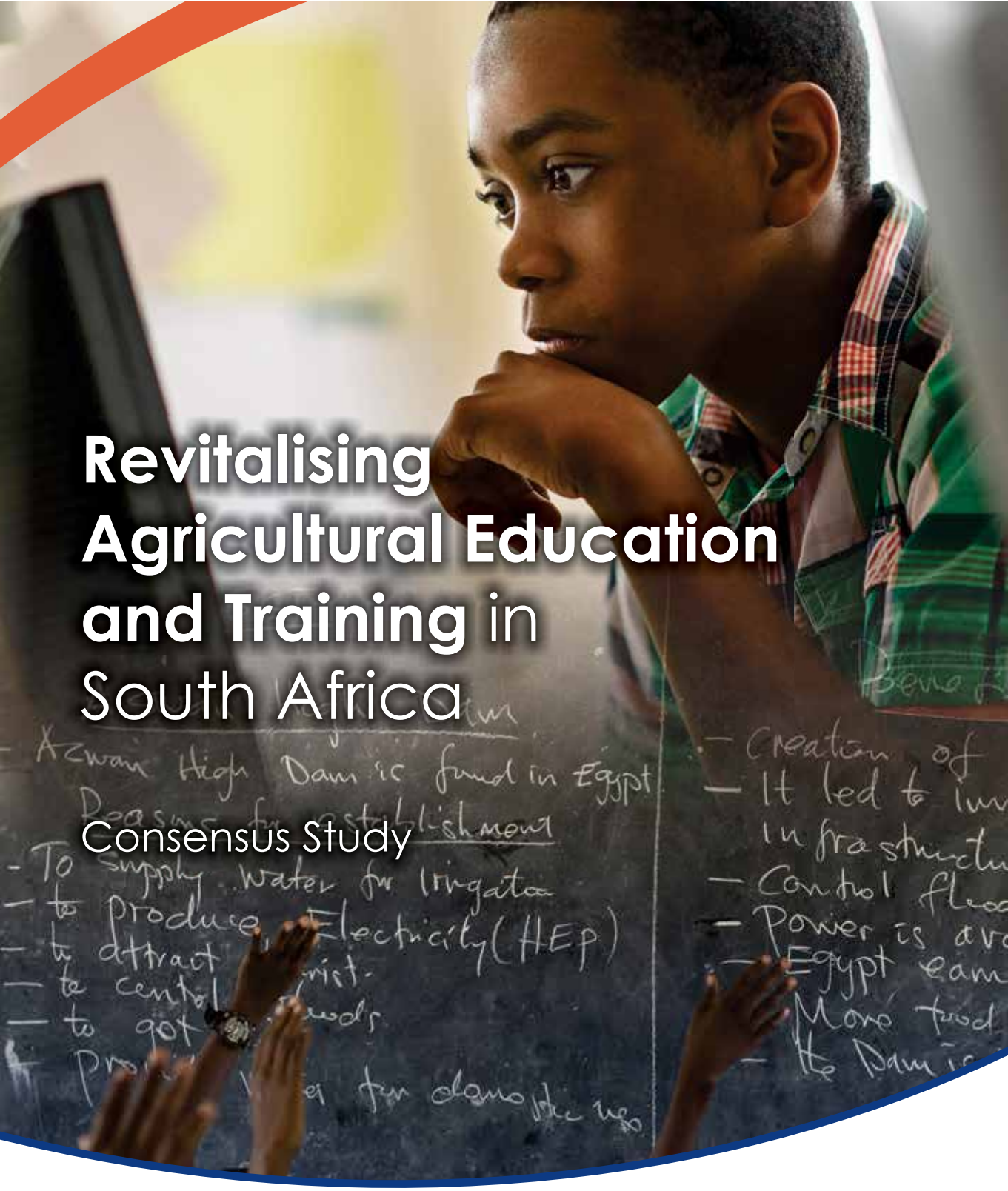

Revitalising Agricultural Education and Training in South Africa

Consensus Study

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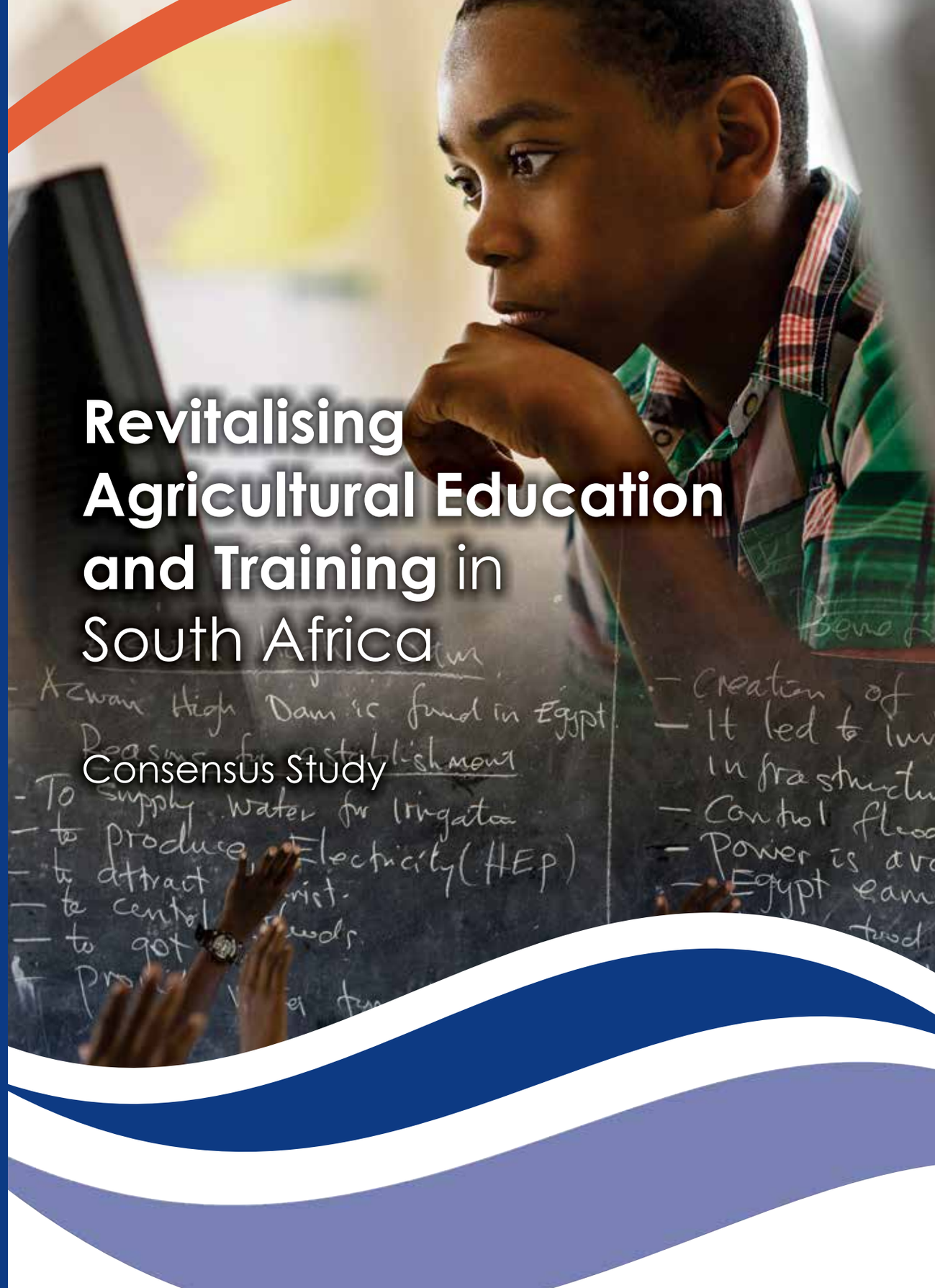
The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science and scholarship for the benefit of society, with a mandate encompassing all scholarly disciplines that use an open-minded and evidence-based approach to build knowledge. ASSAf thus adopted in its name the term 'science' in the singular as reflecting a common way of enquiring rather than an aggregation of different disciplines. Its Members are elected on the basis of a combination of two principal criteria, academic excellence and significant contributions to society.

The Parliament of South Africa passed the Academy of Science of South Africa Act (*No 67 of 2001*), which came into force on 15 May 2002. This made ASSAf the only academy of science in South Africa officially recognised by government and representing the country in the international community of science academies and elsewhere.



Revitalising Agricultural Education and Training in South Africa

Consensus Study

TABLE OF CONTENTS

List of **FIGURES**

List of **TABLES**

List of **ACRONYMS**

AET	Agricultural Education and Training
ABET	Adult Basic Education and Training
ADI	Agricultural Development Institute
AEAS	Agricultural Extension and Advisory Services
AESIF	Agricultural Education and Skills Improvement Framework
AFVC	Agriculture and food value chains
AgriSETA	Agriculture SETA
AIS	Agricultural Innovation System
ANC	African National Congress
API	Animal Production Institute
ARC	Agricultural Research Council
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASGISA	Accelerated and Shared Growth Initiative of South Africa
ATVET	Agriculture Technical and Vocational Education and Training
AU	African Union
AWARD	African Women in Agricultural Research and Development
BATAT	Broadening Access to Agriculture Thrust
BER	Bureau for Economic Research
BSc	Bachelor of Science
BSL	Biological safety level
CAADP	Comprehensive African Agriculture Development Programme
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CESM	Classification of Educational Subject Matter
CEO	Chief Executive Officer
CGIAR	Global agricultural research partnership
CHEC	Cape Higher Education Consortium
CIRAD	French Agricultural Research and International Cooperation Organisation
CoE	Centre of Excellence
CORAF	West and Central African Council for Agricultural Research and Development
CRLR	Commission on Restitution of Land Rights
CPA	Consolidated Plan of Action
CPD	Continuous professional development
CPUT	Cape Peninsula University of Technology
CRDP	Comprehensive Rural Development Programme
CRP	CGIAR Research Programmes
CS	Commissioned studies
CUT	Central University of Technology
DAFF	Department of Agriculture, Forestry and Fisheries
DBE	Department of Basic Education
DRDLR	Department of Rural Development and Land Reform
DHET	Department of Higher Education and Training

