, of which 44.3 per cent were women and the balance were men.

Agricultural S&T depends on an efficient, experienced and highly qualified workforce to manage projects and solve problems. The above findings indicate that the country is in a favourable position in relation to its human-resource needs in agricultural S&T.

These figures also act as a relatively good baseline indicator for human resources within this sector. Future research will indicate where progress has been made and in which areas further work is required.

## 3.3 Investment levels

### 3.3.1 Introduction

Agriculture plays a distinctive role in most developing and low-income countries. The contribution of agricultural production towards the GDP of some of these countries can be as high as 30 per cent. It is therefore imperative that these countries develop crucial new agricultural technologies to boost production. Investments in agricultural R&D and extension can result in particularly high pay-offs if properly managed and coordinated. In developing countries, these investments are often the responsibility of the government as either a performer or a funder of R&D, innovation and related activities. It also falls to these governments to ensure a high-quality regulatory framework to promote agricultural R&D and extension as well as innovation.

The role of, and the support required by, the higher education, business and not-for-profit sectors in agricultural R&D should not be underestimated. Besides creating an environment conducive to investment in agricultural R&D, governments in developing countries should ideally support these sectors directly through grants, contracts and procurements, and/or indirectly through tax credits, allowances and social-security contributions.

It is common practice in developing countries for expensive resources such as R&D equipment and other infrastructure to be shared by researchers and other users nationwide. It is therefore crucial that these infrastructure and facilities are sufficient, appropriate and well-maintained across all levels of the agricultural sector. These resources are necessary for cutting-edge research and extension work, the outcomes of which feed directly into production.

This section presents the levels of investment in R&D and extension in the country, including agricultural expenditure by area of specialisation, sources of funds, type of R&D, research fields, and province. Investments in infrastructure and facilities, the usage and maintenance of these resources and how they are shared by users are also reported. Data on R&D projects by national priority areas, including R&D into drought- and pest-resistant cultivars and breeds, conclude this section.

### 3.3.2 Expenditure on agricultural R&D and extension

Agricultural R&D expenditure amounted to R1.216 billion at current prices in 2010/11. This amounts to a contribution of 0.074 per cent of the total value added[4] at current prices. Of all the sectors surveyed, the government was the largest performer of agricultural R&D, spending 42.9 per cent of total agricultural R&D expenditure. This was followed by science councils, which spent 36.2 per cent. Higher education spent R253 million, or 20.8 per cent, of the R&D expenditure.

Most of the total agricultural R&D expenditure – 60.3 per cent – went to labour (Table 18). The total labour cost of postgraduate students comprised only 2.1 per cent of the total R&D expenditure. The lowest R&D expenditure was on capital goods, which amounted to 14.8 per cent.

[4] Total value added at basic prices, which amounted to R1 646 664 million in 2010 (Stats SA, 2010), plus taxes less subsidies on products amounts to GDP at market prices.

Table 18: In-house R&D expenditure

| Type of expenditure | R 000 | Per cent of total R&D expenditure |
|---|---|---|
| **CAPITAL EXPENDITURE** | **179 916** | **14.8** |
| Land: buildings and other structures | 105 817 | 8.7 |
| Vehicles, plant, machinery, equipment | 74 099 | 6.1 |
| **LABOUR COST EXPENDITURE** | **733 472** | **60.3** |
| Labour costs: R&D personnel | 708 157 | 58.2 |
| Labour costs: postgraduate students | 25 315 | 2.1 |
| **OTHER CURRENT EXPENDITURE** | **303 146** | **24.9** |
| *Other current | 303 146 | 24.9 |
| **TOTAL R&D EXPENDITURE** | **1 216 534** | **100.0** |

*Other includes expenditure on materials, water and electricity, payments for facilities and R&D services, maintenance and repairs, and consultant expenses carried out by the unit.

### *3.3.2.1 Capital expenditure on infrastructure facilities*

Respondents were asked to list their infrastructure and facilities, including their value, maintenance levels and usage. Responding institutions reported 143 new facilities during 2010/11. On a scale of 1 to 10 – where 1 was "very bad", 10 was "excellent" and 5 was "average" – an average of 5.2 was reported for the condition of all infrastructure and facilities (The condition was used as a proxy for measuring how good a facility or infrastructure was). An average of 4.9 out of 10 was reported for the quality of maintenance for reported facilities. The institutions further reported that a budget of R159.237 million was required to maintain these facilities, of which only 19.0 per cent (R30.411 million) was met.

Table 19: Number, condition, maintenance and capital expenditure on infrastructure/facilities

| Number of facilities[1] | Condition[1] (scale of 1 to 10) | Maintenance quality[1] (scale of 1 to 10) | Actual expenditure (R 000) | Required expenditure (R 000) |
|---|---|---|---|---|
| 143 | 5.2 | 4.9 | 30 411 | 159 237 |

[1] The original indicator required was "percentage increase in new infrastructure to support the sector". However, since this is a baseline study these details cannot be provided. Instead, the number of available research facilities, their condition and maintenance levels have been assessed.

### Use of infrastructure and facilities

Some organisations that host specialised facilities or infrastructure allow others to use their facilities for research and other purposes. Private companies, higher-education institutions and science councils were the main users of infrastructure hosted by other institutions.

Table 20: Shared infrastructure usage, by sector and purpose

| Sector | Number of organisations | R&D | Technology transfer | Technology services |
|---|---|---|---|---|
| Private companies | 9 | 7 | 5 | 2 |
| Higher education | 10 | 10 | 8 | 8 |
| Science councils | 5 | 5 | 1 | 2 |
| Other (schools, public) | 3 | 2 | 3 | 2 |

Table 20 above indicates that organisations often used the shared infrastructure for more than one purpose. Private companies and science councils tended to use shared facilities for R&D, while higher-education institutions were heavily involved with all three types of work (although R&D was still the primary use). By contrast, schools and the public, classified under "other", tended to use shared facilities for technology transfer rather than R&D or technology services.

#### *3.3.2.2 Expenditure by source of funds*

Local sources accounted for R1.192 billion (98.0 per cent) of total expenditure on agricultural R&D and extension. Most of this expenditure was through contracts (R535.3 million), with grants (R308.3 million) and own funds (R349.0 million) accounting for the rest. Contracts issued by government departments accounted for more than 57.3 per cent (R306.9 million) of local contract funding. The remaining contracts were divided between the private sector (17.2 per cent of total contract funding); higher education (15.1 per cent); science councils (6.7 per cent); not-for-profit organisations (3.3 per cent) and sources such as philanthropists and donations (0.4 per cent).

Government departments were also the largest grant-makers in agricultural R&D, contributing 67.2 per cent of the total funding from grants.

Funding generated from the sale of goods and services amounted to R 297.1 million while loans were relatively low, at R1.041 million.

Funding from abroad accounted for 2.0 per cent of total agriculture R&D expenditure. Most of this funds came from government funding agencies and not-for-profit organisations which contributed R9.825 million and R7.378 million respectively. Local agriculture R&D did not receive funding from foreign businesses and loans from development banks. Most funding for extension work came from organisations' own funds and amounted to R159 million (82.8 per cent of total expenditure on extension work). Other key sources were grants (6.8 per cent) and contracts (2.9 per cent).

Table 21: Sources of funds for agricultural R&D and extension

| Sources of funds | R&D expenditure (R 000, excluding VAT) | % of total R&D expenditure | Extension expenditure (R 000, excluding VAT) | % of total extension expenditure |
|---|---|---|---|---|
| **Own funds** | **348 951** | **28.7** | **159 000** | **82.8** |
| Sale of goods and services | 297 143 | 24.4 | 155 668 | **81.1** |
| Loans from development banks | 1 041 | 0.1 | 2 654 | **1.4** |
| Other | 50 767 | 4.2 | 678 | **0.4** |
| **Funding from within South Africa** | **843 584** | **69.3** | **18 542** | **9.7** |
| **Contracts** | **535 273** | **44.0** | **5 566** | **2.9** |
| Private enterprises (business) | 92 014 | 7.6 | - | **0.0** |
| Government departments | 306 862 | 25.2 | 4 427 | **2.3** |
| Science councils (including agencies) | 35 981 | 3.0 | 1 061 | **0.6** |
| Higher-education institutions | 80 730 | 6.6 | 78 | **0.0** |
| Not-for-profit organisations | 17 573 | 1.4 | - | **0.0** |
| Other[1] | 2 113 | 0.2 | - | **0.0** |
| **Grants** | **308 311** | **25.3** | **12 976** | **6.8** |
| Private enterprises (business) | 47 573 | 3.9 | - | **0.0** |
| Government departments (core funding) | 207 296 | 17.0 | 11 691 | **6.1** |
| Science councils | 7 916 | 0.7 | - | **0.0** |
| Government funding agencies | 21 546 | 1.8 | 285 | **0.1** |
| Higher-education institutions | 8 150 | 0.7 | - | **0.0** |
| Not-for-profit organisations | 7 145 | 0.6 | - | **0.0** |
| Other[1] | 8 685 | 0.7 | 1 000 | **0.5** |
| **Funding from abroad (contracts and grants)** | **23 997** | **2.0** | **14 450** | **7.5** |
| Private enterprises (business) | - | 0.0 | - | **0.0** |
| Venture capital | - | 0.0 | - | **0.0** |
| Loans from development banks | - | 0.0 | - | **0.0** |
| Government institutions | 1 128 | 0.1 | 6 900 | **3.6** |
| Government funding agencies | 9 825 | 0.8 | 5 000 | **2.6** |
| Higher-education institutions | 1 048 | 0.1 | - | **0.0** |
| Science institutions | 1 028 | 0.1 | 700 | **0.4** |
| Not-for-profit organisations | 7 378 | 0.6 | - | **0.0** |
| Other[1] | 3 590 | 0.3 | 1 850 | **1.0** |
| **Total** | **1 216 532** | **100.0** | **191 992** | **100.0** |

[1]Other includes private donations, philanthropists and foundations

### 3.3.2.3 *Expenditure by type of research*

Applied research accounted for 57.5 per cent of total expenditure on agricultural R&D, of which 27.1 per cent was performed by science councils. Basic research followed, at 28.3 per cent, and was mostly performed in government departments. Experimental development research was the least performed, at 14.2 per cent. This type of research was spread relatively evenly between the three sectors. (See "Concepts and definitions" for definitions of the different types of research.)

The *National Survey of Research and Experimental Development* has found a similar pattern of research activity over the years, with the business sector focusing research on experimental development while higher-education institutions mostly focus on basic research, and science councils and the government focus more on applied research.

Table 22: R&D expenditure by type of research

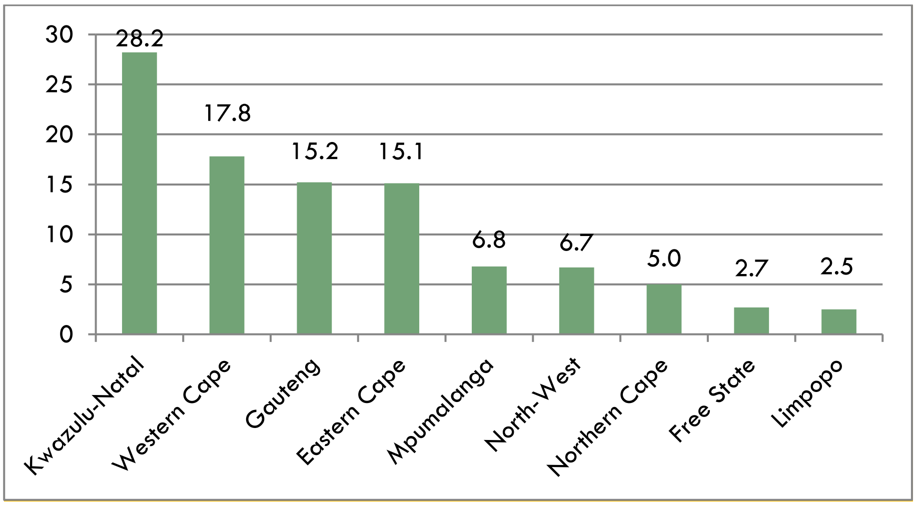
| Type of research | Expenditure (R 000) | Percentage of total R&D expenditure |
|---|---|---|
| **Basic research** | 344 085 | 28.3 |
| Government | 206 920 | 17.0 |
| Science councils | 57 608 | 4.7 |
| Higher-education institutions | 79 557 | 6.5 |
| **Applied research** | 700 034 | 57.5 |
| Government | 241 986 | 19.9 |
| Science councils | 330 066 | 27.1 |
| Higher-education institutions | 127 982 | 10.5 |
| **Experimental development** | 172 414 | 14.2 |
| Government | 73 128 | 6.0 |
| Science councils | 53 386 | 4.4 |
| Higher-education institutions | 45 900 | 3.8 |
| **Total** | **1 216 533** | **100.0** |

### *3.3.2.4 R&D expenditure by province*

R&D expenditure by province refers to the province in which R&D is performed; not where the source of funding for that R&D is from. For instance, a firm or institution based in Gauteng may undertake R&D in the Free State. The expenditure and personnel associated with that R&D will be counted under Free State province.