DoL	Department of Labour
DPW	Department of Public Works
DST	Department of Science and Technology
DVC	Deputy Vice-Chancellor
EMBRAPA	*Empresa Brasileira de Pesquisa Agropecuária* (the Brazilian Corporation of Agricultural Research)
ERC	European Research Commission
ETDP	Education, Training and Development Practices
ETES	Education, Training and Extension Services
E&T	Education and Training
FANRPAN	Food, Agriculture, and Natural Resources Policy Analysis Network
FARA	Forum for Agricultural Research in Africa
FET	Further education and training
FETC	Further education and training colleges
FoodBev	Food & Beverages Manufacturing Industry SETA
FTE	Further training and education
GADI	Grootfontein Agricultural Development Institute
GCHERA	Global Confederation of Higher Education Associations for Agricultural and Life Sciences
GET	General education and training
GETC	General Education and Training Certificate
GIS	Geographic Information System
GDP	Gross domestic product
GFRAS	Global Forum for Rural Advisory Services
HE	Higher education
HEMIS	Higher Education Management Information System
HEQC	Higher Education Quality Council
HSRC	Human Sciences Research Council
IAD	Institute for African Development
ICAR	Indian Council of Agricultural Research
ICT	Information and communications technology
IFPRI	International Food Policy Research Institute
JTTT	Joint Technical Task Team
KALRO	Kenya Agriculture and Livestock Research Organisation
KARI	Kenya Agricultural Research Institute
KZN	KwaZulu-Natal
MOOC	Massive Open Online Courses
MSc	Master of Science
MUT	Mangosuthu University of Technology
NACI	National Advisory Council on Innovation
NAMC	National Agricultural Marketing Council
NAIPs	National Agriculture Investment Plans
NARS	National Agricultural Research Systems
NASCA	National Senior Certificate for Adults
NATED	National Accredited Technical Education Diploma
NCAET	National Council for Agricultural Education and Training
NCV	National Certificate (Vocational)
NDA	National Department of Agriculture
NDP	National Development Plan

NEPAD	New Partnership for Africa's Development
NER	National Extension Reform
NES	National Extension Support
NETSAFF	National Education and Training Strategy for Agriculture, Forestry and Fisheries
NGO	Non-Governmental Organisation
NIHSS	National Institute for the Humanities and Social Sciences
NMMU	Nelson Mandela Metropolitan University
NPC	National Planning Commission
NRF	National Research Foundation
NSC	National Senior Certificate
NSFAS	National Student Financial Aid Scheme
NSI	National System of Innovation
NQF	National Qualification Framework
OBE	Outcomes-based Education
OECD	Organisation for Economic Co-operation and Development
OVI	Onderstepoort Veterinary Institute
PAETA	Primary Agriculture Education and Training Authority
PALCs	Public Adult Learning Centres
PEA	Participatory Extension Approaches
PGSARD	Postgraduate School of Agriculture and Rural Development
QCTO	Quality Council for Trades and Occupations
R&D	Research and development
RDP	Reconstruction and Development Programme
REID	Rural Enterprise and Industrial Development
RID	Rural Industrial Development
RISG	Research and Innovation Strategy Group
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SAALSDA	South African Agricultural and Life Sciences Deans' Association
SAATA	South African Agricultural Teaching Association
SACNASP	South African Council for Natural Scientific Professions
SADC	Southern African Development Community
SANBI	South African National Biodiversity Institute
SAQA	South African Qualifications Authority
SARChI	South African Research Chairs Initiative
SARIMA	Southern African Research and Innovation Management Association
SASAE	South African Society for Agricultural Extension
SASAS	South African Society for Animal Science
SAU	State agricultural universities
SAYAS	South African Young Academy of Science
SBD	Small Business Development
SDGs	Sustainable Development Goals
SET	Sector Education and Training
SETA	Sector Education and Training Authority
SETASA	Sector Education and Training Authority for Secondary Agriculture
SGB	Standards Generating Body
SHD	Smallholder Development
SHFs	Smallholder farmers
SLP	Short Learning Programme (Short Course)

SMME	Small medium and micro enterprise
SOYD	Social Organisation and Youth Development
SRO	Scientific Research Organisation
STEM	Science, technology, engineering and mathematics
STIAS	Stellenbosch Institute for Advanced Study
STI	Science, technology and innovation
STISA	Science, Technology and Innovation Strategy for Africa
SU	Stellenbosch University
SWOT	Strengths, weaknesses, opportunities and threats
S3A	Science Agenda for African Agriculture
TEAM-Africa	Tertiary Education for Agriculture Mechanism in Africa
the dti	Department of Trade and Industry
TUT	Tshwane University of Technology
TVET	Technical and vocational education and training
UFH	University of Fort Hare
UFS	University of the Free State
UKZN	University of KwaZulu-Natal
UNESCO	United Nations Educational, Scientific and Cultural Organisation
Unisa	University of South Africa
UP	University of Pretoria
US	United States
USAf	Universities South Africa
UCT	University of the Western Cape
VC	Vice-Chancellor
WIL	Work-integrated Learning (Internships)
WRC	Water Research Commission

FOREWORD

The Academy of Science of South Africa (ASSAf) has as a specific mandate the provision of evidence-based scientific advice to South African policymakers on matters of crucial scientific importance. Evidence-based study project activities thus form the core of the Academy's function.

This consensus study was initiated by the ASSAf Science, Technology, Engineering and Mathematics (STEM) Education Standing Committee, deriving from a deep concern about the status of agricultural education and training (AET) in the country. The study seeks to identify and address the challenges facing the AET sector in South Africa. It is a timely study given the important role that this sector needs to play in meeting the United Nations' Sustainable Development Goals.

The study aims to provide evidenced-based information and clear recommendations to policymakers and other relevant stakeholders with an interest in agricultural human capital development. Some of the key findings of the study include inadequate funding for practical-level training; weak linkages to industry for understanding training needs; poor quality and inadequate numbers of educators who are appropriately trained to teach agriculture at school level; and poor linkages in the research–teaching–extension nexus. The recommendations are wide-ranging and very practical. It is hoped that they will be used to influence policymakers and thereby result in an improvement in the quality of AET in South Africa.

Although specifically focused on South Africa – a collation and analysis of international practice within the South African context – the report is potentially a useful resource for other countries on the African continent seeking to strengthen their own AET systems.

The report was developed and guided to its successful conclusion by an 11-member study panel of experts, under the leadership of Prof Frans Swanepoel. It was peer-reviewed by three experts and will be made available in an open access and free format.

The ASSAf Council would like to extend its sincere appreciation to the panel for their expert contribution to the study and the attention with which they carried out their task.

Prof Jonathan Jansen
President: Academy of Science of South Africa

ACKNOWLEDGEMENTS

This study was a collaborative endeavour involving many people from start to finish. Although not an exhaustive list, we wish to thank the following people and organisations for their participation in one way or another to ensure the success of the study.

- The Council of ASSAf for their foresight in commissioning this evidence-based study and their ongoing support during the entire process.
- The Agricultural Research Council (ARC) as the primary sponsor of the study, and in particular Dr Shadrack Moephuli, Chief Executive Officer (CEO) of the ARC for his personal interest and support. De Beers Chairman's Fund for their financial support of the project. In particular, the Centre of Excellence in Food Security, co-hosted by the University of the Western Cape (UWC) and the University of Pretoria (UP), for facilitating a two-month writing secondment for the panel chairperson to the French Agricultural Research and International Cooperation Organisation (CIRAD). A special recognition to Dr Patrick Caron for hosting the chairperson of the panel at CIRAD for this period.
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- Dr Melody Mentz, senior researcher appointed to the study, for her support and inputs into the project.
- All the persons, organisations and champions without whose generosity and time the study would not have been possible.
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- Ms Patricia Scholtz and LedCool for the editing and production of the study report.
- And finally, to the support staff, Ms Zuki Mpiyakhe (study director) and Prof Roseanne Diab, Executive Officer for their contribution and assistance throughout the project.

Prof Frans Swanepoel
Chair: ASSAf AET Study

EXECUTIVE SUMMARY

Agriculture is a key component of the South African economy. Agriculture delivers more jobs per Rand invested than any other productive sector, and remains critical in the face of rural poverty and food insecurity. While the primary agricultural sector contributes about 3% to the country's gross domestic product (GDP), if the entire value chain of agriculture is taken into account, its contribution to GDP reaches about 12%. (Department of Agriculture Forestry and Fisheries (DAFF), 2013. Abstract of Agricultural Statistics. Republic of South Africa) Although the country can maintain the ability to meet national food requirements, more than 7 million citizens experience hunger, while 22.6% of households have inadequate access to food (Stats SA, 2016).

South Africa's agricultural sector faces several challenges – above and beyond the implications of climate change. These include the declining accessibility to quality water sources, the impact of unsustainable food production practices, competition with other industries for the use of arable land, and the failure to effectively address land redistribution.

The sector continues to grapple with its haunting historical legacy. Although the intentions and objectives of policy reform in agriculture over the past 20 years have been quite deliberate in seeking redress, continuous changes and lack of systematic follow-through in implementation have limited the effectiveness of the identified pathways to an equitable sector and society.

Among the primary challenges faced by the sector are the challenges experienced in the broader agricultural education and training (AET) system.

An analysis of the targets set forth in the National Development Plan (NDP) places agriculture firmly on the agenda for the next 15 years (NPC, 2011). Specifically, and in relation to AET, the NDP calls for:

- The creation of an additional one million jobs in the agriculture, agro-processing, and related sectors.
- Increased investment in agricultural technologies, research, and the development of adaptation strategies.
- Expanding the college system with a focus on improving quality.
- Improved skills development and training in the agricultural sector, including entrepreneurship training. This should include the training of a new cadre of extension officers.
- Investigation into whether extension and agricultural services are appropriately located at provincial level.
- Innovative means for agricultural extension and training by the state in partnership with industries.

Additional targets of indirect relevance to AET include increasing enrolment at universities, increasing the number of students eligible to study towards mathematics and science-based degrees, increasing the percentage of PhD-qualified staff in the higher education sector, producing more than 100 doctoral graduates per million per year (from the current 30 to 35 per million per year). Furthermore, the aim is to expand science, technology, and

innovation outputs by increasing research and development spending by government, and through encouraging industry towards increased support.

Whilst on the one hand, AET is firmly on the agenda, on the other hand the implication is that the agricultural sector will be competing for resources with a range of other subject-matter areas; to do so, the AET system needs to articulate its impact areas beyond agricultural production and consider the training of persons who participate in the total agricultural value chain and related sectors.

Key Objectives of the Study

The following key objectives were identified for the study:

- Provide a situation analysis of South African AET.
- Identify the challenges faced at each level and provide a set of recommendations to address these challenges.
- Assess the relevance of curricula to current global challenges of food security, climate change, and poverty alleviation.
- Determine where agriculture graduates get employed after graduation and the roles they play in society.
- Relate findings to best international practices and compare with the situation and needs elsewhere in Africa.
- Provide a set of recommendations to address the identified challenges.

In order to address these objectives, four key questions were posed: (i) where are we now, (ii) where do we want to be, (iii) what would be the road(s) to transformation, and (iv) what conditions will make it work?