Agricultural R&D was mostly conducted in KwaZulu-Natal (Figure 1), attracting 28.2 per cent of total agricultural R&D expenditure. This was followed by the Western Cape (17.8 per cent), Gauteng (15.2 per cent) and the Eastern Cape (15.1 per cent). The provinces that had the least agricultural R&D conducted in their territories were the Northern Cape (5 per cent), Free State (2.7 per cent) and Limpopo (2.5 per cent). This differs from the *National Survey of Research and Experimental Development*, which has traditionally placed Gauteng as the main hub for general R&D performance, followed by the Western Cape and KwaZulu-Natal.

Figure 1: R&D expenditure by province (as per cent of national expenditure)



#### *3.3.2.5 R&D expenditure conducted by the provincial department of agriculture*

Table 23 shows the agricultural R&D expenditure for each provincial department of agriculture (PDA) in South Africa. The Eastern Cape spent R142 million in R&D, followed by KwaZulu-Natal (R89.0 million) and the Northern Cape (R33.6 million). Mpumalanga and the North West province had the lowest R&D expenditure, at R22.3 million and R21.9 million respectively. The provincial departments with no R&D expenditure noted had outsourced their R&D to other entities. The outsourced R&D is counted as in-house R&D by the R&D performing unit, not the funder and only if performed within South African borders.

Table 23: Agricultural expenditure by provincial agricultural departments

| Provincial agricultural department | In-house R&D expenditure (R 000) | Per cent of total expenditure |
|---|---|---|
| Eastern Cape | 142 826 | 34.9 |
| Free State[1] | – | – |
| Gauteng | No R&D | |
| KwaZulu-Natal | 89 038 | 21.8 |
| Limpopo[1] | – | – |
| Mpumalanga | 22 399 | 5.5 |
| Northern Cape | 33 619 | 8.2 |
| North West | 21 998 | 5.4 |
| Western Cape | 99 320 | 24.3 |
| **Total** | **409 200** | **100.0** |

[1] Entity did not respond to survey.

#### *3.3.2.6 R&D expenditure by research field*

The majority of R&D expenditure in the agriculture, forestry and fisheries sector – 86.2 per cent – went to agricultural sciences. Crop and pasture production was the main contributor to the sector (26.3 per cent of total R&D expenditure), animal production (16.5 per cent) and horticulture (13.9 per cent). Expenditure into research on engineering, biological sciences and environmental sciences had relatively similar, but also far lower expenditure.

Table 24: Agricultural R&D expenditure by research field

| Category | Subcategory | RF codes[1] | Percentage of total expenditure |
|---|---|---|---|
| **Earth sciences** | | | |
| | Earth sciences | **RF 10401** | 1.3 |
| **Engineering sciences** | | | |
| | Engineering sciences | **RF 10706** | 3.6 |
| **Biological sciences** | | | |
| | Biological sciences | **RF 10801** | 4.1 |
| **Agricultural sciences** | | | |
| **86.2% of total expenditure** | Soil and water sciences | **RF 109011** | 8.2 |
| | Crop and pasture production (including rice) | **RF 109021** | 26.3 |
| | Horticulture (including plantation and fruit crops) | **RF 109031** | 13.9 |
| | Animal production | **RF 109041** | 16.5 |
| | Veterinary sciences | **RF 109051** | 11.3 |
| | Forestry sciences | **RF 10906** | 2.1 |
| | Food and nutrition development | **RF 10907** | 4.1 |
| | Plant physiology | **RF 10908** | 0.2 |
| | Agricultural economics | **RF 10909** | 3.6 |
| **Environmental sciences** | | | |
| | Environmental sciences | **RF 11101** | 2.9 |
| **Fishery sciences** | | | |
| | Fishery sciences | **RF 11301** | 1.1 |

[1] See appendix for explanation of RF codes and the codes table.

#### *3.3.2.7 Agricultural R&D by national priority area*

The National Agricultural Research and Development Strategy emphasises those research areas and specialisations relevant to the core priorities of the government and the sector (economic growth, job creation, rural development, sustainable use of natural resources and food security). Of the 3 191 projects undertaken in the agricultural sector in 2010/11, 1 653 projects were in animal management and were evenly distributed across the five national priority areas. This was followed by agronomic research (223 projects) and crop genetic improvement (175 projects). Agricultural engineering (nine projects) bio-nanotechnology (eight projects) and agro-energy (five projects), had the fewest. Mapping the developmental components of these projects to the government's priorities indicate that agricultural R&D projects primarily contributed to economic growth (773 projects), food security (754 projects) and the sustainability of natural resources (696 projects). While they did contribute somewhat to rural development and job creation, these components were rarely a primary aim, with only 574 projects contributing to rural development and 394 projects adding to job creation.

Table 25: Agricultural R&D projects by specialisation field and national priorities

| Area of specialisation | Specialisation area total | National priorities | | | | |
|---|---|---|---|---|---|---|
| | | Economic growth | Job creation | Rural development | Sustainable use of natural resources | Food security |
| Crop genetic improvement | 175 | 76 | 5 | 32 | 29 | 33 |
| Agronomic | 223 | 77 | 2 | 29 | 48 | 67 |
| Crop pest and disease | 77 | 75 | 0 | 0 | 2 | 0 |
| Other crop-related[1] | 55 | 19 | 4 | 4 | 7 | 21 |
| Animal genetic | 66 | 22 | 7 | 12 | 11 | 14 |
| Animal management | 1 653 | 311 | 305 | 338 | 377 | 322 |
| Pastures | 70 | 21 | 0 | 9 | 17 | 23 |
| Animal pest and disease | 39 | 6 | 1 | 11 | 3 | 18 |
| Other livestock[2] | 53 | 8 | 0 | 9 | 10 | 26 |
| Soil | 65 | 12 | 1 | 4 | 22 | 26 |
| Water | 53 | 1 | 4 | 5 | 28 | 15 |
| Other natural resources[3] | 15 | 1 | 1 | 1 | 11 | 1 |
| On-farm storage | 14 | 11 | 1 | 1 | 1 | 0 |
| On-farm post-harvest | 52 | 25 | 9 | 3 | 9 | 6 |
| Agricultural engineering | 9 | 0 | 1 | 1 | 6 | 1 |
| Food safety | 56 | 4 | 1 | 8 | 5 | 38 |
| Farming systems | 48 | 9 | 3 | 14 | 10 | 12 |
| Socioeconomics | 24 | 3 | 1 | 9 | 4 | 7 |
| Training | 175 | 25 | 34 | 42 | 17 | 57 |
| Other[4] | 11 | 1 | 1 | 1 | 4 | 4 |
| Biotechnology | 65 | 39 | 0 | 1 | 14 | 11 |
| Agro-energy | 5 | 1 | 0 | 1 | 2 | 1 |
| Bio-nanotechnology | 8 | 1 | 0 | 1 | 5 | 1 |
| Climate change | 39 | 3 | 3 | 4 | 21 | 8 |
| Water resources | 14 | 1 | 1 | 4 | 5 | 3 |
| Precision agriculture | 20 | 2 | 1 | 4 | 9 | 4 |
| Indigenous crops | 56 | 6 | 6 | 16 | 15 | 13 |
| Market development | 15 | 3 | 2 | 7 | 0 | 3 |
| Other[5] | 36 | 10 | 0 | 3 | 4 | 19 |
| **National priorities total** | **3 191** | **773** | **394** | **574** | **696** | **754** |

[1] Other crop-related specialisations: horticulture, biochemistry, forage breeding and modern biotechnology.
[2] Other livestock: wildlife, milk quality, cattle/dairy, animal fertility.
[3] Other natural resources: geography.
[4] Any other: market development and conservation agriculture.
[5] Emerging critical themes: horticulture.

### *3.3.2.8 Projects addressing production of specific commodities*

A total of 635 projects addressed the production of specific commodities. Together, these projects produced 418 new drought- and pest-resistant breeds and cultivars. Most of the research was on cereals (160 projects) and animals (133 projects). Animal research had a higher success rate, however, producing 132 drought-resistant breeds compared to the 53 drought-resistant cereal cultivars produced.

Table 26: Number of drought resistant cultivars and pest resistant breeds

| Commodity | Number of projects | Number of drought cultivars/breeds | Number of pest-resistant cultivars/breeds |
|---|---|---|---|
| Cereals | 160 | 53 | 12 |
| Roots and tubers | 35 | 8 | 13 |
| Pulses | 38 | 8 | 9 |
| Oil-bearing crops | 29 | 8 | 5 |
| Horticulture | 27 | 6 | 7 |
| Nuts | 27 | 14 | 12 |
| Other crops | 113 | 37 | 44 |
| Animals | 133 | 132 | 22 |
| Pastures and forages | 30 | 7 | 6 |
| Off-farm post-harvest | 4 | 4 | 0 |
| Non-commodity categories | 39 | 7 | 4 |
| **TOTAL** | **635** | **284** | **134** |

### 3.3.3 Conclusion: Investment levels

Investment into R&D in the agriculture, forestry and fisheries sector amounted to R1.216 billion in 2010/11. This amounts to a contribution of 0.074 per cent of the total value added.

The agriculture, forestry and fishing sector's contribution to the economy is low. The agriculture, forestry and fishing sector contributed 2.5 per cent to the total value added in 2010/11. This is low compared to other sectors such as finance, real estate and business services (23.5 per cent), manufacturing (17.2 per cent) and the wholesale, retail, motor trade and accommodation (13.7 per cent). Increasing investments in agricultural R&D is essential not only for the agriculture sector, but for the economy as well.

Expenditure on R&D infrastructure was also low. Maintenance of infrastructure and facilities was reported as just above average – 5.2 on a scale of 1 (bad) to 10 (excellent). The approved budget for such maintenance provided only 19 per cent of the required funds.

Other users use existing agricultural facilities and infrastructure, albeit infrequently. Timeline series data and case studies would be needed to determine exactly why usage is so low, although lack of awareness about these resources and their limited/inappropriate functionality are two possible reasons. Low maintenance expenditure may also lead to deterioration or obsolescence of infrastructure, exacerbating the situation.

Insufficient infrastructure and lack of funding have often been cited as impediments to R&D and innovation, which are particularly important in the agricultural sector, which relies heavily on up-to-date and well-maintained infrastructure for output. It is therefore advisable to increase funding for establishing and maintaining infrastructure for agricultural R&D and other S&T activities.

Of the R1.216 billion investment, 98.0 per cent came from local sources, primarily through government contracts and grants. Foreign investment accounted for only 2.1 per cent of agricultural R&D expenditure. This could perhaps be improved by strengthening collaboration between local and international agricultural researchers.

The survey was limited to research conducted by public and related organisations like universities and excluded the business sector. However, the national research and development survey indicated that the business sector's contribution to agricultural R&D is not substantial. Nevertheless, future surveys should aim to capture the private sector's role in agricultural R&D and extension too.

The *National Survey of Research and Experimental Development* has, over the years, shown Gauteng and the Western Cape to be the country's top-performing provinces in terms of conducting general R&D. However, when it comes to agricultural R&D, other provinces such as KwaZulu-Natal are more prominent. Regional agricultural R&D and innovation policies and strategies should therefore be strengthened to ensure R&D performance and the uptake of resulting technologies.

Of the 3 191 agricultural research projects, only 12.3 per cent addressed job creation. Their focus was mainly on economic growth, food security and sustainable natural resources. The findings regarding national priority areas have been both positive and negative: while most projects are in line with the government and the DAFF's key national priorities, research on projects that promote job creation and rural development need more support to bring these areas in line with other priorities.