Approach

Through the deliberations of the panel at its inaugural meeting, it was agreed that the most appropriate path to achieving the objectives and answering the key questions of the consensus study, was to adopt a two-phased approach; each phase including several commissioned studies to inform the development of the report and the panel's final recommendations.

The Phase I studies provided a comprehensive understanding of the current situation in the AET system. Based on the findings of these studies, a series of more focused, in-depth studies were commissioned for Phase II, resulting in a total of ten papers and/or inputs. An overview of the studies and their respective methodologies is presented in Chapter 2.

Findings

The findings from the consensus study are organised conceptually according to the ideal AET system identified in Chapter 4.

KEY FINDING 1

There are numerous, continued challenges facing AET

These challenges are largely historical, identified early on in South Africa's democracy, and there is an urgent, pressing need to address these issues. This must be done cognisant of the fact that the public education and training system has been in a state of fairly constant reform since 1994. Now is an opportune time for transformation (not more reform for the sake of reform) as the system as it relates to AET is highly fluid.

KEY FINDING 2

AET currently operates within a largely disenabling environment

2.1. Governance and coordination: The system is in dire need of substantial governance reform directed towards greater integration, cooperation, and accountability to maximise the returns on available finances, human capital, and physical infrastructure. A coherent vision of the future agricultural system(s) toward which South African agriculture must move is needed to inform the focus and direction of the future AET system and the governance thereof.

2.2. The case of the agricultural colleges: The colleges have usually been administered and governed by the relevant line department or provincial department, and have not been formally part of the higher education system. This is being revised, with some colleges being moved directly to the Department of Higher Education and Training (DHET). Despite this Cabinet-approved decision, there is still uncertainty about the full implications.

Attempts were made by the study panel to meet with the respective parties to understand fully the situation and to position the panel to make recommendations regarding this important component of the AET system. The engagement was not sufficiently robust to allow for such recommendations to be made. A Joint Technical Task Team (JTTT) to investigate the matter has been appointed by the DHET. Since the JTTT was appointed in late 2016, significant progress had not been made at the time of finalising the study report.

KEY FINDING 3

Relevant institutions and adequate resources are needed to sustain an effective, efficient AET system

3.1 Articulation and integration: Although supported in principle and allowed for within the National Qualification Framework (NQF), there is very little articulation between the various components of the AET system, with key blockages hindering the realisation of a fully integrated system.

The transition from school to post-school education is one such key blockage point. Agricultural subjects at high school may ironically be a disadvantage to students trying to enter higher education, and mathematics is the biggest single blockage in the pipeline, as most science and commerce-related programmes, as

well as vocational programmes at colleges and universities of technology, require mathematics passes. Agricultural curricula at school level need to feed into the system. There is no legal framework to encourage or require systemic relations between universities and colleges of agriculture. The lack of clarity and progress around the agricultural colleges and their positioning within DHET has significant ripple effects on the quality of educational provision and the potential for enhanced articulation.

3.2 Reversing the inverted pyramid: South Africa's post-school inverted pyramid negatively impacts the delivery of AET in the country. Too many institutions focus on academic programmes and too few prepare people for the intermediate and lower levels of skills. This situation is unsustainable when taking into consideration the NDP targets.

Significant growth in enrolments and high-quality graduates are required in the technical and vocational education and training (TVET) colleges for South Africa to 'flip' its inverted pyramid. The important role of the colleges and the potential role of the proposed community colleges are key levers in addressing the situation. Practical and feasible solutions, which are innovative and forward-looking, should be encouraged in order to address the situation.

Complex social and economic factors drive the current over-emphasis on university-level training. Proposed solutions to address the matter must focus on ensuring quality of education, exposure to cutting-edge practical training, and employability of graduates, in order to be successful. This will require innovative collaboration between the components of the AET system and the private sector.

3.3 Funding and resource allocation: Funding for education is a highly contested issue across institutions in South Africa. The need for greater funding for AET was raised at all stakeholder workshops, particularly the need for increased funding to enable institutions to provide practical, vocationally relevant training.

The capacity of schools to effectively deliver agricultural science as a subject is limited by a lack of funding and the absence of appropriate infrastructure for practical training. Funds which are available are not efficiently distributed or effectively managed.

Funding support was identified as a key factor to draw students into AET in post-school education. Access to funding for students, particularly in the colleges where the National Student Financial Aid Scheme (NSFAS) is not accessible, is critical.

The AET system will need to engage in non-traditional approaches for funding for practical-level training, including building linkages to industry and the private sector. In the light of the current turmoil and uncertainty with regard to funding from government, the sector cannot afford to be short-sighted in this.

KEY FINDING 4

An adequate number of appropriately trained graduates are not currently being produced by AET

4.1 Relevance and responsiveness of curricula: There is no shortage of registered qualifications in the field of agriculture in the NQF. To date, the focus has been primarily on production; yet, skills for the agricultural supply chain come from a wider range of disciplines than the specific agriculture-focused qualifications. There is an urgent need for improved relevance in the curricula.

Although there are exceptions, students are primarily educated for commercial agriculture, with little focus on smallholder farmers (SHF) or on the social and human dimensions of agriculture. Linked to the need for relevance, is the need for multi and transdisciplinary approaches to curricula that address modern-day topics, find solutions to grand challenges, such as climate change, and drive economic development.

Training fails to meet the needs of industry and bridge the skills-knowledge-practice gap. Navigating the modern-day world of work requires the development of the so-called T-shaped skills, where depth in discipline-specific knowledge is balanced by a breadth of soft skills. Taking into consideration the important role that entrepreneurship is expected to play in South African economic development, T-shaped skills must be positioned as essential supplements to disciplinary knowledge, rather than add-on components.

Industry stakeholders have specifically expressed a clear need for the inclusion of more practical exposure, internships, and industry placements; the need for the development of combined skill sets; and improved communication between the industry and tertiary education providers regarding AET programmes.

4.2 The AET system is in dire need of quality, qualified educators: The quality of educators, as well as the number of teachers appropriately trained to teach agriculture at school level and in vocational contexts is of serious concern. It will become increasingly difficult to appropriately train adequate numbers of students without addressing the need to replenish and build the cadre of agricultural educators.

The need for an increase in qualified educators is, however, not limited to any one specific component of the AET system; rather, the need for improved skills is critical across the board from school level to PhD level.

4.3 Diversity and transformation in the context of access and meaningful participation: Within higher education, the profile of academics in terms of race remains predominantly white, with at least five out of ten academics with a PhD in a science field being white in 2014. However, the share of whites has decreased over the period 2010 to 2014 (HEMIS, 2016). The discrepancy is most pronounced at the PhD level, with a clear evening out at the Masters and Bachelors level. Initiatives to enable and support black academics to pursue their PhD in the sciences thus remain a high priority.

There are also distinct gender gaps in the agricultural sciences, with significantly lower numbers of female staff in this group; women hold only about 30% of the doctoral qualifications in 2014. The share of female staff has in general increased from 2010 to 2014 (HEMIS, 2016).

Neither the profile of enrolments nor of graduates has shifted over the period 2010 to 2014 with respect to the level of qualification. In 2014, 44% and 40% of the students in the agricultural sciences continue to be enrolled in BSc and certificate or diploma-level qualifications, respectively.

In 2014, white students accounted for only 34% of the total enrolled students in agricultural sciences. Their shares declined at all qualification levels over the period 2010 to 2014. In contrast to the profile of staff, the proportion of female students enrolled in the agricultural sciences has equalled the proportion of male students, whilst graduation of female students exceeded male students, albeit slightly, in 2014 (HEMIS, 2016).

4.4 Professionalisation of extension work: Within the framework of the Natural Scientific Professions Act (No 27 of 2003), the latest fields of practice published under *Government Gazette* Notice 36 of 2014 by the Minister of Science and Technology include extension science as a field of practice. Thus, only registered persons may practise in a consulting, extension, or advisory capacity. The process of professional registration of extensionists with the South African Council for Natural Scientific Professions (SACNASP) was launched in the second half of 2014. The study panel welcomes this development.

The Natural Scientific Professions Act also calls for continuous professional development (CPD). Persons registered as professionals are required by their code of conduct to practise strictly within their area of competence and to maintain and enhance this competence. The study panel views this development as a key opportunity for the sector.

4.5 Use of information and communications technology (ICT) and social media: Across all provinces and levels of education there was little evidence for the use of ICT and social media in education and extension, despite the numerous opportunities these present.

The lack of ICT engagement at educational level translates into poor skills and weak engagement with these technologies in the professional workspace, which is a disadvantage for students.

4.6 Agriculture as first choice and career pathways: Agriculture is not a career of first choice. This creates challenges for effective sourcing of high-quality students for post-school studies. Within higher education there are very clearly articulated career pathways within academia. There is, however, limited understanding or awareness of the vast number of agri-business and entrepreneurship careers that exist along the entire food and nutrition value chain. This lack of awareness is evident at both school and higher education level.

KEY FINDING 5

Linkages and feedback mechanisms need to be intentionally strengthened

5.1 The knowledge triangle: The linkages between research, teaching, and extension are poor, and there is a need for better coordination within this research–teaching–extension knowledge triangle.

5.2 Research and research support: Greater cooperation between the Agricultural Research Council (ARC) and the National Research Foundation (NRF) is urgently needed. These organisations have a similar vision and mission as it relates to capacity development, but a greater level of formalised cooperation towards a more focused contribution to AET is required.

5.3 Research and education to extension: International evidence suggests that fostering agricultural innovation through enhanced research support and entrepreneurship can become a key driver of development. However, this cannot be realised without effective innovation transfer, diffusion, and uptake. In the context of AET this process is facilitated in a very large part by extension and rural advisory services.

The study panel considered the plausibility of implementing a land-grant type model in South Africa. Several case studies in the United States (US), Brazil, India, and Kenya were considered. Each case study was selected for the comparability of context to South Africa, as well as to illustrate how various adaptions of the land-grant model have been implemented globally.

Initial findings support the assertion that adapted, context-sensitive land-grant type models have high potential for success in the South African context. Revising institutional arrangements at governmental level to achieve direct reporting of those responsible for research, education, and extension is difficult to achieve in many African countries, including South Africa. It likely would involve parliamentary action, with divisive and complex politics in budget-constrained environments. The cases of Brazil and Kenya have demonstrated that different organisational structures are workable to achieve the same level of coordination and relevance if steps are taken to ensure that the needed communication, transparency, and trust are in place.

However, creating institutions with integrated organisational charts that link undergraduate and graduate instruction, research, and extension programmes is not sufficient to overcome poor communication and management; an enabling environment, leadership, and good policy also are essential.