## 3.4 Collaborations and strategic partnerships

### 3.4.1 Introduction

One of the goals of the National Agricultural Research and Development Strategy is to promote collaboration between National Agricultural Research System components and regional and international research institutions to refocus on the government's strategic priorities, innovation and adaptive research.

The number and quality of linkages between various R&D-performing facilities are a measure of how well a sector leverages its R&D and innovation infrastructure. This section presents the results of the 2010/11 survey with respect to the number of collaborative partnerships between:

- any two of the following types of role-players: farmers, higher-education institutions, industry, state-owned enterprises, provincial and other government departments;
- national and international partners, by type of partner and area of specialisation (R&D, technology transfer, technology services, innovation or other).

### 3.4.2 Collaboration in South Africa

The tracking system required data for the following indicators:

- collaborations between industry and basic researchers as a percentage of all industry collaborations;
- collaborations between farmers and higher-education institutions as a percentage of all farmer collaborations;
- collaborations between farmers and industry as a percentage of all farmer collaborations;
- collaborations between state-owned entities and provincial departments of agriculture as a percentage of all state-owned entity collaborations.

Either data for these indicators were not sourced because the intended party/sector was not included in the pilot phase of the survey (which did not interview farmers, industry or state-owned enterprises), or the intended partner was interviewed instead (higher-education institutions and provincial departments of agriculture). In the latter case, the proportion of collaborations between the partner and the role-player was computed instead. For instance, instead of finding the collaborations between farmers and higher-education institutions as a percentage of all farmer collaborations, the relationship was assessed as a percentage of all higher-institution collaborations. Similarly, collaborations between provincial departments of agriculture and state-owned entities were represented as a proportion of all provincial-department collaborations (Table 27).

Of the 450 collaborative partnerships higher-education institutions reported, 53.8 per cent were with famers. Of the 169 collaborations provincial departments of agriculture had, 10.7 per cent were with state-owned enterprises.

In general, all responding institutions collaborated more with farmers than any other type of partner. Science councils and higher-education institutions had the highest total number of collaborative partners, the majority of which were farmers for both types of institutions. These collaborations were mainly on technology services and technology transfer. Science councils and higher-education institutions both had a substantial number of university and industry partners. These collaborations were mostly on research and development (R&D), and innovations. Higher-education institutions also had a considerable number of collaborations with state-owned entities and provincial departments of agriculture, the majority of which were on R&D and technology transfer.

Provincial departments of agriculture had a substantial number of partnerships with higher-education institutions (mainly on R&D, technology services and innovations), industry (mostly on R&D, technology transfer and technology services), state-owned entities (predominantly on R&D and innovations), and provincial departments of agriculture (largely on R&D and technology transfer), and a moderate number of partnerships with state-owned enterprises (primarily on R&D and innovations). The DAFF, on the other hand had one partnership with a provincial department of agriculture. This indicates a need to develop this category of partnerships as they are necessary for the advancement of National Agricultural Research and Development Strategy objectives.

Table 27: Agricultural R&D collaboration by institution, area of specialisation and partner (South Africa only)

| Type of institution Area / specialisation | Total number of collaborations | Number (%) of collaboration with: | | | | | |
|---|---|---|---|---|---|---|---|
| | | Farmers | Higher-education institutions | Industry | State-owned enterprises | Provincial departments | Other state entities |
| **Higher education** | | | | | | | |
| Research & Development | 167 (100.0) | 59 (35.3) | 42 (25.1) | 35 (21.0) | 14 (8.4) | 17 (10.2) | 0 (0.0) |
| Technology Transfer | 80 (100.0) | 38 (47.5) | 9 (11.3) | 14 (17.5) | 5 (6.3) | 14 (17.5) | 0 (0.0) |
| Technology Services | 162 (100.0) | 131 (80.9) | 5 (3.1) | 13 (8.0) | 5 (3.1) | 8 (4.9) | 0 (0.0) |
| Innovations | 41 (100.0) | 14 (34.1) | 12 (29.3) | 9 (22.0) | 4 (9.8) | 2 (4.9) | 0 (0.0) |
| Sub-Total | 450 (100.0) | 242 (53.8) | 68 (15.1) | 71 (15.8) | 28 (6.2) | 41 (9.1) | 0 (0.0) |
| **Not-for-profit organisations** | | | | | | | |
| Research & Development | 5 (100.0) | 5 (100.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Technology Transfer | | | | | | | |
| Technology Services | 3 (100.0) | 0 (0.0) | 0 (0.0) | 3 (100.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Innovations | 5 (100.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 5 (100.0) | 0 (0.0) | 0 (0.0) |
| Sub-Total | 13 (100.0) | 5 (38.5) | 0 (0.0) | 3 (23.1) | 5 (38.5) | 0 (0.0) | 0 (0.0) |
| **Provincial departments of agriculture** | | | | | | | |
| Research & Development | 115 (100.0) | 54 (47.0) | 13 (11.3) | 23 (20.0) | 12 (10.4) | 11 (9.6) | 2 (1.7) |
| Technology Transfer | 32 (100.0) | 17 (53.1) | 0 (0.0) | 5 (15.6) | 0 (0.0) | 9 (28.1) | 1 (3.1) |
| Technology Services | 14 (100.0) | 0 (0.0) | 5 (35.7) | 8 (57.1) | 1 (7.1) | 0 (0.0) | 0 (0.0) |
| Innovations | 8 (100.0) | 0 (0.0) | 2 (25.0) | 1 (12.5) | 5 (62.5) | 0 (0.0) | 0 (0.0) |
| Sub-Total | 169 (100.0) | 71 (42.0) | 20 (11.8) | 37 (21.9) | 18 (10.7) | 20 (11.8) | 3 (1.8) |
| **The DAFF** | | | | | | | |
| Research & Development | 19 (100.0) | 6 (31.6) | 6 (31.6) | 5 (26.3) | 1 (5.3) | 1 (5.3) | 0 (0.0) |
| Sub-Total | 19 (100.0) | 6 (31.6) | 6 (31.6) | 5 (26.3) | 1 (5.3) | 1 (5.3) | 0 (0.0) |
| **Science Councils** | | | | | | | |
| Research & Development | 151 (100.0) | 61 (40.4) | 22 (14.6) | 51 (33.8) | 3 (2.0) | 12 (7.9) | 2 (1.3) |
| Technology Transfer | 2 533 (100.0) | 2 510 (99.1) | 4 (0.2) | 7 (0.3) | 0 (0.0) | 11 (0.4) | 1 (0.0) |
| Technology Services | 103 (100.0) | 100 (97.1) | 0 (0.0) | 3 (2.9) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Innovations | 14 (100.0) | 5 (35.7) | 5 (35.7) | 4 (28.6) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Sub-Total | 2 801 (100.0) | 2 676 (95.5) | 31 (1.1) | 65 (2.3) | 3 (0.1) | 23 (0.8) | 3 (0.1) |
| **Total** | **3 452 (100.0)** | **3 000 (86.9)** | **125 (3.6)** | **181 (5.2)** | **55 (1.6)** | **85 (2.5)** | **6 (0.2)** |

### 3.4.3 Foreign collaborations

Table 28 shows there was substantially less collaboration with foreign institutions than with local ones. International partnerships were predominantly on R&D (85.5 per cent). Foreign partnerships on innovation (7.6 per cent) exceeded those on technology transfer (4.6 per cent) and technology services (2.3 per cent), although all three collaboration areas were distant runners-up to R&D.
R&D also dominated collaborations when assessed in terms of the foreign institutions involved, with the exception of international collaborations with farmers, which were evenly spread across all specialisation areas.

Most international R&D partnerships were with foreign universities (66.1 per cent), although the number of partnerships with foreign industry and state-owned enterprises was also considerable. A similar pattern emerged with partnerships in other areas of specialisation.

Table 28: Collaborations by foreign partners and specialisation

| Area of specialisation | Total | Foreign partners | | | | | |
|---|---|---|---|---|---|---|---|
| | | Farmers (% of total collaboration with farmers) | Higher-education institutions (% of total collaboration with higher-education institutions) | Industry (% of total collaboration with industry) | State-owned enterprises (% of total collaboration with state-owned enterprises) | Provincial departments (% of total collaboration with provincial departments) | Other state entities (% of total collaboration with other state entities) |
| R&D | 112 (85.5) | 1 (25.0) | 74 (86.0) | 12 (80.0) | 19 (95.0) | 1 (100.0) | 5 (100.0 |
| Technology transfer | 6 (4.6) | 1 (25.0) | 3 (3.5) | 2 (13.3) | 0 (0) | 0 (0) | 0 (0) |
| Technology services | 3 (2.3) | 1 (25.0) | 2 (2.3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Innovation | 10 (7.6) | 1 (25.0) | 7 (8.1) | 1 (6.7) | 1 (5.0) | 0 (0) | 0 (0) |
| **Total** | 131 (100.0) | 4 (100.0) | 86 (100.0) | 15 (100.0) | 20 (100.0) | 1 (100.0) | 5 (100.0) |

### 3.4.4 Conclusion: Collaborations and strategic partnerships

In general, all institutions formed more collaborative networks with farmers than with other partners, with science councils topping the list. Higher-education institutions and science councils also had notable numbers of partnerships with industry, and provincial departments of agriculture with higher-education institutions, industry and state-owned entities. Provincial departments of agriculture had a moderate number of partnerships with other provincial departments of agriculture, but only one provincial department of agriculture had a partnership with the DAFF.

Locally, the surveyed public-sector institutions mainly collaborated with farmers, and more on technology transfer than on R&D and technology services. Collaborations with other types of partners – higher-education institutions, industry, state-owned enterprises, provincial departments and other government departments – were mainly on R&D. However, noteworthy numbers of partners were also observed collaborating on technology transfer (especially higher-education institutions, industry and provincial departments) and innovation (higher-education institutions, industry and state-owned enterprises). Internationally, collaborations were mainly on R&D and with higher-education institutions, industry and state-owned enterprises.

The patterns in these findings corroborate those of the last two South African innovation surveys, covering the periods 2002 to 2004 and 2005 to 2007 (Department of Science and Technology, 2005; 2008). These surveys showed that, domestically, the most important collaborative partnerships for innovation were between enterprises and their clients/customers, and between enterprises and their suppliers. In the context of the current survey, farmers are the clients/customers, and universities and public institutions are the enterprises. The results of the last two innovation surveys also showed that, internationally, enterprises, among other partners, tended to collaborate with universities and other higher-education institutions on innovation.

The implications of these results is that existing partnerships need to be increased and developed, and established where they are currently lacking, for example, between universities and provincial agricultural departments on R&D, technology services and innovations.

## 3.5 Scientific outcomes

### 3.5.1 Introduction

This section outlines the outcomes of basic research that has been converted to commercial research. It also includes measurements of the extent of introduction of new agricultural technologies and processes to contribute to farmers' competitiveness and the number of publications per agricultural researcher. These scientific outcomes and measurements can be used to help guide future national agricultural R&D programmes, with the ultimate aim of significantly increasing the number of new plant varieties, livestock breeds, natural-resource management techniques and other technologies by the year 2020.

### 3.5.2 Product innovation

The Eurostat-OECD's guidelines for collecting and interpreting innovation data (Eurostat/OECD, 2005) define product innovation as "the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses". In the agriculture sector, new products that have been released or commercialised are an important outcome of research and other S&T activities.
Table 29 presents the rate of release/commercialisation of new agricultural products. A total of 251 agricultural products were developed during the five-year period from 2006/07 to 2010/11. Of this, 48.2 per cent were viable products used by farmers, and 33.9 per cent were commercialised or released to the market. Although less than half of the products developed were viable, the success rate is nonetheless considerable and can be improved by working on the quality of new products and strengthening agricultural marketing systems.

Table 29: New products developed, viable and commercialised, 2006/07 to 2010/11

| Outcome status of new product | Number | % of total number |
|---|---|---|
| Total number of agricultural products developed | 251 | 100.0 |
| Products released/commercialised | 85 | 33.9 |
| Viable products in use by smallholding/commercial farmers | 121 | 48.2 |

### 3.5.3 Process innovation

Process innovation is "the implementation of a new or significantly improved production or delivery method". This includes significant changes in techniques, equipment and/or software.
Table 30 shows that 135 new agricultural processes were developed during the period from 2006/07 to 2010/11. Of these, 23.7 per cent were viable and of benefit to smallholding and commercial farmers. It is recommended to conduct further research into possible mechanisms that might improve the development of processes.

Table 30: Process innovations developed and of benefit to farmers, 2006/07 to 2010/11*

| Outcome status of new processes | Number | % of total number |
|---|---|---|
| Agricultural processes developed | 135 | 100.0 |
| Viable and of benefit to smallholding/commercial farmers | 32 | 23.7 |

Process innovations take time to develop, therefore, the numbers reported here are those of innovations that were developed over the period 2006/07 to 2010/11

### 3.5.4 Farmers benefiting from research

Table 31 shows the number of farmers that benefited from R&D or extension work. Most of the benefiting farmers (74.9 per cent) were smallholders. Only 18.3 per cent of established commercial farmers and 6.8 per cent of new commercial farmers benefited.

Table 31: Farmers benefiting from research

| Farmer categories | Number | % of total farmers |
|---|---|---|
| New commercial farmers | 9 478 | 6.8 |
| Established commercial farmers | 25 648 | 18.3 |
| Smallholder farmers | 104 856 | 74.9 |
| **Total** | 139 982 | 100.0 |
| Farmers with income from on-farm activities | 84 953 | 60.7 |

### 3.5.5 Research projects addressing agricultural productivity

Research projects that address agricultural productivity are those that may lead to increased quality, yields or sustainability of agricultural output.

A total of 208 new R&D projects addressing agricultural productivity were introduced in 2010/11. These projects benefited 72 272 smallholder farmers – three times the number of commercial farmers that benefited (26 285).

### 3.5.6 Farmers who implemented new projects, products and processes

In total, 20 991 smallholder farmers and 4 905 commercial farmers implemented new projects, products or processes. Table 32 indicates which R&D outcomes were implemented by each category of farmer.

Table 32: Number of farmers who implemented new projects, products and processes§

| | Number of farmers | | | | | |
|---|---|---|---|---|---|---|
| | Small-holder | | | Commercial | | |
| | **Total** | Men | Women | **Total** | Men | Women |
| Farmers who have introduced new research, product or process innovation | **8 172** | 5 810 | 2 362 | **3 727** | 3 641 | 86 |
| Farmers who have adopted new technologies | **5 313** | 5 302 | 5 504 | **117** | 106 | 11 |
| Farmers who have adopted new natural resource management technique | **2 013** | 1 075 | 938 | **1 061** | 1 034 | 27 |
| **Total** | **20 991** | **12 187** | **8 804** | **4 905** | **4 781** | **124** |

§ The ratio of R&D personnel to farmers is calculated as number of farmers divided by the number of R&D personnel, which totalled 3 726.

### 3.5.7 Conclusion: Scientific outcomes

Even though a large number of agricultural products developed from research are never commercialised/released, a great number of them are nonetheless viable and being used by farmers, especially smallholders. Further study is needed to determine the actual benefits for farmers of research products and processes, and their impact on productivity.

## 3.6 Extension work

### 3.6.1 Introduction

This section explores aspects of extension work that have not already been covered in this report. Specifically, it focuses on:

- extension agents' level of responsiveness to the needs of agriculture;
- the effect of limited capacity on user satisfaction;
- scientific outputs;
- patents, royalties, trademarks and intellectual property;
- dissemination tools, technology-transfer events and services, and technology services.

### 3.6.2 Responsiveness to agriculture's needs

The response rate is a measure of how successful extension agents are at resolving farmers' requests for assistance in terms of R&D, technology transfer, and/or technological and other services.
Table 33 shows that the overall response rate – calculated as the total number of requests resolved as a proportion of the total number of requests received – is 86.6 per cent. Most of the requests received were for technological services (9 995), which also had the highest response rate (94.7 per cent). This was followed by technology-transfer services (8 933 requests with a response rate of 79.4 per cent). Although R&D had a fairly competitive response rate (77.6 per cent), the number of requests for this category was substantially lower, at 1 807. Even though the categories are not mutually exclusive – that is, a request might have both an R&D and a technology-transfer aspect – as a general observation, extension agents were the most successful at meeting requests for technological services.

Table 33: Number of requests received and resolved, by type of query

| | Number | | | |
|---|---|---|---|---|
| | R&D | Technology transfer | Services | Total |
| **Requests received (number)** | 1 807 | 8 933 | 9 995 | 20 735 |
| **Requests resolved (number)** | 1 403 | 7 095 | 9 466 | 17 964 |
| **Response rate (%)[1]** | **77.6** | **79.4** | **94.7** | **86.6** |

[1]Response rate = (number of requests resolved / number of requests received) × 100.

### 3.6.3 Effect of capacity on user satisfaction

The ability to respond to requests for R&D, technology transfer or technology services depends heavily on capacity in terms of funding, human resources (the number of extension agents, their skill and training levels) and infrastructure. Extension agents were asked whether they experienced constraints that limited their ability to meet farmers' extension-work needs with regard to the following aspects, the majority of which relate to human resources:

- headcount numbers (human resources);
- skills and qualifications (human resources);
- infrastructure;
- training (human resources);
- funding.

To obtain this information, the extension agents were asked to rate how strongly they agreed or disagreed that capacity constraints in these areas were placing limitations on their ability to satisfy farmers' extension-work needs. An average rating of "strongly agree" therefore meant that not only were extension workers experiencing constraints with regard a particular factor, but that these constraints were substantial enough to jeopardise their ability to effectively conduct extension work. The respondents were asked to assess whether capacity constraints on certain aspects (for example, funding and infrastructure) affected their ability to meet farmers' extension needs by providing a rating on a scale of 1 to 5, where 1 meant "strongly disagree (that capacity constraints are affecting their performance" and 5 meant "strongly agree (that capacity constraints are affecting their performance)".

Table 34 indicates that funding (with a rating of 4.4), human-resources skills (4.3) and human-resource numbers (4.2) were the three areas where capacity constraints were most affecting extension workers' ability to meet farmers' needs. Infrastructure (3.9) and human-resource training (3.5) drew above-neutral ratings.

Table 34: Areas where constrained capacity affects extension work

| | Average rating[1] |
|---|---|
| Headcount numbers (human resources) | 4.2 |
| Skills and qualifications (human resources) | 4.3 |
| Infrastructure | 3.9 |
| Training (human resources) | 3.5 |
| Funding | 4.4 |
| **Total** | **4.0** |

[1] Ratings are on a scale of 1 to 5, where 1 equals "strongly disagree (that this factor affects the capacity to meet needs)" and 5 equals "strongly agree (that this factor affects the capacity to meet needs)".

Figure 2 indicates that 88.3 per cent of extension workers surveyed agreed that human-resource numbers affected their ability to meet farmers' extension needs, with 41.2 per cent expressing strong agreement. A minority – 5.9 per cent – strongly disagreed, while a further 5.9 per cent neither agreed nor disagreed.

Figures 3 to 6 provide further detail on the extension workers' responses. These indicate that:

- 66.7 per cent of respondents "strongly agreed" that funding constraints affected extension workers' ability to meet farmers' needs;
- 56.3 per cent "strongly agreed" that skills and qualifications constraints affected extension workers' ability to meet farmers' needs;
- 41.2 per cent "strongly agreed" that constraints in the number of extension workers affected their ability to meet farmers' needs.

Figure 2 indicates that 88.3 per cent of extension workers surveyed agreed that human-resource numbers affected their ability to meet farmers' extension needs, with 41.2 per cent expressing strong agreement. A minority – 5.9 per cent – strongly disagreed, while a further 5.9 per cent neither agreed nor disagreed.

Figure 2: Breakdown of responses on human-resource numbers indicator

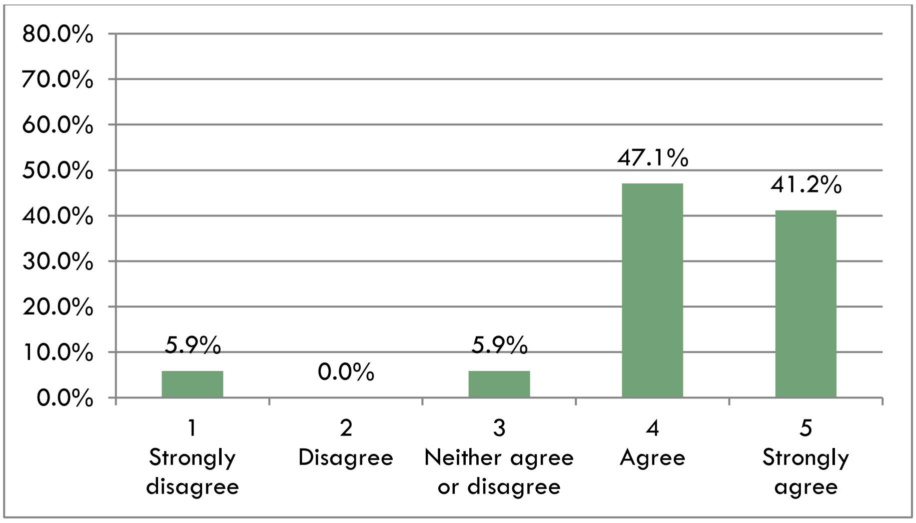



Figure 3 shows that 81.3 per cent of respondents thought that limitations in human-resources skills and qualifications affect user satisfaction, with 56.3 per cent expressing strong agreement. Strong disagreement was expressed by 6.3 per cent of respondents, while another 12.5 per cent took a neutral stance.

Figure 3: Breakdown of responses on human-resources skills and qualifications indicator

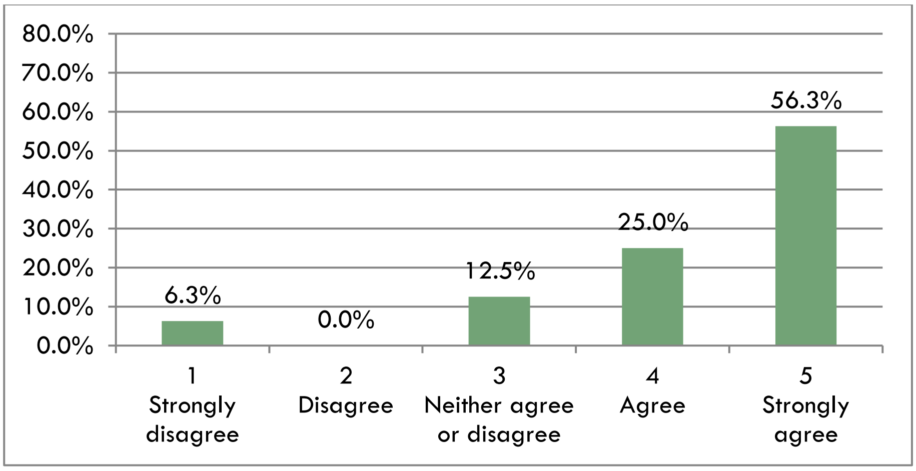



Figure 4 indicates that 71.9 per cent of extension workers surveyed agreed that limitations in infrastructure capacity were affecting their ability to meet farmers' extension needs, with 28.1 per cent expressing strong agreement. A substantially smaller proportion either strongly disagreed (3.1 per cent) or disagreed (6.3 per cent), with 18.8 per cent neither agreeing nor disagreeing.