5.4 Opportunities for regional partnerships and collaboration: South African institutions have experiences to share in terms of reforms and developments that craft a well-integrated, self-productive, self-regenerating system of education, research, and advisory services. The current consensus study is an exemplar in the respect that it reflects candidly on the system and envisions a transformed future. The very process of conducting the consensus study can serve as a learning opportunity for other countries seeking to undertake similar processes.

Various opportunities for contribution and collaboration within the region were identified in the study. South African institutions should seek to identify ways in which they can participate in continental partnerships that can strengthen AET in the country and contribute to African development. Key role players with significant reputation and leverage should be engaged. Networks, such as the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), provide a platform for this type of highly impactful collaboration.

South African AET institutions should seek ways of providing spaces for more open flow of people, knowledge, and resources among other African countries.

Concluding reflection: Challenges in the South African Innovation System

Since the adoption of the White Paper on Science and Technology (DACST, 1996), the National System of Innovation (NSI) has made progress in several areas. However, various challenges still need to be addressed. Each of the challenges identified by the National Advisory Council on Innovation (NACI) in the South African NSI is relevant to the AET context, and in this respect the AET system represents a microcosm of the South African NSI.

Two further points must be noted. First, agriculture (and the agri-food value chain) has been identified by NACI as one of the key priorities in the NSI as it relates to the water-energy-food security nexus. Working towards an efficient AET system is therefore an urgent national priority. Second, the strong overlap between the key challenges identified by the study panel and the NACI situational analysis affirms the findings of the consensus report and enables prioritisation in addressing the current challenges.

Recommendations

The study panel notes that Recommendations 1 and 2 are core and fundamental to the transformation of the AET system. Without the implementation of these two recommendations, changes will be incremental, uncoordinated, and unlikely to catalyse the scale of change needed. Conversely, the panel is of the conviction that should all the recommendations be implemented, the synergistic gains will be far greater than any individual effort. It therefore stands to reason that the recommendations are closely related and highly integrated.

1
KEY ACTORS MUST ACKNOWLEDGE THE SEVERITY OF THE CONTINUED CHALLENGES IN AET AND THE URGENT NEED FOR CHANGE

The panel recommends that ASSAf should put forth the findings of the consensus study to the Minister of Science and Technology with the request to bring the urgent need for change to the attention of Cabinet.

The panel further recommends that the findings of the study be broadly communicated to key stakeholders in government. These include (but are not limited to) the Ministries of Science and Technology; Agriculture, Forestry and Fisheries; Higher Education and Training; Basic Education; Trade and Industry; as well as all the provincial departments of agriculture.

2
ESTABLISH A MINISTERIAL COMMITTEE FOR AGRICULTURAL EDUCATION AND TRAINING

The panel believes that it is necessary to establish a National Council for Agricultural Education and Training (NCAET) which ensures the inclusion and participation of the linked departments whose policy and programmes need to be synergised with the AET system. A recommendation for a similar statutory body was made in 2003, and has not been implemented – with consequences to the system.

However, the panel appreciates that there is currently a moratorium on establishing new statutory bodies, and therefore recommends that a Ministerial Committee for AET be established as a matter of urgency to look into the critical areas highlighted in this report.

The purpose of the committee will be to oversee activities related to AET for a period of three years, with the goal of addressing the core challenges in the system – most specifically to guide the system towards greater integration, cooperation and accountability.

After this period, an evaluation of progress should be commissioned to determine the effectiveness of the committee. If there is a lack of drastic and significant change, it will be necessary to give consideration to the establishment of the initially proposed statutory NCAET.

3
EXPEDITE THE WORKING OF THE JOINT TECHNICAL TASK TEAM

The panel strongly recommends that the workings of the JTTT on the agricultural colleges be expedited, and that sufficient resource allocations be appropriated to enable its progress. The JTTT should report directly to and work closely with the Ministerial Committee for AET.

4
COMMISSION A DETAILED STUDY ON ARTICULATION PATHWAYS AND CURRICULUM INNOVATION

Once the Ministerial Committee for AET has proposed and approved a coordinated governance framework, a clear matrix of human capital needs (Recommendation 1) and related qualifications, in the context of a well-structured AET Human Capital System, should be developed.

The study panel recommends that based on the human capital needs matrix, an in-depth case study on articulation pathways and curriculum innovation be commissioned to demonstrate practically how a fully articulated system, which leverages ICT innovations and a multi-disciplinary conceptualisation of agriculture, could be designed.

The outcome of the case study will allow for a foresight and modelling exercise which should examine alternatives for implementation and pilot testing (Recommendation 5).

5
INVEST IN A PILOT PROJECT TO TEST THE FEASIBILITY OF AN ADAPTED LAND-GRANT MODEL WHICH EMPHASISES INNOVATIVE CURRICULUM DESIGN AND DELIVERY

The outcome of the articulation pathways and curriculum innovation study (Recommendation 4) will allow for a foresight and modelling exercise to be conducted, which proposes alternatives for implementation and pilot testing of a fully articulated micro-AET system at provincial level, based on an adapted land-grant model.

Innovative approaches to curriculum design and delivery should be piloted within this project, drawing lessons from successful international models (such as EARTH University) and using cutting-edge ICTs.

The panel recommends that the Ministerial Committee for AET (or its successor, the NCAET) be responsible for the oversight and coordination of the pilot study feasibility analysis and the pilot study implementation.

6
STRENGTHEN THE AGRICULTURAL (FOOD VALUE CHAIN) RESEARCH ENVIRONMENT

Greater formalised cooperation between the ARC and NRF is urgently needed. The study panel recommends the establishment of a joint working group to coordinate and integrate efforts between these institutions towards achieving a strengthened agri-food value chain research environment, including funding postgraduate education and research through the development of a resource allocation model to support AET high-level training. Activities in this regard can begin immediately.

There is a need to strengthen the link between research at universities and the activities of the ARC. Increased engagement between the NRF-ARC joint working group and the South African Agriculture and Life Sciences Deans' Association (SAALSDA) can facilitate increased collaboration on high-relevance research projects. The study panel therefore recommends that SAALSDA receives additional support to strengthen its activities.

7
TRAIN THE TRAINERS

Training the trainers is an important priority in sustaining a strong AET system. Specifically, persons engaged in the extension and rural advisory services component of the sector are influenced by AET in multiple ways; they are beneficiaries of AET through the training they receive, but then themselves become educators and facilitators of knowledge. For this reason, the training of extension workers should receive substantial focus, as they have the potential to be the primary agents through which innovation is translated from the laboratory into practice.

In this context, the study panel recommends: (i) the establishment of a bursary fund for persons training to be educators in AET, with an internship service component of at least two years to retain skills; and (ii) more purposeful use of Sectoral Education and Training Association (SETA) funding for reskilling and upskilling extension workers, in line with the professional registration and for continuous professional development.

8
FOSTER LINKAGES THAT INCENTIVISE COLLABORATION, PROMOTE INNOVATION, AND DIVERSIFY THE FUNDING BASE

The study panel recommends that the Ministerial Committee constitute a special working group to investigate and propose strategies to increase the collaboration and partnership between AET and related industry and business partners, in order to promote inclusive innovation in the agri-food value chain. These partnership agreements should consider platforms for internships and practical training opportunities for students in the AET system (Recommendation 9), and should propose an incentive-based structure for industry and business partners to increase participation.

High-net worth persons with an interest in the agriculture and food sector can play an important role in funding AET. Opportunities of this nature should be explored and pursued in the South African context.

9
INCREASE THE ATTRACTIVENESS OF VOCATIONAL TRAINING THROUGH A COMBINATION OF INCENTIVE STRUCTURES

Skills-based training, particularly around high-demand skills, clearly has a fundamental role to play in economic growth, reducing (youth) unemployment, and improved livelihoods. The study panel recommends that the Ministerial Committee sets up a task team to develop a holistic model for vocational AET that takes into consideration successful global models, as well as the governance reform required in South Africa. The task team should develop proposals on how to creatively and efficiently incentivise investment and participation in vocational training by industry, business, students, and educators.

10
MONITORING, EVALUATION, AND LEARNING FOR UNDERSTANDING TRANSFORMATIONAL CHANGE

In South Africa, there is an urgent need for the development of responsive informational and monitoring data on the AET system. The Minister has assigned NACI the task of developing and hosting a science, technology and innovation (STI) data portal for the NSI, a central repository that will be important in the establishment of research and strategic intelligence. The panel recommends that the Ministerial Committee collaborates with NACI, as well as a monitoring and evaluation expert to develop AET-specific indicators which feed into and align with the broader national data portal. Collaboration with the NRF's new division for Strategy, Planning and Partnerships should also be explored to enhance foresight capabilities, including strategic planning, modelling and analysis of

"critical technology needs" to support sustainable agriculture as a means of systematic analysis and interpretation of data and perspectives to better understand trends and future challenges to enhance AET.

An important component of this will be to design and conduct a national tracer study to understand graduate employment in the sector.

CHAPTER 1: Introduction

The Inception of the Study

The initial request for the study was presented to the Academy of Science of South Africa (ASSAf) by the South African Agricultural Teaching Association (SAATA) after the compilation of a report on challenges facing agricultural schools. Based on the report, the Science, Technology, Engineering and Mathematics (STEM) Standing Committee of ASSAf was convinced that the request by the association had merit. The proposal for the current consensus study was drafted after consultation with stakeholders and inputs from the ASSAf Council.

In 2013, ASSAf commissioned the consensus study to identify the challenges facing agricultural education and training (AET) in South Africa, and in February 2013 the panel members appointed for the consensus study were approved by the ASSAf Council.

The study was chaired by Prof Frans Swanepoel (former Deputy Vice-Chancellor: Research and Innovation, University of the Western Cape; currently Professor at Future Africa, University of Pretoria). Biographies of all panel members are included in Appendix 1.

The Relevance

The consensus study was commissioned at an opportune time, and the findings from the study are of direct interest to at least three government departments who have previously expressed the need for and highlighted the relevance of the study.

The **Department of Higher Education and Training** (DHET) and the **Department of Agriculture, Forestry and Fisheries** (DAFF) seek advice on how to most effectively establish working relationships between agricultural training colleges and how best to address issues of articulation between colleges and universities. Both departments seek to understand more clearly how the agricultural colleges should link to the higher education and training sector in the context of the proposed shift of the colleges from DAFF to the DHET. The study will inform the deliberation of the Joint Technical Task Team (JTTT) which has been commissioned to provide in-depth recommendations on the way forward with regard to this shift. The study will also provide valuable insights to the recently established National Education and Training Forum for Agriculture, Forestry and Fisheries (NETFAFF), which is responsible for the implementation of the revised National Education and Training Strategy for Agriculture, Forestry and Fisheries (NETSAFF).