Figure 4: Breakdown of responses on infrastructure indicator

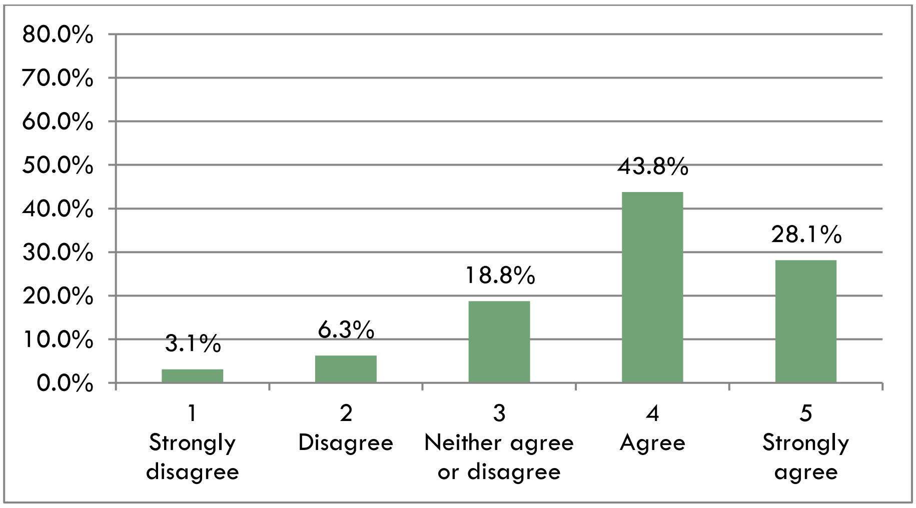
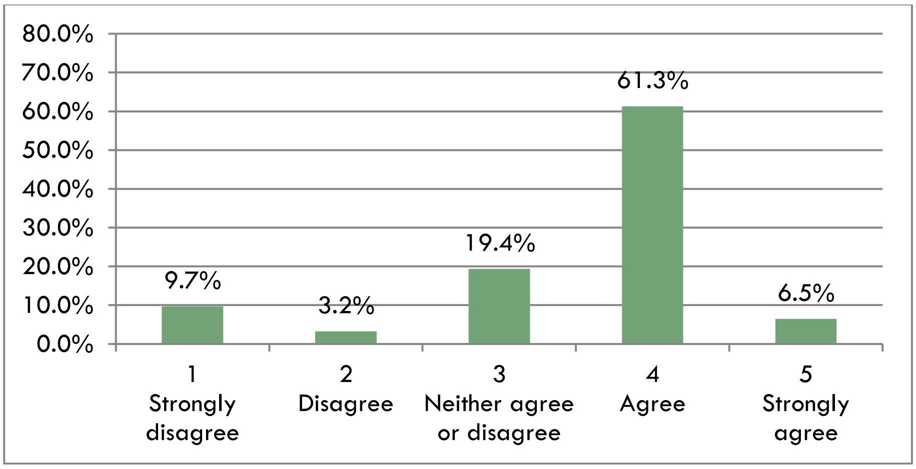


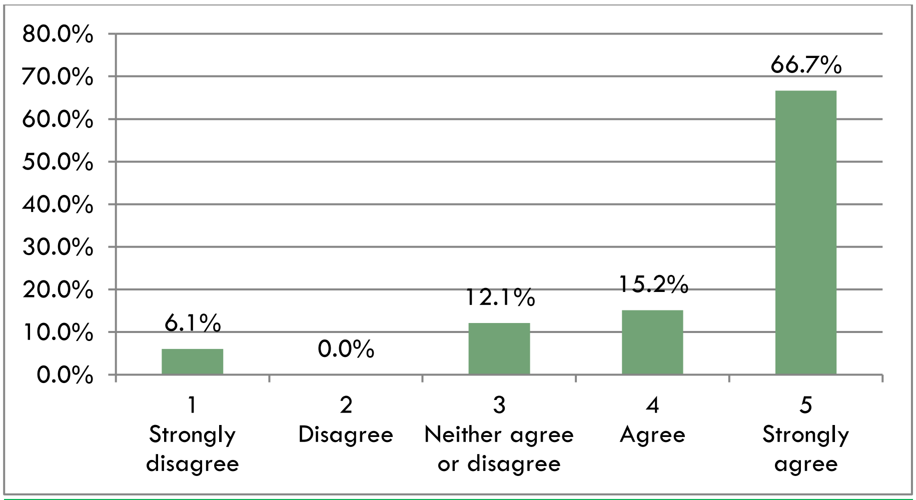

Figure 5 shows that 67.8 per cent of extension workers questioned agreed that constraints in training levels affect their ability to meet farmers' extension needs, although only 6.5 per cent expressed strong agreement (more respondents – 9.7 per cent – expressed strong disagreement). Only 3.2 per cent disagreed, while a substantial 19.4 per cent neither agreed nor disagreed.

Figure 5: Breakdown of responses on training indicator




As indicated in
Figure 6, 81.9 per cent of respondents agreed that funding constraints affect extension workers' ability to meet farmers' extension-work needs, of which 66.7 per cent expressed strong agreement. Only 6.1 per cent strongly disagreed, and 12.1 per cent neither agreed nor disagreed.

Figure 6: Breakdown of responses on funding indicator




### 3.6.4 Scientific research outputs

Scientific research outputs, as defined for this survey, are defined as:

- the number of research publications in local and international peer-reviewed journals and books (including citations);
- the number of research publications in local and international non-peer-reviewed journals and books (including citations);
- the number of papers and posters presented at local and international conferences;
- the number of articles in local and international popular publications.

Table 35 indicates that more peer-reviewed journal articles appeared in international journals than in South African journals during the reference period. This indicates that the agricultural research conducted locally is of a high quality and is relevant to the international agricultural community. There were also 903 posters and papers presented at national and international conferences, of which 578 were peer-reviewed.

Combined, researchers employed at higher-education institutions and science councils produced the largest proportion (82.4 per cent) of academic research articles. Higher-education staff predominantly published in international peer-reviewed journals. Government staff also produced research publications, albeit in smaller numbers.

Table 35: Scientific research outputs, by type and organisation

| Agricultural research outputs | South African | | International | |
|---|---|---|---|---|
| | Peer-reviewed | Non-peer reviewed | Peer-reviewed | Non-peer reviewed |
| **GOVERNMENT** | | | | |
| Journal articles | 64 | 39 | 52 | 2 |
| Books, chapters in books (including citations) | 4 | 3 | 1 | 0 |
| Semi-scientific and scientific articles/publications | 9 | 16 | 0 | 0 |
| Papers and posters presented at national and international scientific conferences | 97 | 15 | 30 | 0 |
| Popular publications | 12 | 206 | 0 | 10 |
| **Subtotal** | **186** | **279** | **83** | **12** |
| **SCIENCE COUNCILS** | | | | |
| Journal articles | 127 | 0 | 50 | 3 |
| Books, chapters in books (including citations) | 3 | 34 | 1 | 0 |
| Semi-scientific and scientific articles/publications | 19 | 27 | 5 | 0 |
| Papers and posters presented at national and international scientific conferences | 53 | 137 | 72 | 12 |
| Popular publications | 50 | 116 | 0 | 0 |
| **Subtotal** | **252** | **314** | **128** | **15** |
| **HIGHER EDUCATION** | | | | |
| Journal articles | 158 | 16 | 381 | 1 |
| Books, chapters in books (including citations) | 30 | 2 | 34 | 0 |
| Semi-scientific and scientific articles/publications | 41 | 21 | 18 | 2 |
| Papers and posters presented at national and international scientific conferences | 219 | 99 | 105 | 62 |
| Popular publications | 16 | 48 | 0 | 0 |
| **Subtotal** | **464** | **186** | **538** | **65** |
| **NOT-FOR-PROFIT** | | | | |
| Journal articles | 3 | 0 | 0 | 0 |
| Books, chapters in books (including citations) | 0 | 0 | 0 | 0 |
| Semi-scientific and scientific articles/publications | 1 | 0 | 0 | 0 |
| Papers and posters presented at national and international scientific conferences | 0 | 0 | 2 | 0 |
| Popular publications | 11 | 15 | 0 | 0 |
| **Subtotal** | **15** | **15** | **2** | **0** |
| **Total** | **917** | **794** | **751** | **92** |

## 3.6.5 Intellectual property, patents, royalties and trademarks

Intellectual property (IP) refers to the ownership of intangible and non-physical goods. This includes ideas, names, designs, symbols, artwork, writing and other creations. The data on intellectual property outputs contained in Table 36 should not be taken as a measure of the size of intellectual property outputs within agricultural R&D, since companies/farmers use plant-breeders rights to gain intellectual property protection on new cultivars and they do not as a rule use patents for this purpose.

The first row of Table 36 gives the total number of reporting units (entities) surveyed for each sector in 2010/11. The next four rows give the number of those units reporting an IP output as a percentage of the total number of units in the sector. This is not an indicator of the total number of intellectual property outputs, though; instead it gives a count of the number of units reporting any one of the four categories (patents, royalties, trademarks, other IPs) as a proportion of the total number of reporting units within the sector. Any one unit may report on more than one type of IP output. That is to say, the percentages are calculated as a proportion of the number of reporting units per sector. The distribution of IP outputs shows that royalties were reported most frequently, followed equally by patents and other IP outputs, with trademarks the least frequently recorded. Science councils reported royalties more frequently (50 per cent of the total number of responding science councils) than any other type of organisation. Higher-education institutions, meanwhile, primarily focused on registering patents.

Table 36: Number (and percentage) of entities (units) reporting different types of intellectual property outputs by sector

| | All sectors | Government | Science councils | Higher education | Not-for-profit |
|---|---|---|---|---|---|
| **Number of units** | 46 | 9 | 8 | 25 | 4 |
| Patents | 4 (8.7 %) | 0 (0.0%) | 1 (12.5%) | 3 (12.0%) | 0 (0.0%) |
| Royalties | 5 (10.9 %) | 1 (11.1%) | 4 (50%) | 0 (0.0%) | 0 (0.0%) |
| Trademarks | 2 (4.3%) | 1 (11.1%) | 0 (0.0%) | 1 (4.0%) | 0 (0.0%) |
| Other IPs | 4 (8.7%) | 0 (0.0%) | 3 (37.5%) | 0 (0.0%) | 1 (25.0%) |

Note: Respondents did not indicate the category (patents, royalties, trademarks or other IPs) in which their IP outputs fell. Therefore, the total number of IP outcomes for each IP category cannot be reported.

Table 37 shows that 541 IP outputs were applied for and/or registered in 2010/11. Most of these were applications, which formed 92.8 per cent of the total. Science councils applied for and registered the most IP outputs (97.8 per cent of total).

Table 37: Number of trademarks, patents and other IP applications and registrations, by sector

| Number of IP outputs | Government | Science councils | Higher education | Not-for-profit | Total |
|---|---|---|---|---|---|
| Applied | 2 | 497 | 3 | 0 | **502** |
| Registered | 3 | 32 | 4 | 0 | **39** |
| **Total** | **5** | **529** | **7** | **0** | **541** |

### 3.6.6 Dissemination tools

"Dissemination tools" refers to any platform that facilitates access to, and dissemination of, technology and information generated by agricultural research to farmers. Table 38 shows that extension workers used new incubation models and decision-support tools 359 times. Of this, they used hardware-based tools (such as instruments to check soil humidity) 221 times and software-based tools (such as data modelling) 138 times. Information packs were used to convey research in 99 instances.

Table 38: Agricultural technology dissemination tools

| Technology type | | Number |
|---|---|---|
| **New incubation models and decision support tools for extension** | | 359 |
| | Hardware | 221 |
| | Software | 138 |
| **New information packs** | | 99 |
| **New methods of technology transfer** | | 796 |
| | **Total** | **1 254** |

Table 39 provides greater detail on the 796 instances where new methods were used to transfer technology to farmers. These have been clustered into four categories, namely people-focused methods (516 new methods), ICT-based methods (167 new methods), publishing (98 new methods) and knowledge creation (10 new methods). Most respondents pursued unique interventions, suggesting that a platform to share these contributions should be explored. Forty-three methods were described, but only six new methods were reported by more than one respondent.

The "n" in Table 39 indicates the number of respondents who mentioned a given intervention. The total number of new methods for transferring technologies to farmers is shown in brackets after the name of the dissemination tool category. The column on the right indicates the total number of times a given tool was used.

Table 39: New tools for technology and information dissemination

| n | People-focused methods (17) | 516 | | n | Information and communication technologies (11) | 167 |
|---|---|---|---|---|---|---|
| 1 | Workshops | 158 | | 2 | Cell phones | 122 |
| 1 | Presentations | 120 | | 1 | Radio/TV talks | 13 |
| 1 | Presentations in Setswana | 60 | | 3 | Videos | 9 |
| 1 | Farmer study-group talks/“Farmer days” presentations | 60 | | 3 | Websites | 7 |
| 1 | Field day presentations to the forest industry | 43 | | 1 | Flat screens at regional departmental offices | 6 |
| 2 | Farmers’ days (regular talks/lectures) | 12 | | 1 | Using GPS to acquire spatial information | 4 |
| 1 | Mentorship programmes | 12 | | 1 | DVDs depicting farming methods | 2 |
| 1 | Presentations | 10 | | 1 | Info-toons | 1 |
| 1 | “Walks and talks” | 10 | | 1 | SMS technologies | 1 |
| 2 | Hands-on demonstration | 7 | | 1 | DVDs | 1 |
| 1 | Exhibitions | 6 | | 1 | Decision support system | 1 |
| 1 | Study groups | 6 | | | | |
| 1 | Exchange visits | 6 | | **n** | **Knowledge creation (9)** | **10** |
| 1 | Green tours on conservation agriculture | 4 | | 1 | Agricultural Research for Development | 3 |
| 1 | Workshops with farmers | 2 | | 1 | Redefining agricultural extension processes in ext. new approach (doctorate) | 1 |
| 1 | Training | 0 | | 1 | Model for estimating dosage intake – wildlife | 1 |
| 1 | Hands-on support during planting and harvest | 0 | | 1 | Methods for improved crop production | 1 |
| | | | | 1 | Introduction of silage-preparation methods during drought in Mafikeng area specifically | 1 |
| **n** | **Publishing (6)** | **98** | | 1 | Soil-water determination | 1 |
| 1 | Client reports | 32 | | 1 | Molecular analysis of pumpkin breeds | 1 |
| 2 | Article in in-house newsletter/magazine | 22 | | 1 | Improvement and innovation in beef business | 1 |
| 1 | Popular articles | 21 | | 1 | Low-cost drilling techniques (in progress) | 0 |
| 1 | Information packs | 20 | | | | |
| 1 | Development of dossiers | 3 | | **51** | **TOTAL** | **796** |
| 1 | Posters in progress | 0 | | | | |

People-focused dissemination methods were the most commonly used, accounting for 64.8 per cent (516 out of 796) of technology-dissemination instances. Technology-based methods of information dissemination (such as cell phones, videos and TV broadcasts) accounted for 21.0 per cent (167 out of 796) of technology-dissemination instances, while publishing methods accounted for 12.3 per cent (98 out of 796) and new methods in knowledge creation accounted for 1.3 per cent (10 out of 796) of instances.

Technology-based methods were dominated by cell phone-based communications and radio/TV broadcasts. Radio and TV have relatively deep penetration in rural South Africa due to high numbers of radios and TVs in these areas. The same is true of cell phones. However, internet access in rural areas remains low (Sithole et al, 2013). This suggests that radio, TV and cell phone-based communication methods will be most effective for knowledge transfer of agricultural technology in rural areas. "Infomercials" (information advertising commercials), video demonstrations and "info-toons" (information cartoons) appear to be useful methods for ensuring that new agricultural information and technologies reach farmers.

Six new publishing methods were described, from client reports (32) and in-house circulation of a newsletter/magazine (22) to the distribution of popular articles (21), the creation of information packs (20), dossiers (3) and posters (being developed).

New knowledge creation accounted for 10 new technology transferring methods in nine areas.

### 3.6.7 Technology-transfer events

The number of technology-transfer events that took place is an indication of the total effort by extension agents to actively engage with farmers on agricultural technologies and R&D opportunities. Technology-transfer events included demonstration trials, farmer education and training of extension officers on new technology tools.

Table 40 indicates that all sectors are actively involved in hosting technology-transfer and training events. During 2010/11, 7 629 farmer training sessions took place across the country, reaching 20 234 farmers. Science councils and not-for-profit organisations in particular trained a large number of farmers, although the government sector conducted the greatest number of training sessions (6 454). A total of 835 on-farm trial demonstrations also took place.

Extension workers received 628 training sessions. These sessions were structured to both build their capacity and to place them in a position where they could transfer their newly acquired skills to farmers.

Table 40: Technology-transfer events

| | Events hosted by | | | | Total |
|---|---|---|---|---|---|
| | Government | Higher education | Science councils | Not-for-profit organisations | |
| **Type of event** | | | | | |
| Farmer training sessions | 6 454 | 198 | 315 | 662 | **7 629** |
| Demonstration farm trials | 151 | 200 | 460 | 24 | **835** |
| **Number of people reached** | | | | | |
| Farmers trained | 4 388 | 790 | 6 656 | 8 400 | **20 234** |
| Extension officers trained on new technologies | 166 | 267 | 35 | 160 | **628** |
| Other | 66 | 47 | 0 | 3 | 116 |

These results are encouraging as it shows that the government, higher-education institutions, not-for-profit organisations and science councils are interacting with farmers. This interaction creates opportunities to share knowledge on agricultural technologies and farming practices in order to improve crop productivity.

### 3.6.8 Technology-transfer services

Organisations reported how much extension work they performed in each province, as a percentage of total extension work. Table 41 shows that most (23.2 per cent) technology-transfer services took place in KwaZulu-Natal, almost double what took place in the two next-highest recipient provinces – the

Western Cape and the Eastern Cape. The lowest recipient of extension activities at 6.4 per cent was also the smallest province geographically; i.e. Gauteng. The remaining provinces received between 7.2 per cent and 10.8 per cent of the share of extension activities.

Table 41: Extension work by province

| Location | Percentage of extension activity |
|---|---|
| Eastern Cape | 12.3 |
| Free State | 8.6 |
| Gauteng | 6.4 |
| KwaZulu-Natal | 23.2 |
| Limpopo | 9.9 |
| Mpumalanga | 7.2 |
| Northern Cape | 8.5 |
| North-West | 10.8 |
| Western Cape | 13.0 |
| TOTAL | 100.0* |

* Rounding of parts may cause minor variance from the stated total

### 3.6.9 Technology services

Technology services include those that recipients cannot perform themselves, for example, laboratory-related diagnostic and analytical services, advisory services, decision-support services, and plant and animal health services.

Table 42 indicates that advisory services (33 570) and diagnostic and analytical (30 910) services were the most common defined services provided by public-sector agricultural R&D and S&T facilities. Similarly, they attracted the largest funding subsidies (R68.5 million for advisory services and R66.4 million for diagnostic and analytical services). Data acquisition (5 016 services for R9.5 million in funding) also featured, as did decision-support services (2 131 services for R3.2 million) and animal health (1 008 services for R1.5 million). Equipment testing (18 services for R1.8 million) and plant health (7 services for R3.3 million) were the least common with plant health also being the most expensive per service offered.

The main areas for new technology services offered were new diagnostic and analytical services (54), new decision support services (39), new advisory services (11) and new data acquisition services (8).

Table 42: Number, funding and accreditation of agricultural technology services

| Description | Total number of services | Number of new services | Funding subsidies (R 000) | Internationally accredited | Nationally accredited | In-house standards |
|---|---|---|---|---|---|---|
| Diagnostic and analytical | 30 910 | 54 | 66 420 | 59 | 238 | 671 |
| Advisory | 33 570 | 11 | 68 485 | 1 680 | 1 704 | 7 |
| Decision support | 2 131 | 39 | 3 220 | 0 | 36 | 0 |
| Plant health | 7 | 1 | 3 327 | 1 | 1 | 6 |
| Animal health | 1 008 | 1 | 1 526 | 4 | 1 007 | 4 |
| Data acquisition | 5 016 | 8 | 9 500 | 2 | 4 | 6 |
| Equipment testing | 18 | 0 | 1 750 | 1 | 6 | 11 |
| Other | 174 620 | 0 | 9 885 | 0 | 82 | 1 378 |
| **Total** | 247 280 | 114 | 164 113 | 1 747 | 3 078 | 2 083 |

The majority of the total internationally accredited services (1 747) were advisory services (1 680), similarly the majority of the total nationally accredited services (3 078) were advisory services (1 704), followed by health services (1 007).

Diagnostic and analytical services had the highest number of in-house standards (671) besides the "other" category, where 1 378 in-house standards were recorded.

### 3.6.10 Conclusion: Extension work

The survey found that farmers and extension agents were actively interacting and that most extension activities were taking place in KwaZulu-Natal (23.2 per cent), the Western Cape (13.0 per cent) and Eastern Cape (12.3 per cent), with the least occurring in Gauteng (6.4 per cent).

Survey respondents strongly agreed that limitations in funding (66.7 per cent), human resource skills (56.3 per cent) and headcount numbers (41.2 per cent) were constraints affecting the user satisfaction in response to farmer needs. An audit of the human-resource numbers and skills required at public institutions to offer effective and sustainable technology services to farmers across the country would help ensure that these capacity constraints are addressed in future. This audit could include assessing the extent to which public institutions' funding needs are not being met and asking the technology practitioners themselves how the funding gap might be closed.

Despite the fact that more than 20 234 farmers were trained, only 628 extension officers were trained on new technologies during the reference period. This figure might be improved by ensuring that extension officers receive more frequent training and support on new technologies to better capitalise on these farmer interactions.

The tools used to disseminate agricultural information and training were innovative and made good use of a range of media, both traditional (workshops and lectures, research papers and DVDs) and digital (websites and SMS services). However, the sheer diversity was an indication that there might be unnecessary duplication in terms of dissemination-tool development. A feasibility study into a shared platform for sharing new knowledge of agricultural technologies might be useful to maximise expenditure in this regard. Even though face-to-face interaction remains the most effective method for transferring information, in rural areas SMS, radio and video could also productively be used as most rural farmers have access to these technologies.

Most user requests were for technological and other services, followed by technology-transfer services and then R&D. The volume of requests in each category was mirrored by extension agents' success at resolving queries: they were the most effective at responding to requests for technological and other services, while their success rates for technology-transfer services and R&D requests were lower (but still substantial).

There were a substantial number of scientific research outputs in the year, with numerous articles, chapters and citations appearing in local and international peer-reviewed journals. Peer-review is the "golden standard" of academic publishing, so the high figure for peer-reviewed publications is an indication that local agricultural research is of a high standard and both locally and internationally relevant.

# PART 4: SUMMARY OF FINDINGS AND RECOMMENDATIONS

## 4.1 Summary of findings

The key findings of this phase of the national survey on R&D and other S&T related activities in agriculture were as detailed below.

### 4.1.1 Human resources

- More men than women were active in agricultural S&T. However, there were a substantial number of highly qualified female actors, many of them doctorate-holders.
- The bulk of agricultural S&T staff was between 31 and 55 years of age. There were fewer younger people.
- Only 57.8 per cent of jobs in scarce skills areas were filled in 2010/11.
- Encouragingly, a large number of agricultural S&T students were enrolled in higher-education institutions, indicating a strong potential supply of S&T staff members in future. While the ratio between men and women was still greatly skewed in favour of men, the high student population, if well managed, may solve both the scarce-skills problem and fill the potential future gap due to most agricultural S&T workers being aged between 31 and 55 years in 2010/11.

### 4.1.2 Infrastructure and facilities

- The condition of most agricultural S&T facilities was slightly above moderate, with similar levels of maintenance. The expenditure required to maintain facilities was about five times greater than the amount actually spent. This implies that funding for maintenance of facilities needs to be increased.
- Five out of seven institutions used public S&T facilities for technology transfer.
- Education institutions primarily used public S&T facilities for R&D; 80.0 per cent also used them for technology transfer.
- Science councils mostly used their facilities for technology services.

### 4.1.3 Investment levels

- During the 2010/11 period, R1.217 billion was spent on agricultural R&D in South Africa. This was low, representing a contribution of only 0.074 per cent of the total value added, given the importance of the sector to the economy. However, most of the projects were in line with the government and the DAFF's key national priority areas, focusing as they did on economic development, food security and sustainable natural resources. That said, despite the fact that the agriculture sector accounts for about 10.0 per cent of formal employment, only 12.3 per cent of R&D projects focused on job creation.
- Most of the funding for agricultural R&D and S&T – 98.0 per cent – was from local sources, with the government being the largest funder through contracts and grants. Foreign funding was low (2.0 per cent), indicating that there is probably untapped potential for collaboration between local researchers and their foreign counterparts.

- Expenditure on R&D infrastructure was low and needs to be urgently addressed, as agricultural activities heavily rely on these resources for their outputs.
- In the national R&D survey, which included all sectors, Gauteng emerged as the most prominent in terms of expenditure on R&D. This survey focused only on agricultural R&D expenditure, resulting in other, more agriculturally focused provinces such as the Eastern Cape being prominent.