DAFF seeks advice on the future provision and management of public extension services in the country.

The **Department of Science and Technology** (DST) seeks to understand more clearly the importance of the agricultural and life sciences in the context of growing the knowledge-based economy, particularly from the perspective of the PhD as key driver and the 2020 Strategy of the National Research Foundation (NRF).

Simultaneously, the **Agricultural Research Council (ARC)** completed its statutory five-year review in mid-2015 and the findings from the study can inform critical decision-making for the increased impact of the ARC's work in South Africa as it seeks to respond to the review and implement its findings. Similarly, the recommendations of the ARC review are most appropriate to inform the recommendations put forward in this study report.

In addition to the targeted interests of the above, the importance of the study is inextricably linked to the national development agenda.

The 2013 National Planning Commission (NPC) report highlighted that "**a significant resurgence in AET is urgently required**" if South Africa wants to reach the target of creating **at least a million jobs within the agricultural value chain by 2030**.

The Strategic Position of the Academy

ASSAf aspires to be the apex organisation for science and scholarship in South Africa, recognised and connected both nationally and internationally. Through its consensus studies ASSAf facilitates the production of authoritative reports on issues of national importance with the aim to impact policymaking.

As an independent body that holds the Membership of many of the most prominent scientists in the country, the Academy can draw on a pool of committed expertise across disciplines and across universities and other science-based organisations to address questions related to the production of high-level capacity for South African society and its economy. The impact of earlier consensus studies is clear evidence of the high quality and influential nature of these reports.

The ground-breaking *PhD Study* (2010) remains the definitive study in South Africa articulating the *status quo* of PhD training in the country, and has come to serve as a reference point for monitoring progress in this regard nationally. Furthermore, the study provided a solid foundation for the establishment of key national initiatives – most pertinently the national PhD as key driver initiative which has been accepted by DHET and DST and is coordinated by the NRF.

Similarly, the study on the *State of Humanities in South Africa* (ASSAf, 2011) led to the establishment of the National Institute for the Humanities and Social Sciences (NIHSS), and has played an unquestionably important role in arguing for the fundamental role the humanities play in the national development agenda.

The AET Consensus Study Approach

During the period 2013-2016, the study panel held a total of five face-to-face panel meetings, and hosted a national Imbizo at the NRF in partnership with the Standard Bank Centre of Agribusiness Development and Leadership (Stellenbosch University (SU)) under the auspices of the NPC.

The inaugural meeting of the panel was held from 2-4 October 2013 at the Stellenbosch Institute for Advanced Study (STIAS), SU. Through the deliberations of the panel at this meeting, it was decided that the most appropriate path to achieving the objectives of the consensus study was to adopt a two-phased approach – each with a number of commissioned studies to inform the development of the report and the panel's final recommendations.

An iterative process of internal and external review was implemented during the study – allowing for panel member and expert feedback on the commissioned studies.

In accordance with ASSAf policy, the report was peer-reviewed to critically examine the findings and recommendations of the study. For this purpose, the following individuals provided useful input: Prof Malcolm Blackie (Professor Emeritus of Soil Sciences at the University of Zimbabwe, and RUFORUM advisory board member currently living in the United Kingdom), Dr Lindiwe Sibanda (Chief Executive Officer and Head of Mission of the Food, Agriculture, and Natural Resources Policy Analysis Network (FANRPAN)), and Dr Joyce Chitja (African Centre for Food Security at the University of KwaZulu-Natal (UKZN) and ARC Board Member).

Study Timeline

2-4 October 2013

Inaugural Meeting
Phase I Studies commissioned

July 2014

Panel Meeting Two
Phase I Studies presented
Phase II Studies commissioned

September 2014

National Imbizo
In partnership with the Standard Bank Centre of Agribusiness Development and Leadership of Stellenbosch University and the National Planning Commission (NPC)

October 2014

Panel Meeting Three
Revised Phase I Studies presented
Phase II Studies progress reports

May 2015

Panel Meeting Four
Phase II Studies feedback and input

October 2016

Consultative Session held with the South African Agriculture and Life Science Deans Association (SAALSDA) hosted at the 5th RUFORUM Biennial Conference

The final study report was approved by the ASSAf Council in March 2017.

The Commissioned Studies

Through the deliberations of the panel at its inaugural meeting, it was decided that the most appropriate path to achieving the objectives of the consensus study was to adopt a two-phased approach, each including a few commissioned studies (CS) to inform the development of the report and the panel's final recommendations.

The Phase I studies provided a comprehensive understanding of the current situation in the AET system. Based on the findings of these Phase I studies, a series of more focused, in-depth studies were commissioned for Phase II, resulting in a total of ten papers and/or inputs.

An overview of each of the studies and their resultant outputs is described below.

Envisioning the Future (CS1)

The first study is a conceptual paper by **Bongiwe Njobe** which envisions the future of agriculture in general and AET in particular in South Africa. The paper reflects on the critical elements of policy and practice that potentially impact on the existing system in order to present a context for a future vision for the system.

Whilst the starting point for the envisioning study is biased towards the agricultural policy environment, consideration is given to the higher education and science and technology policy environments and expectations from the study. Given the linkages and impacts of the agricultural sector on other economic and social sectors, reference is made to the possible influences of other sectors where appropriate.

The paper attempts to define what a future system would look like, what the expectations of such a system would be, and how it would function. More specifically, it considers how effective working relationships could be established between different AET role players within such a new system, and how issues of articulation within the system could be addressed. The findings of this study are primarily incorporated in Chapter 4; however, the foundational arguments are included in the description of the South African context in Chapter 3.

Mapping the System (CS2&3)

The second and third contributions aim to map the AET sector in South Africa.

Johan van Rooyen, **Jan Greyling**, and **Johann Boonzaaier** undertook a mapping exercise of the AET landscape focused on institutional responsibilities and relationships at a national level (CS2). In their paper they identify and describe the (national) stakeholders in AET, the relationships and interactions (or lack thereof) between these stakeholders, and the barriers which inhibit or restrict cooperation between them.

The detailed map is both described and graphically depicted in the report in Chapter 3. In their paper, Van Rooyen *et al.* also provide strategic directions and pointers based, *inter alia*, on interactions with stakeholders during the investigation, and suggest areas for further research and analysis.

Luvuyo Mabombo and **Linus Opara** conducted a similar mapping exercise, but focusing on the provincial rather than the national AET landscape. Through provincial workshops these investigators explored the AET system in terms of educational institutions and other public and private stakeholders with an interest in AET, including professional associations, unions, and other appropriate bodies.

Based on a series of feedback sessions at the panel meetings, Mabombo and Opara (CS3) describe governance and management in the provincial AET system; the relationships and the possibilities for articulation between the different AET providers; and the typical career paths in agriculture from training to earning, in particular, career paths in science, farming, extension, and education.

Mabombo and Opara also provide reflections on the funding of AET and the quantity and quality of teaching skills available at provincial level, as well as the role of information and communication technologies and social media. Their findings are reflected in Chapter 3, along with the mapping of the national system.

Understanding the Teaching, Research and Extension Nexus in South Africa (CS4–7)

The next four commissioned studies focused in depth on three separate, but interrelated aspects of the national AET landscape, namely (i) education, (ii) extension, and (iii) research. The results of these studies are discussed in Chapter 3.

Volker Wedekind reviewed the first of these – education (CS4). His work reflects the nested nature of agricultural education within a wider education system that shapes, enables, and constrains AET. This paper therefore provides a broad overview of the South African education system in order to locate the AET system within it.

Wedekind begins with an outline of the architecture of the South African education system post-1994, including an analysis of how the vestiges of the apartheid system have continued to mark the system in various ways. Thereafter, he discusses the general education system, focusing on agriculture in the curriculum and the state of agricultural high schools. Existing AET provision in the tertiary or post-school system is also described.

Wedekind ends with a discussion of some of the possibilities for agricultural education and training within the new landscape, and the possible blockages that may arise.

Nienke Beintema, in collaboration with **Melody Mentz** and **Aldo Stroebel**, analysed the demographic profile of South African tertiary education in agricultural sciences (CS5) using data available through the Higher Education Management Information System (HEMIS) of the DHET. The data were used to investigate numerous common knowledge notions about the profile of students and staff.

The paper by **Kristin Davis** and **Fanie Terblanché** summarises the available literature on extension and advisory services in South Africa and internationally (CS6).

More specifically, Davis and Terblanché review the issues and challenges facing the national and international agricultural extension landscape in terms of the policy

environment; different governance models; capacity, management and advisory service organisation; and the approaches, tools and methods used to fulfil extension functions. They consider the extension characteristics that affect the performance and impact of advisory services and examine the ingredients for effective provision.

Research in the South African AET system is best explored within the context of the South African ARC. During 2015, the ARC conducted its statutory five-year review. Based on the review documentation, and their participation in the process, **Frans Swanepoel** and **Aldo Stroebel** provide an analysis of the current positioning of the ARC and the most pressing issues facing the institution within the South African AET landscape. The insights and linkages emerging from the review are integrated into the consensus study report where relevant (CS7).

Opportunities for South African AET to Support the Science Agenda for Agriculture in Africa (CS8)

In his paper, **Mandi Rukuni** explores the opportunities for South Africa's AET system to support the new Science Agenda for Agriculture in Africa (CS8). This new science agenda requires innovative educational and training approaches that are more connected to the new challenges facing rural communities and that build the capacity of young people to be part of the transformation of the agricultural sector. The science agenda now has broad stakeholder buy-in and has been endorsed by the African Union (AU), the New Partnership for Africa's Development (NEPAD), as well as all Africa's major sub-regional organisations, as the main framework for driving science and technology in the Comprehensive African Agriculture Development Programme (CAADP) process.

Rukuni explores the implications of this unfolding integration of the science agenda into the CAADP programmes and Results Frameworks, as well as the AU's Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. More specifically, Rukuni explores the opportunities that present themselves for AET institutions in South Africa to make a contribution to these developments.

Integration and Governance Reform (CS9&10)

Ensuring that the knowledge and educational needs of food systems are met poses organisational and structural questions across the globe. How can the next generation of scientists, educators, and entrepreneurs access cutting-edge research results? How can educational programmes be designed to be relevant to current issues, while at the same time anticipating the skills that will be needed 20 years from now?

In her paper (CS9), **Alice Pell** attempts to answer these questions through an investigation of the experiences of three countries – Brazil, India, and the US – to determine how these can inform the ongoing development of educational and research programmes that support the development of South Africa's food system.