### 4.1.4 Collaborations and strategic partnerships

- In general, all the public institutions collaborated more with farmers than any other type of partner. Most farmer collaborations were on technology transfer.
- Science councils and higher-education institutions had the highest total number of collaborative partners, primarily with farmers but also with higher-education institutions and industry. Higher-education institutions also had a considerable number of collaborations with state-owned entities and provincial departments of agriculture.
- Higher-education institutions mainly collaborated with local and foreign universities, industry and state-owned entities on R&D.
- Provincial departments of agriculture had a substantial number of partnerships with higher-education institutions, industry, state-owned entities and other provincial departments of agriculture, and a moderate number of partnerships with state-owned enterprises.
- The DAFF reported only one collaborative relationship with a provincial agricultural department.

### 4.1.5 Scientific outcomes

- Although many agricultural products and processes developed through research were never commercialised, many of them were nonetheless viable and used by farmers, especially smallholders. However, the actual benefits of using these products and processes were still to be determined.
- Mentorship and incentive programmes are some of the ways the agricultural sector strives to address the gap in scarce skills. During the review period, there were substantially more incentive programmes than mentorship programmes.

### 4.1.6 Extension work

- Extension work was mostly carried out in KwaZulu-Natal, the Western Cape and the Eastern Cape.
- Technology and other services received the most attention, followed by technology-transfer services and then R&D.
- In terms of dissemination of research, local research appeared in local and international peer-reviewed journals and books, as well as at seminars and conferences both in South Africa and internationally, indicating that local knowledge-creation outputs are highly regarded the world over.

## 4.2 Key recommendations

### 4.2.1 General

- Since this was a baseline survey, the study should be conducted again at regular intervals, with a focus on gathering reliable, comparable and timely data.

- To increase awareness of the report, response rates and data quality, the pilot survey report should be launched at an event to which all stakeholders are invited, after which an advocacy and training strategy should be developed and deployed countrywide.
- Provincial agricultural R&D strategies and policies should be strengthened in those provinces where agriculture is more important.
- There were several challenges in conducting this first survey, for instance, respondents new to the questionnaire often required extensive encouragement and assistance when providing data for their institutions. An evaluation report will collect feedback from the entire survey team. It is recommended that the evaluation report feed into plans for the next survey.
- A study of international data to establish global benchmarks for resources allocated to agricultural R&D and S&T is recommended.
- The survey should be extended to include R&D and S&T institutions that focus on forestry and fisheries.
- The survey should be extended to include not-for-profit organisations and the business sector.
- A shorter, simplified version of this report should be drawn up for the benefit of research users.
- At the end of each survey cycle, the data should be curated for long-term preservation and stored off-site at both the DAFF and the HSRC using the facilities, expertise and standard data-curation procedures of the HSRC Data Curation Unit.

### 4.2.2 Human resources

- The large population of agricultural students in higher-education institutions should be taken advantage of to fill scarce-skills positions and manage the future skills gap that might occur when the current body of researchers, which is primarily between 31 to 55 years of age, begins to mature. The gender bias in favour of men should also be balanced out.
- In the interim, attempts should be made to fill current scarce-skills vacancies by recruiting both nationally and internationally.

### 4.2.3 Infrastructure and facilities

- Funding for infrastructure and facilities for agricultural R&D and other S&T activities, as well as for their maintenance, should be increased to the levels indicated in this survey.

### 4.2.4 Expenditure

- Expenditure should be increased to promote production and reflect the importance of the agriculture sector in the economy.
- Given that agriculture provides 10.0 per cent of South Africa's formal employment, agricultural R&D projects should sharpen their focus on job creation, while maintaining their current focus on economic growth, food security and sustainable natural resources.

### 4.2.5 Collaborations and strategic partnerships

- Existing collaborations with domestic and international partners should be developed, and new ones established where they are lacking, for example, between higher-education institutions and industry on R&D, technology transfer and technology services. Locally, provincial departments of agriculture should collaborate better among themselves and with the DAFF.

### 4.2.6 Scientific outcomes

- To increase scientific outcomes of research and other S&T, more programmes should be incentivised and commercialised.

### 4.2.7 Extension work

- An audit of the human-resource numbers and skills required at public institutions to offer effective, sustainable R&D and extension services would help address human-resource concerns in R&D and extension work.
- While personal interaction (such as workshops and open days) remains the preferred method of transferring information on new agricultural technologies to farmers, in rural areas dissemination could also be productively pursued through SMS, radio and video, which are usually available to farmers in outlying areas.

## 4.3 Limitations and challenges

### 4.3.1 Limitations

This survey gathered baseline information for a system that will track the performance of investment in R&D and S&T activities. In order for these baseline findings to be meaningful, future data has to be gathered and compared to these findings. Only then can trends in local investment performance be identified.

This survey covered only agriculture, a subsector of the greater sector of agriculture, forestry and fisheries. As such, the findings and recommendations are only applicable to these sectors. Future rounds of the survey are expected to include S&T investment in forestry and fisheries in both public and private institutions.

### 4.3.2 Challenges

The survey was the first of its kind and, as such, most of the questions and indicators in the questionnaire were being tested. Although the survey had a very high response rate (92.5 per cent), it took a lot of hard work to adapt the original fieldwork plan to respondents' needs to enable them to provide quality data. This included:

- combining data for two or more collection units within an institution into a single, completed questionnaire, resulting in a reduced sample frame list;
- postponement of interviews;
- numerous phone and email follow-ups, including the DAFF's intervention in a few cases, to get completed questionnaires returned where an interview had not been completed during the first visit.

An evaluation of the survey process is recommended to assess these challenges and put forward ways to streamline the data-collection process in future.

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# APPENDICES

## Appendix A – Principles of international statistical activities

The principles of official statistics (United Nations Statistics Division, 2013) are:

**Principle 1:** Official statistics provide an indispensable element in the information system of a democratic society, serving the government, the economy and the public with data about the economic, demographic, social and environmental situation. To this end, official statistics that meet the test of practical utility are to be compiled and made available on an impartial basis by official statistical agencies to honour citizens' entitlement to public information.

**Principle 2:** To retain trust in official statistics, the statistical agencies need to decide according to strictly professional considerations, including scientific principles and professional ethics, on the methods and procedures for the collection, processing, storage and presentation of statistical data.

**Principle 3:** To facilitate a correct interpretation of the data, the statistical agencies are to present information according to scientific standards on the sources, methods and procedures of the statistics.

**Principle 4:** The statistical agencies are entitled to comment on erroneous interpretation and misuse of statistics.

**Principle 5:** Data for statistical purposes may be drawn from all types of sources, be they statistical surveys or administrative records. Statistical agencies are to choose the source with regard to quality, timeliness, costs and the burden on respondents.

**Principle 6:** Individual data collected by statistical agencies for statistical compilation, whether they refer to natural or legal persons, are to be strictly confidential and used exclusively for statistical purposes.

**Principle 7:** The laws, regulations and measures under which the statistical systems operate are to be made public.

**Principle 8:** Coordination among statistical agencies within countries is essential to achieve consistency and efficiency in the statistical system.

**Principle 9:** The use by statistical agencies in each country of international concepts, classifications and methods promotes the consistency and efficiency of statistical systems at all official levels.

**Principle 10:** Bilateral and multilateral cooperation in statistics contributes to the improvement of systems of official statistics in all countries.

# Appendix B – Detailed description of methodology

This survey followed the survey value chain recommended by the South African Statistical Quality Assessment Framework (Statistics South Africa, 2010). The survey value chain involves a range of statistical operations, organised into nine phases. The ninth phase is an audit performed by an authoritative body, for example, the statistician-general of South Africa. Since this survey was not subjected to an audit, this is not included as one of the phases described in Table 43.

Table 43: Statistical value chain steps followed

| 1. Need | 2. Design | 3. Build | 4. Collect | 5. Process | 6. Analyse | 7. Disseminate | 8. Archive |
|---|---|---|---|---|---|---|---|
| 1.1. Determine information need | 2.1. Outputs | 3.1. Data collection instrument | 4.1. Draw sample | 5.1. Classify and code | 6.1. Acquire ancillary information | 7.1. Update output systems | 8.1. Manage archive repository |
| 1.2. Confirm information requirements | 2.2. Frame and sample methodology | 3.2. Process components | 4.2. Set up collection | 5.2. Load data into processing environment | 6.2. Calculate aggregates | 7.2. Produce products | 8.2. Preserve data and associated metadata |
| 1.3. Establish output objectives | 2.3. Tabulation plan | 3.3. Configure workflows | 4.3. Run collection | 5.3. Integrate data | 6.3. Prepare draft outputs | 7.3. Manage release of products | 8.3. Dispose of data and metadata |
| 1.4. Check data availability | 2.4. Data collection | 3.4. Test end-to-end | | 5.4. Edit and impute definitions of data | 6.4. Validate | 7.4. Manage customer enquiries | |
| 1.5. Prepare business case (including detailed project plan) | 2.5. Statistical processing methodology | 3.5. Finalise production systems | | 5.5. Derive new variables | 6.5. Describe and explain | | |
| | 2.6. Define archive rules | | | | 6.6. Disclosure control/ anonymisation | | |
| | 2.7. Processing systems and workflow | | | | 6.7. Finalise outputs | | |

## Need

The "need" phase entails determining the information need, confirming information requirements, establishing the output objectives, checking the current availability of data and preparing a business case (including a detailed project plan).

### Determine need for information

The DAFF and its partners/stakeholders together identified the need for a tracking system for public investment in R&D and S&T. Consultation between DAFF and its partners identified which statistics were needed, and what they would achieve. CeSTII has extensive experience in conducting R&D surveys, so its methods were adopted as standard.

### Confirm information requirements

The DAFF and CeSTII communicated closely, both via email and in person, regarding the indicator definitions. Information requirements were amended to be line with questionnaires from the International Food Policy Research Institute, allowing the data to be integrated with International Food Policy Research Institute data at a later stage.

### Establish output objectives

The required statistics were derived from the indicator list received from the DAFF and amended as necessary by CeSTII.

### Check data availability

Two types of data were required: R&D data and data on technology transfer/extension work. The R&D data currently available were not as comprehensive as what the DAFF required, although data on some indicators (such as R&D expenditure) were in existence up until 2008. There were no data on technology transfer at the time of the survey.

### Prepare business case (including detailed project plan)

The final project plan was presented as part of the business case. The project started on 9 December 2011 and ended 16 January 2013.

## Design

This involves designing the statistical outputs, frame and sampling techniques, tabulation, data collection, statistical processing methodology, definition of archive rules, processing systems and workflow.

### Outputs

The survey's required outputs were determined by the indicators in the tracking system for public investment in R&D in the sector. These were selected to track inputs into the agriculture sector (primarily financial investments and human resources) and the outputs of research, innovation, technology development, and technology transfer and extension. The identified outputs included:

- survey/project reports;
- standard operating procedures;
- policy briefs;
- a database with unit-level data.

### Frame and sample methodology

*Frame construction*

Frame construction involves identifying and specifying the population of interest and the sampling frame, if any.

A registry comprising all entities was compiled from the existing CeSTII database on R&D performers and a list of agricultural R&D entities obtained from the DAFF. This list specified:

- the entity's name;
- a contact person/people and their designation in the organisation;
- the entity's physical, postal and email addresses, as well as telephone and facsimile numbers.

This registry was updated before the questionnaires were dispatched to ensure that the questionnaires reached the right person in the organisation.

The agreement between the DAFF and CeSTII stipulated that the baseline study should focus only on the public sector and not on business entities, except for state-owned enterprises within the business sector. The public sector includes government or quasi-governmental organisations and the higher-education sector, which in this survey included public enterprises and not-for-profit organisations that undertake R&D and/or extension activities.

The Frascati Manual (OECD, 2002) recommends that concepts within the national system of innovation be defined to correspond with concepts in the System of National Accounts conceptual framework, which describes the government sector as "all departments, offices and other bodies which furnish, but normally do not sell to the community, those common services, other than higher education, which cannot otherwise be conveniently and economically provided, as well as those that administer the state and the economic and social policy of the community. (Public enterprises are included in the business enterprise sector.) The System of National Accounts makes the following recommendation for the definition of public enterprises (non-financial corporations): "These consist of resident non-financial corporations and quasi-corporations that are subject to control by government units, control over a corporation being defined as the ability to determine general corporate policy by choosing appropriate directors, if necessary. The government may secure control over a corporation:

- by owning more than half the voting shares or otherwise controlling more than half the shareholders' voting power; or
- as a result of special legislation, decree or regulation which empowers the government to determine corporate policy or to appoint the directors." (EC, IMF, OECD, UN and the World Bank, 1993. p93, par 4.72)

Not-for-profit institutions are those that are controlled and mainly financed by the government but not administered by the higher-education sector (adapted from the Frascati Manual (OECD, 2002)). Within this institutional sector, not-for-profit organisations constitute the most relevant target objects for R&D performance.