Pell explores institutional arrangements, organisational structures, and social and economic contexts to see how the agricultural knowledge system can be structured to deliver a safe, adequate, and affordable food supply, while simultaneously providing strong environmental stewardship and good livelihoods for those working in food production, processing, and marketing.

The goal of this paper is to promote discussion within South Africa on the strengths and weaknesses of the current system and to develop a vision of what food system education and research should look like in the future. To this end, Pell analyses the successes and failures of several education, research, and outreach systems to assess which approaches are most relevant and appropriate for the South African context and goals. The findings and recommendations of Pell's work are provided in Chapter 4.

Taking into consideration the insights gleaned from all the commissioned studies and the panel deliberations, **Frans Swanepoel** and **Aldo Stroebel** reflect on the conceptualisation of an ideal AET system (CS10). Drawing on the recent edited book, *Towards Impact and Resilience: Transformative Change in and Through Agricultural Education and Training in sub-Saharan Africa* (Swanepoel, Ofir and Stroebel, 2014), they reflect on the pathways to the transformative change required to position AET in South Africa to fulfil its role in developing the requisite capacity for an agro-food-processing value chain that can provide nutritious food to the population, whilst contributing to improved livelihoods.

CHAPTER 2: Methodology

Key Objectives and Aims

Several objectives were agreed upon for the consensus study. The deliberations of the panel, as well as the selection of the commissioned studies, were targeted towards investigating each of these objectives. When considered together, the objectives allowed the study panel to reflect on four key questions in the context of AET in South Africa. The objectives and the associated key questions are summarised below:

Key Question One: Where are we now?

This question sought to understand what the *status quo* of AET in South Africa is, but also to understand what factors led to the current situation. Through its deliberations and commissioned studies, the panel sought to understand the *status quo* from an integrated systemic perspective. This key question relates directly to several of the study objectives, and it is answered in an integrated fashion by the different commissioned studies.

STUDY PANEL OBJECTIVE	COMMISSIONED STUDIES LINKED TO OBJECTIVE
Provide a situation analysis of South African AET	National Mapping Study (CS2) Provincial Mapping Study (CS3) Nested Overview of the Education System (CS4) Demographic Analysis of Tertiary Education (CS5) Analysis of Extension and Advisory Services (CS6) Critical Reflection on the ARC Five-year Review (CS7)
Identify the challenges faced at each of these levels and provide a set of recommendations to address these challenges; to enhance the attractiveness of agricultural education and training; and to increase the number of students studying these courses successfully.	National Mapping Study (CS2) Provincial Mapping Study (CS3) Nested Overview of the Education System (CS4) Analysis of Extension and Advisory Services (CS6) Critical Reflection on the ARC Five-year Review (CS7)
Assess the relevance of curricula to current global challenges of food security, climate change, and poverty alleviation. *Determine where agriculture graduates get employed* after graduation and the roles they play in society.	Provincial Mapping Study (CS3) Nested Overview of the Education System (CS4) Analysis of Extension and Advisory Services (CS6)

Key Question Two: Where do we want to be in the future?

A solid situation analysis which considers the system in its totality, as well as the intersections with other systems, creates the space to reflect on an ideal future. This key question sought to rethink what an ideal situation would look like in the future. The panel and the commissioned studies focused both on the national system and on the continental role that AET in South Africa can play. This guiding question relates directly to one study objective, and is answered in part by two commissioned studies.

STUDY PANEL OBJECTIVE	COMMISSIONED STUDIES LINKED TO OBJECTIVE
Relate findings to best international practices and compare with the situation and needs elsewhere in Africa, and provide a set of recommendations to address the challenges.	Envisioning the Future (CS1) Opportunities for South Africa to contribute to the Science Agenda for African Agriculture (S3A) (CS8) Governance and Reform – an International Perspective (CS9)

Key Question Three: What would be the road(s) to transformation?
Key Question Four: What conditions will make it work?

These two guiding questions relate directly to one study objective, and are answered in part by two commissioned studies (CS9 and 10). However, the findings and insights reflected throughout this report provided critical inputs into answering these key questions.

STUDY PANEL OBJECTIVE	COMMISSIONED STUDIES LINKED TO OBJECTIVE
Relate findings to best international practices and provide a set of recommendations to address the challenges.	Governance and Reform – an International Perspective (CS9) A Reflection on the Ideal AET System (CS10)

Commissioned Study Methodologies

Envisioning the Future (CS1)

Njobe contemplated various frameworks for strategic thinking as a basis for developing a vision statement for the AET study panel.

Ideally, the use of scenario (planning) option analysis and/or market future analysis would have been more accurate in terms of creating a vision for the future of AET in South Africa, as it is a complex challenge that has been the subject of numerous reviews over the past two decades.

However, in the light of the time and resource constraints, the study document draws on the knowledge, experience, and perspectives of the panel members, invited experts, a literature review, and a SWOT (strengths, weaknesses, opportunities and threats) analysis that included consultative workshops with critical stakeholders.

National Mapping Study (CS2)

Van Rooyen *et al.* considered an analysis of the AET system through the use of social network analysis techniques, as presented by Borgatti *et al.* (2013), but the use of this methodology was dismissed given the limited scope of the study.

In consultation with the chair of the ASSAf AET study panel, it was decided to rather construct an AET map that identifies the relevant stakeholders and reflects their interaction (or lack thereof). It was envisioned that this map could assist in the identification of areas of duplication, non-cooperation, and other structural challenges.

The construction of the map took place in a two-phased process. The first phase consisted primarily of a desktop study in which the perceived stakeholders were identified and their interaction evaluated. This was supplemented with telephone interviews and participation in some of the ASSAf – AET provincial mapping study meetings. Collectively this resulted in the compilation of a first draft national AET stakeholder map.

During the second phase, this map was presented in person to some of the stakeholders identified for validation and improvement. Stakeholders were also asked to provide their insights as to how the AET system should be improved.

Provincial Mapping Study (CS3)

Workshops were held in each of South Africa's nine provinces in order for **Mabombo** and **Opara** to obtain inputs directly from stakeholders on AET within the provinces. The purpose of the provincial mapping was to understand the system in terms of:

- Institutions providing AET and qualifications awarded at provincial level. This included describing the interrelationship of the various actors with each other, and illustrating clearly where articulation between institutions or providers is possible.
- Stakeholders with an interest in AET, including public and private stakeholders at all levels. This also included professional associations, unions, and other appropriate bodies.
- Governance and management.
- Typical career paths in agriculture from training to earning. This included broadly describing career paths in science, farming, extension, and education.

An average of 20 stakeholders was at each provincial workshop, representing government (agriculture and education), academia, students, as well as farmers and agri-business. The various provincial case studies were analysed and the findings synthesised to identify common themes and challenges for integration into the consensus study report.

Understanding the Teaching, Research, and Extension Nexus: Education (CS4)

Wedekind drew on his personal research and a desktop review to provide a synthesis and overview of the education system in South Africa and to articulate how AET is nested within this broader system.

By situating the AET system within the broader South African system, Wedekind used policy analysis to identify the origins of various educational challenges facing the system broadly, and highlighted blockages pertinent to AET.

He provided a synthesis of historic policy development and drew on current educational policy frameworks to identify potential opportunities for AET within the education and training landscape.

A Demographic Profile of South African Tertiary Education (CS5)

Beintema extracted and synthesised data from HEMIS to compile a quantitative profile of the students and staff at South Africa's higher education institutions.

The study was somewhat hampered by restrictions inherent to public domain HEMIS data. For example, the manner in which agricultural engineering and veterinary medicine is coded in the Classification of Educational Subject Matter (CESM) system resulted in these disciplines being omitted from the dataset. The CESM system also underwent a major revision in 2009 and as a result the 2005 to 2009 data cannot be compared to the post-2009 data. At the time of the study the data available in the public domain did not extend beyond 2013. Missing data on gender and race also meant that a small percentage of students and staff were omitted from the analyses of these demographic characteristics.

Understanding the Teaching, Research, and Extension Nexus: Extension (CS5)

Davis and **Terblanché** conducted a desktop study of international extension and advisory research from 2001 to 2015. They utilised the 'best-fit' framework of Birner *et al.* (2009) to examine policy environment, governance structures, capacity and management, and extension approaches, and organised the identified challenges that the sector is facing according to the framework. The best-fit approach embraces both the pluralism of approaches used today and the diversity found within agricultural innovation systems (GFRAS, 2012).

The framework looks at the impact pathways and influencing factors for successful performance, and the impact of extension services. It starts with the contextual factors or 'frame conditions', including the policy environment, the general capacity of service providers, and the production/farming systems and community aspects. The framework then looks at the characteristics of the advisory service system that must respond to the frame conditions. These characteristics include governance structures, capacity, management, and extension techniques or methods used. These frame conditions and characteristics then affect the performance of the service. Additionally, the response through capacity and decision-making of farm households leads to impact.

Understanding the Teaching, Research, and Extension Nexus: Research (CS7)

Swanepoel and **Stroebel** critically analysed the findings of the ARC five-year review from the perspective of the intersection between the ARC and the broader AET system.

The findings and recommendations from the review process were used to reflect on specific factors, including stakeholder relationships, relevance of the science, and the relationship between the research–teaching–extension nexus and governance reform.

Alignment with Science Agenda for African Agriculture (CS8)

Based on his extensive experience on the continent and first-hand participation in the development of the Science Agenda for Africa, **Rukuni** provided an overview of the S3A and its core purpose.

Through a combination of literature review, expert input, and panel engagement, Rukuni provided critical commentary on the potential role of South Africa in the African agenda, as well as the benefits to AET nationally from alignment and engagement.

Integration and Governance Reform (CS9)

Pell selected the US, India, and Brazil as case studies to determine if the experiences of these countries can inform the development of educational and research programmes to support the development of South Africa's food system.

These countries were selected because they all have endeavoured to link agricultural outreach, research, and education; their experiences have been well documented; each has made distinctive contributions to the organisation and delivery of food system research and education; and each faces problems similar to those of South Africa and therefore has experiences that are relevant to the South African context.

Like South Africa, these are culturally and economically diverse countries that face problems of inequality and discrimination, but have strong commitments to democracy, inclusive development, and improved livelihoods for all citizens. Agriculture has considerable economic and social importance in all three nations and all have experienced marked failures and impressive successes in generating knowledge and providing information to ensure that the food system contributes to economic, environmental, and human health.

Towards the Conceptualisation of an Ideal AET System (CS10)

Swanepoel and **Stroebel** drew on the insights of their own research and practice to provide an overall synthesis framework for an ideal future AET system.

The framework took into consideration international literature and the national context. The conceptualisation is based on a peer-reviewed edited book by Swanepoel *et al.* (2014).

Agriculture on the Forefront of the International Agenda

The world population is hungry and malnourished

About 40% of the world's population is either under or over-nourished to the extent that their health and life expectancy are affected; about 900 million people are undernourished and two billion are overweight, a quarter of whom are obese. A revolutionary change in the global agriculture and food system is needed if we are to nourish today's 795 million hungry and the additional two billion people expected by 2050. Africa and South Asia are the areas with the highest levels of under-nutrition, yet both face increasing challenges related to over-nutrition and non-communicable disease (McArthur, n.d.).

Increase in population size means more food is needed

Humanity needs to substantially increase the amount of food it produces to meet the needs of a growing population and rising average incomes per person.

The rapidly growing population is increasingly living in urban areas

In 1970, about a quarter of the African population lived in urban areas. By 2050, nearly 60% of Africans will live in cities (World Bank, 2015). This situation will require significant shifts in food production and distribution, necessitating a focus on the agro-food-processing chain, as opposed to a focus on productivity.

Agriculture both contributes to and is highly susceptible to the effects of climate change

Agriculture accounts for approximately 14% of greenhouse gas emissions, and 25% when including forestry and other land use. The major drivers of the problem are deforestation, soil and nutrient management, and livestock emissions, so a 'business as usual' approach to boosting global food production would have substantial negative consequences for climate change.

Due to its dependence on the biophysical environment, agriculture is the economic sector most uniquely susceptible to changes in climate patterns.

Agriculture will need to provide food, but it can also secure incomes

If done correctly, agriculture, forestry, and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centred rural development and protecting the environment.

Already, agriculture is the single largest employer in the world, providing livelihoods for 40% of today's global population, and it is the largest source of income and jobs for poor rural households (UN, n.d.).

The Sustainable Development Goals (SDGs) clearly illustrate the importance of the agricultural value chain in the global development agenda, linking agriculture to no fewer than 11 out of 17 goals (UN, n.d.).

More than any other sector, agriculture is the common thread which holds the 17 SDGs together.
Investing in agriculture can address not only hunger and malnutrition, but also other challenges, including poverty; water and energy use; climate change; and unsustainable production and consumption; as well as protecting biodiversity on land and in water.

Continental Developments and Opportunities

Two hundred and twenty-seven million of the world's chronically hungry live in Africa. This translates to approximately 30% of this group (Farming First, n.d.).

Seven out of ten people living in sub-Saharan Africa are farmers (compared to the US, where the ratio is two out of a hundred); yet, Africa has to rely on imports and food aid to feed itself. Though it is the poorest continent in the world, it spends about $50 billion a year buying food from rich countries (Gates and Gates, 2015). Bill and Melinda Gates made their 'big bet' that Africa would be able to feed itself by 2030 – an ideal which will only be attainable by **accelerating the rate of innovation and access to agricultural extension** services for smallholder farmers.

Sub-Saharan Africa is considered the 'youngest' region though the majority of this younger population remains unemployed and their skills and capabilities under-utilised. Sixty per cent of the continent's unemployed are aged 15–24 years and about 40% of Africa's workforce is under the age of 23 (Swanepoel and Stroebel, 2016).

Science can and should drive transformation of agriculture in Africa. Science contributes towards making agriculture in Africa more productive, competitive, sustainable, and inclusive. Scientific solutions for agricultural transformation need to be pursued further, while recognising the fragility of African environments, its rich biodiversity, and the complexity of the agricultural production systems across Africa. Transforming Africa's agriculture requires a science system that produces both 'technical' and 'institutional' innovations.

Encouragingly, political support for African agricultural development and the role therein of science, technology, and innovation has reached an apex on the continent. This impetus for a science-driven agriculture in Africa requires innovative educational and training approaches that are more connected to the new challenges facing rural communities and that build the capacity of young people to be part of the transformation of the agricultural sector. Ultimately, science and innovation have to be mainstreamed as an essential part of agriculture-led social and economic transformation in Africa.

The need for transformation in African agricultural has been widely acknowledged. However, despite the plethora of programmes and initiatives, as well as significant investment, the results to date have not met expectations. This can be attributed in part to a lack of coordination between initiatives and role players and the fragmented nature of the approach to change. The past three years have brought about a number of notable developments which hold promise for a more focused and coordinated attempt at effecting the needed change.

The first development is the articulation of the AU's vision for the continent, **Agenda 2063**, which envisages "[a]n integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in global arena" (AU Commission, 2015). This is a vision that is expected to be achieved over a 50-year timeline and thus takes into consideration the reality of where the continent is today and the complexity of moving towards the future. The Science, Technology and Innovation Strategy for Africa (STISA-2024) – accepted by Heads of State and Government to replace the 2005 Consolidated Plan of Action (CPA) has prioritised food and nutrition security and the eradication of hunger as one of six focus areas (AU, 2013).[i*]

Over the next ten years, the agricultural agenda within Agenda 2063 will be primarily driven by the **Comprehensive Africa Agriculture Development Programme (CAADP)** – an agreement between Heads of State and Government in 2002 – and the **Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods**, adopted during the 23rd Ordinary Session of the AU's Heads of State and Government (AU Commission, 2015).

2014 was a landmark year for African agriculture. It was the Year of Agriculture, Food, and Nutrition Security, and the year in which the Malabo Declaration was adopted to realise the continent's agricultural transformation by 2025.

In the CAADP's ten-year review and subsequent forward planning (NEPAD, 2012), Africa's **capacity to generate knowledge, foster learning, and enable skills development among its workforce is recognised as a game changer** in the context of the rally to fundamentally reshape African agriculture. Yet, notwithstanding widespread acceptance of the essential role of AET in igniting agricultural transformation, there was until very recently no credible and overarching continental-level framework, with a realistic and achievable concomitant strategic plan, to effectively address the core problem of human capacity deficit within the Agricultural Innovation System (AIS). The *CAADP – Sustaining the Momentum into the Next Decade* NEPAD report (2012) therefore called for a roadmap – an Agricultural Education and Skills Improvement Framework (AESIF) to excite and harmonise a vision and agenda that will both power, and empower, AET. This framework was to include, centrally, vocational education and training, as well as tertiary education over the next decade (2015-2025). AESIF was finalised in 2015, and is as much an exercise in advocating for out-of-the-box thinking, as it is a call for grounding, a search for

*Refer to the Endnotes

complementarity, and an effort at consolidation. The idea that Africa acts in a smart and unified fashion cannot be overstated; therefore, AESIF begins by iterating how intelligent load-sharing and an integrated approach between the different strategic and policy frameworks, implementers, and financing catalysts, will undergird its success and impact over the coming decade.

A Science Agenda for African Agriculture (CS8)

The outsourcing of science for agriculture in Africa is not an alternative. African leaders – in science and government – must take responsibility for the role of science on the continent. Taking cognisance of the critical role of science and agriculture in the global sustainable development agenda, now is the opportune time for Africa to make its mark as a player in global science. African solidarity for science is the most significant strategy in achieving the vision, which is articulated in the Science Agenda for African Agriculture or S3A (FARA, 2014). Led by the Forum for Agricultural Research in Africa (FARA), the Science Agenda has been endorsed by the AU, NEPAD, as well as all Africa's major sub-regional organisations as the main framework for driving science and technology in the CAADP process. The S3A provides a collective vision for science in agriculture in Africa, through a framework and set of guidelines to shape immediate priority setting for implementing CAADP.

The core of the agenda is to connect science with end users in a more effective way for the benefit of society. This will be accomplished in several ways:

- Identifying the **broad areas of science to be developed** in partnership with the main stakeholders.
- **Facilitating the necessary transformation and strengthening** of national science and technology institutions.
- Focusing on the need for **human capacity building** at all levels.
- Facilitating increased **funding from diversified sources** to support science.
- Facilitating **alignment of actions and resources** to ensure value-for-money and desirable impact,
- Facilitating **effective partnerships among mandated African institutions** at sub-regional/regional levels and between these actors and their external partners.
- Committing to **solidarity in science by sharing** information, technologies, information, facilities and staff in pursuit of common challenges and opportunities.
- Creating **favourable policy environments** for science.

It is clear that the need to transform agricultural education and training is imperative in the light of the fundamental role that the sector will play in the development agenda on the continent, but also in the international arena. Ultimately, the ability of the people on the continent to feed themselves, and potentially feed the global community, is inextricably linked to the sector's capacity to innovate, educate and diffuse climate smart approaches to agro-food-processing in an economically inclusive manner.

Major Themes of the Science Agenda

Table 3.1: Themes of the science agenda

SUSTAINABLE PRODUCTIVITY IN MAJOR FARMING SYSTEMS	FOOD SYSTEMS AND VALUE CHAINS	AGRICULTURAL BIODIVERSITY & NATURAL RESOURCE MANAGEMENT	STRENGTHENING INSTITUTIONAL SYSTEMS OF SCIENCE FOR AGRICULTURE
• Transforming production systems. • Crop improvement and protection. • Livestock breeds, heath and feed. • Aquatic and inland fisheries. • Agro-forestry and forestry. • Agricultural mechanisation.	Food and nutritional security, food processing, safety and storage. Post-harvest handling, processing and storage.	Conserving and enhancement of biodiversity. Land and water resources and irrigation management.	**Sustaining basic science capacity** at the national level. Effective national systems are the building blocks for **regional and continental partnerships.** **Global partnerships in science:** The CGIAR is a key partner of the National Agricultural Research Systems (NARS) and Scientific Research Organisations (SROs). Recent reform of the CGIAR including CGIAR Research Programmes (CRPs) targeting collaboration on specific themes is expected to improve alignment with CAADP.
MEGA TRENDS AND CHALLENGES FOR AGRICULTURE IN AFRICA	**CROSS-CUTTING THEMES**		
Climate change, variability adaptation and mitigation. **Policy and institutional research**, including market access and trade. **Improving livelihoods** of rural communities.	**Sustainable intensification:** as an organising framework for enhancing productivity, at all scales of production. **Modern genetics and genomics:** to give better understanding of gene function, leading to more specific targeting of genetic improvement in agriculturally important species of crops, livestock, fish and trees. **Foresight capabilities,** including strategic planning, modelling, and analysis of 'critical technologies', as a means of systematic analysis and interpretation of data and perspectives to better understand trends and future challenges.		

Source: Based on FARA (2014)

The South African Context

Agriculture is a key component of the South African economy

Agriculture delivers more jobs per Rand invested than any other productive sector, and remains critical in the face of rural poverty and food insecurity (DAFF, 2016).