This study adopted Agricultural Science and Technology Indicators' categorisation of R&D activities (Agricultural Science and Technology Indicators, 2010), adapted slightly to accommodate science councils as a fourth category in the public sector, similar to the adaptation done on the Frascati Manual (OECD, 2002) institutional sector categorisation in the South African R&D survey series (CeSTII, 2004-2008).

*Sampling technique*

A sampling technique is the specific process used to select entities in a population sample. The survey was purposive in design and followed a census-sampling approach to include national and provincial government departments, science councils and other statutory or research institutions, higher-education institutions, not-for-profit organisations and other likely agricultural R&D entities not specified elsewhere.

*Tabulation plan*

The tabulation plan contains the variables to be collected using the data-collection instrument, any other variables that will be derived from them, and any other classifications to be used.

For this survey, these included:

- human-resource information, such as the number of researchers and technicians by degree level, headcounts and FTEs (that is, staffing adjusted for time spent on research), age, field of science, share of female researchers, and support staff by various categories;
- financial resources, such as expenditure by cost category and funding source;
- research focus, by commodity and by theme;
- innovative activities data;
- output data, including patents and publications.

These indicators were chosen because they would address the key areas of technology development and areas of specialisation of agriculture R&D and extension personnel – areas of investigation by the tracking system. Other S&T indicators were also included (see list of tables at the beginning of this report).

**<u>Data collection</u>**

Agricultural Science and Technology Indicators' data procedures and methodology for tracking R&D investment indicators, which follows international best practice, were adopted (Agricultural Science and Technology Indicators, 2010). The definitions used were in line with the Frascati Manual's guidelines (OECD, 2002) for R&D and the Oslo Manual (OECD/Eurostat, 2005) for innovation. The data-collection instrument was a paper questionnaire based on the variables required to compute the indicators. Time-series data were collected for the main indicators (research investments, research funding sources, research staff totals, extension-work personnel and their activities); the remaining indicators were mostly for the reference period. Additional information in the following was obtained from secondary data:

- GDP and agricultural GDP (source: Stats SA)
- Number of farmers, total donor subscriptions and projects implemented from donor-funded institutions in Africa, Southern Africa and South Africa (source: DAFF).

**Statistical processing methodology**
The statistical processes used mirror the data-management and processing section in Agricultural Science and Technology Indicators' document on data procedures and methodology, These consist of recording data, internally validating data and coding completed questionnaires, data capture using a double-blind data-capture system, data cleaning, imputation for missing data and data analysis.

**Define archive rules**
Archiving will be performed in line with the HSRC's methodology, which provides for secure, off-site storage and retrieval systems for survey data. This will be done a year after the publication of this report, at earliest. Data will be made accessible to the public after a specified period of time.

**Processing systems and workflow**

The workflows that CeSTII has used for previous, similar surveys were retained (CeSTII, 2004–2008). The database and systems were designed and developed by the CeSTII database specialist *in situ*. The fieldwork and management arrangement used experienced CeSTII staff.

## Build

This phase includes developing the survey collection instrument, new software-processing components, configuring workflows, conducting end-to-end testing, finalising production systems and sampling.

### Data-collection instrument

The survey instrument used was a paper questionnaire, which was used in face-to-face interviews. An electronic version was designed in the second phase of the project. The questionnaire was designed to obtain data relating to the suite of indicators identified by the DAFF. The instrument was developed in collaboration with the DAFF.

The questionnaire pack contained the following:

- An explanation of the purpose of the survey.
- A confidentiality clause and a statement of authority to administer the survey.
- Definitions extracted from the Frascati Manual, the Oslo Manual and DAFF documents.
- Place to fill in an institution's details (address, affiliations, organisational structure) and the name and contact details of the person completing the questionnaire.
- Place to fill in data relating to:
    - human resource information, such as number of researchers and technicians by degree level, headcounts and FTEs, proportion of female researchers, and support staff by various categories;
    - financial resources, such as expenditures by cost category and funding source;
    - research focus, by commodity and by theme;
    - outputs, including publications, patents and royalties;
    - extension-work personnel and activities;
    - technology-transfer activities;
    - innovation indicators.
- Any additional information not contained in the questionnaire but crucial to data collection such as the codes booklet.
- Coding or numbering of questionnaires to assist with fieldwork and capturing.

### Process components

New software components were built based on previous systems that HSRC-CeSTII had used for similar survey processes.

### Configure workflows

The workflows were based on systems CeSTII had successfully used in the past. They were adapted from workflows and associated staffing structures used in the national R&D surveys.[5]

### Test end-to-end

A pilot survey of 18 institutions was conducted to test survey procedures and evaluate the survey instrument by gathering actual responses. The pilot survey included processing and analysing the collected data to ensure that correct and relevant data was collected.

[5] HSRC-CeSTII, 2004–2008.

The 18 institutions that took part in the pilot survey were spread across all organisation types (four provincial departments, seven higher-education institutions, two national departments and five science councils).

A clear and comprehensive record was kept throughout the pilot to document difficulties, issues and concerns that could be remedied before the rollout of the main study.

**Finalise production systems**
Production systems were finalised based on the findings of the pilot study. These systems included an operations manual, protocols and training manuals. The development of the database relied on the format and content of the final questionnaire.

**Collect**

This phase involves drawing the sample, setting up the collection and running it according to a detailed project plan.

**Draw sample**
The sample was drawn according to the sample specifications and technique reported above. Since the survey was a census survey, the sample was equivalent to the frame.

**Set up collection**
This process involved preparing the collection strategy, which entailed:

- allocating contracted fieldworkers to provinces/regions and assigning CeSTII staff to supervise them;
- setting up appointments with potential respondents;
- dispatching questionnaires before interviews to familiarise respondents with their contents;
- conducting face-to-face interviews.

Setting up collection also required logistics for the fieldwork.

This included recruiting and training fieldworkers, who had to have at least a first university degree (or equivalent) or a background in agriculture in order to have the confidence and critical thinking necessary to engage with the respondents. A useful recruitment resource was the National Research Foundation's list of interns and university departments of agricultural sciences. Care had to be taken that the overall profile of fieldworkers was demographically representative and met other institutional requirements. Researchers and senior employees conversant with the survey process and subject matter acted as field managers to these fieldworkers.

The project team developed a fieldwork manual, which was used to train the field staff. Training for the first phase was done in Cape Town and Pretoria. It covered the aims of the survey and interviewing techniques, and outlined a code of conduct for fieldworkers. A protocol had to be developed to inform relevant authorities of the research being conducted in their institution as a means of reassuring doubtful or hesitant respondents.

The fieldworkers and researchers were supplied with the necessary resources for efficient collection and communication. An electronic form of the questionnaire was developed as an alternative to providing a hardcopy response. This required conscientious monitoring for data veracity. The DAFF was updated on progress at various times during the fieldwork, and was asked to intervene in cases where respondents were reluctant to respond to the survey.

**Run collection**

The following general guidelines were followed when collecting data:

- all fields of science with an agricultural component were compassed, including social sciences and humanities, as well as R&D performed by not-for-profit organisations;
- fieldworkers had to ensure that all parties understood the instructions to avoid common mistakes like reporting currency in millions rather than thousands, excluding VAT, confusing in-house and outsourced activities, and confusing the surveyor with the institution that commissioned the survey;
- respondents were asked to provide data for the stipulated financial year or nearest complete financial year;
- careful estimates could be provided if the data were not readily available or not in the format required by the questionnaire, provided that this was clearly indicated on the questionnaire;
- fieldworkers and respondents were urged to take extra care when calculating FTEs, which is often problematic;
- non-research activities such as teaching and administration were to be excluded when calculating higher-education institutions' R&D resources.

Initial contact with respondents was made and follow-up or reminder actions enacted. At least three follow-ups were made after initial contact. Interactions with respondents were recorded: when, how and whether they had responded.

Good training of fieldworkers resulted in good management of respondents to ensure that the relationship between the statistical organisation and respondents remained positive. Respondents' comments, queries and complaints were recorded.

The collection was closed when the collection targets were met and agreed upon by the DAFF.

**<u>Process</u>**

Upon receiving a completed questionnaire from the fieldworkers, the data-management coordinator (or statistician) assigned a unique identification code to each questionnaire. These codes and other identification information were entered into the data-processing environment. Each questionnaire then underwent checks by the researcher for fieldwork errors of completeness of information, consistency of responses, and discrepancies (mathematical or textual). Potential errors were investigated by following internal guidelines to manage questionnaire and database discrepancies. This included using a double-blind data-capturing system. Errors were corrected by contacting the respondent by email or phone to clarify or correct the data.

A detailed description of each step of the process follows.

**Classify and code**

Data was classified and coded to facilitate input into the data-processing system.

**Load data into processing environment**

A double-capture system was used when entering data onto the computers to ensure that the codes were accurately captured. This involved having two data capturers independently enter all the data, with the more experienced of the two being the reference point. A separate system was used to check the codes against the original questionnaire and to check the two sets of codes against each other. All discrepancies were corrected at this point.

**Integrate data**
The collected data was integrated with existing available sources. The new data was prioritised over existing agricultural R&D data from the National R&D Survey 2010/11 when considering data for the same variable from different sources.

**Edit and impute definition of terms**
This was an iterative phase, as is normally the case. Some discrepancies arose after the initial discrepancy checks were run. The relevant respondents were contacted to correct the anomalies.

**Derive new variables**
New variables were derived from collected variables to produce summary tables and indicator results as needed.

**Analyse**

This phase consists of acquiring ancillary data, calculating aggregates, preparing draft outputs, validating data, interpreting and explaining results, controlling disclosure and finalising the statistical outputs for dissemination.

**Acquire ancillary information**
Supporting information was gathered and collective CeSTII expertise was engaged to build up a body of information about the topic under examination. Statistics were compared with data from other sources (such as the national R&D surveys and Agricultural Science and Technology Indicators data) and inconsistencies were investigated.

This phase overlapped with the preparation of draft outputs and validation phases, and was performed iteratively.

**Calculate aggregates**
National aggregates were computed for all the statistics and indicators stipulated.

**Prepare draft outputs**
Draft outputs of tables were prepared. These motivated further consistency checks.

**Validate**
Cross-checking summary totals validated the internal consistency of data. Data on agricultural R&D expenditure from the national R&D survey of 2010/11 was used to validate related data in the survey.

**Describe and explain**
Summary data were analysed and explained in draft reports.

**Disclosure control/anonymisation**
Data were anonymised to varying degrees. Summary tables were checked for involuntary disclosure by individual researchers.

**Finalise outputs**
Outputs were finalised after all inconsistencies were clarified. This report was compiled using final data and accompanying analysis.

**Disseminate**

This phase involves updating output systems, producing statistical products, managing the release of products, and managing customer queries.

**Update output systems**
Output systems were specifically designed for this survey. These involved preparing and loading data and metadata onto output databases.

**Produce products**
This report was written by the CeSTII research team. Team members were allocated sections of the report to write and each section was reviewed by another researcher on the team. All data analysis done and tables presented were checked. This included checking that all numbers presented correspond to the data that were extracted, but also re-calculating the totals and percentages presented to ensure that no errors in formulae writing occurred and that data weren't corrupted while being transferred to the report. All data were checked by the in-house data committee, which consists of senior research staff, a data analyst, an applied mathematician and a statistician.

**Manage customer enquiries**
User enquiries will be managed by CeSTII, in collaboration with the DAFF.

## Archive

Archiving consists of managing the archive repository, preserving data and associated metadata, and disposing of data and associated metadata.

**Manage archive repository**
Survey evaluation is an important quality-control measure for future surveys. This entails evaluating the entire survey process, from planning to report-writing, to identify weak points that can be strengthened in future. It also entails evaluating the survey from the respondent's perspective and making sure the survey is of benefit to all parties involved.

**Preserve data and associated metadata**
This was done in line with HSRC institutional policy.

**Dispose of data and metadata**
All data and metadata will be kept on record (or "curated" as it is known at the HSRC).