While the primary agricultural sector contributes about 3% to the country's GDP, if the entire value chain of agriculture is taken into account, its contribution to GDP reaches about 12%. (Department of Agriculture Forestry and Fisheries (DAFF), 2013. Abstract of Agricultural Statistics. Republic of South Africa)

The number of households engaged in agriculture (referred to as agricultural households), was 2.9 million in 2011. Nationally, 24.9%, 20.7% and 16.3% of agricultural households were in KwaZulu-Natal, Eastern Cape, and Limpopo respectively (DAFF, 2016).

Although the country can maintain the ability to meet national food requirements, more than seven million citizens experience hunger, while 22.6% of households have inadequate access to food (Stats SA, 2016). Malnutrition continues to rise due to income inequality and inadequate access to appropriate foods.

Although South Africa is a net exporter of food and commodities (especially grains), it is a dual economy, with a combination of large scale and medium commercial enterprises on the one hand, and small-scale farmers on the other hand. The highly productive and competitive sector includes approximately 23 500 farmers contributing to exports. More than 1.5 million farmers constitute the uncompetitive sector, and consist of new entrants (land reform beneficiaries), smallholder farmers, and communal farmers; these are typically very low in productivity (DAFF, 2016).

South Africa's agricultural sector faces several challenges above and beyond the implications of climate change (including a crippling drought in the 2015/2016 period). These include the declining accessibility to quality water sources, the impact of unsustainable food production practices, and competition with other industries for the use of arable land.

Among the primary challenges faced by the sector are the challenges experienced in the broader AET system – including in the education, extension, and research components.

A Haunting Historical Legacy (CS1)

During apartheid, the South African economy "was built on systematically enforced racial division in every sphere of society" (ANC, 1994). This division was pertinent to both the agricultural and education sectors. In agriculture, the provision of services was disaggregated by race, location, commercial farming orientation, and allocation of public resources.

Post-democracy, the **Reconstruction and Development Programme (RDP) was the founding policy document for transformation** in South Africa. It was an "integrated, coherent socio-economic policy framework intended to mobilise people and resources towards the building of a democratic, non-racial, non-sexist future" (ANC, 1994).

The emphasis in the RDP was on the need to de-racialise access to basic needs such as land, education, and social services as a means of redress of poverty and inequality.

Agriculture was identified as one of the established sectors in the economy that had excluded the participation of the majority. The required change would therefore need to create access to agriculture for historically disadvantaged groups and this was inextricably linked to land reform. Consequently, the assumption was that agricultural and other support services would be made available in relation to land reform programmes. **What was not adequately dealt with at the time was the articulation of the problem with respect to the then existent agricultural sector and specifically the provision of agricultural support services (through extension), the orientation of agricultural education, and the limited levels of competence and relevance with respect to agricultural science research.** Furthermore, in its assumption that rural development and poverty reduction would be achieved primarily through following a pathway from land reform through agriculture to food security, the RDP left a gap in articulating the opportunity that an immediate reform of the prevailing extension services could have contributed to agricultural income growth in the then homeland areas.

Since 1994, various reforms have been introduced to the agricultural sector "with the intention of improving the efficiency of the commercial sector, and addressing the structural inequality characterising South African agriculture" (Tregurtha *et al.*, 2010). The initial approach to the agricultural sector transformation was articulated in the Broadening Access to Agriculture Thrust (BATAT) in 1995, which was the outcome of multi-stakeholder consultations and provided key inputs into the Agricultural White Paper in 1995 (DoA, 1995). BATAT suggested various focus areas for driving transformation in agriculture, including access to finance, human resources development, and technology transfer. Within the ambit of the BATAT Programme, over 100 agricultural extension practitioners and farmers were jointly exposed to a range of experiences of smallholder agricultural systems in Kenya, Zambia, Zimbabwe, Chile, and Indonesia.

The RDP, BATAT and Accelerated and Shared Growth Initiative of South Africa (ASGISA) were expected to have a substantial impact on future agricultural education policies, because human capital is viewed as one of the cornerstones. The anticipated impact did not transpire.

In the subsequent years, with a change in the political leadership at the level of Ministry, a new policy discussion document with three main strategic areas was developed, titled **Agricultural Policy in South Africa: A Discussion Document** (Ministry for Agriculture and Land Affairs, 1998). AET was not explicitly articulated as a strategic area, although education and training clearly underpinned the accomplishments of the identified strategies.

In 2004, there was once again a change in political leadership that brought higher level attention to the agricultural sector through the establishment of the **Presidential Working Group on Agriculture**. This forum was chaired by the President and brought together the different ministries which had an impact on agriculture as well as the leaders of the farmers' organisations. In 2001, the **Strategic Plan for South African Agriculture** was adopted as a strategy document for the sector with a unified vision of a 'united and prosperous sector' (DoA, 2001).

The intentions and objectives of policy reform in agriculture over the past 20 years have been quite deliberate in their intention for redress. In hindsight, however, the weakness of the RDP was that it was an all-encompassing 'clarion call' for development of an equitable society without the requisite clarity on the outputs, sequencing, and capacity being in place.

The challenge in South Africa is identifying the key policy objectives that should be driving the evolution of agricultural education and training in the country.

In the early days of democracy, an overview of AET in South Africa by Van Rooyen *et al.* (1996) concluded that AET would **"require a substantial reorientation to serve a much wider clientele"**. Included in the parameters they suggested were consideration of the responsiveness of the system to the ongoing social, economic, and political changes; the need for rationalisation and greater integration and linkages between the various components of the AET system, as well as in relation to the Southern African Development Community (SADC) region; and targeted training programmes to effect affirmative action and enhance the skills of the providers of extension within the public sector.

For the first decade following the new democracy in South Africa, structural challenges encountered with the constitutionally defined decentralisation of extension, inadequate allocation of resources to agriculture, and a focus on production, all reinforced the gaps in problem definition with respect to the role and significance of agriculture, and within that, the role of AET. The numerous policy development processes in South Africa's democracy did not immediately translate into well-resourced nationwide programmes, and consequently the opportunity to transform the agricultural education and training system has remained ineffective.

In 2003, the National Department of Agriculture developed a strategy for AET, which envisioned the following for the system:

- An **effective and well-coordinated AET that is integrated at all levels** and responds appropriately to South African Agriculture.
- Equitable **access and meaningful participation** in AET for all South Africans.
- The application of effective **quality assurance** of AET at all levels.

The strategy defined several aspects of the problems faced by the AET system at the time:

- AET lacked coherence and co-ordination both between the formal and non-formal sub-sections, and vertically within the formal education and training sector.
- The funding of the programmes was skewed and uneven across different sites of provision with former white institutions still better resourced than their historically black counterparts.
- Programmes differed markedly in quality, standards, outcomes, and curriculum and therefore limited the opportunities for students to change institutions, which created further barriers to higher levels.

Whilst the document was quite comprehensive in the overview of the challenges facing the sector it was weak in defining an implementation plan. The key activity that was envisioned was an AET Council. The strategy states that "[t]he primary function of such an entity would be to provide public accountability, policy formulation and maintenance, coordination and strategic guidance for AET" (NDA, 2003). To date, there is no evidence of implementation of the structure, despite its significant importance at the time. The relevance of the priorities identified in the 2003 strategy became increasingly clear during the work of the study panel, and the proposed establishment of an AET Council is of particular significance to the study recommendations.

The National Agenda (CS1)

The NDP vision for South Africa has a 2030 target date for achievement, and the vision document is written in a form that is aspirational in its attempts to mobilise people to participate in creating the future (NPC, 2011).

South Africa belongs to all its peoples. We, the people, belong to one another.

We live the rainbow.
Our homes, neighbourhoods, villages, towns, and cities are safe and filled with laughter.

Through our institutions, we order our lives.

The faces of our children tell of the future we have crafted.
National Development Plan, South Africa (NPC, 2011)

The NDP Vision 2030 focus is on employment creation, access to basic social services and redistribution of access to assets for economic development. An analysis of the targets set forth in the NDP places agriculture firmly on the agenda for the next 15 years.

Specifically, and in relation to AET, the NDP calls for:

- The creation of an additional 643 000 direct jobs and 326 000 indirect jobs in the agriculture, agro-processing, and related sectors.
- **Increased investment in new agricultural technologies, research, and the development of adaptation strategies** for the protection of rural livelihoods. Support services for small scale and rural farmers and expansion of commercial agriculture.
- **Maintaining a positive trade balance** for primary and processed agricultural products.
- **Expanding the college system** with a focus on improving quality.
- **Improved skills development and training in the agricultural sector, including entrepreneurship training.** This should include the training of a new cadre of extension officers that will respond effectively to the needs of smallholder farmers and contribute to their successful integration into the food value chain.

- Investigation into whether extension and other agricultural services are appropriately located at provincial level.
- Innovative means for agricultural extension and training by the state in partnership with industries.

Additional targets of indirect relevance to AET include:

- **1 million learning opportunities** through Community Education and Training Centres.
- Increased **enrolment at universities** by at least 70% by 2030.
- Increased number of **students eligible to study towards mathematics and science**-based degrees to 450 000 by 2030.
- **Increase the percentage of PhD qualified staff** in the higher education sector from the current 34% to over 75% by 2030.
- **Produce more than 100 doctoral graduates per million per year**; a significant increase from the current 30 to 35.
- **Expand science, technology and innovation outputs** by increasing research and development spending by government and through encouraging industry to do so.

The education targets in the NDP are quite specific in terms of numbers and the requirements for increasing public expenditure in science and new technologies are emphasised. What is not clear in the NDP 2030, however, is the relative importance of agriculture within these targets.

So whilst on the one hand AET is firmly on the agenda, on the other hand the implication is that the agricultural sector will be competing for resources with a range of other subject matter areas; to do so the AET system needs to articulate its impact areas beyond agricultural production and consider the training of persons who participate in the total agricultural value chain and related sectors.

Mapping AET in South Africa

National Mapping Study (CS2)

The national mapping study sought to construct an AET map that identifies the relevant stakeholders and reflects their interaction (or lack thereof) within the AET system. It was envisioned that this map could assist in the identification of areas of duplication, non-cooperation and other structural challenges.

The national mapping exercise distinctly highlighted the complex nature of the AET system and the interaction between the various stakeholders. The map highlights the urgent need for a greater level of alignment, the removal of duplication, and the removal of compartmentalised (silo) structures that do not serve a coordinated and integrated AET system. Clearly, from the analysis, the AET system is in dire need of substantial governance reform directed towards greater integration, cooperation, and accountability to maximise the returns on available financial, human capital, and physical infrastructure.

The AET map (Fig. 3.1) illustrates the sheer number of stakeholders and the complexity of the interaction between them.

Key Primary Role Players

A visual inspection of the number of interactions between stakeholders identifies the most involved role players and parties in the broader AET system (Table 3.2), all of whom are engaged in the delivery of AET.

Table 3.2: Role players in the delivery of AET

DEPARTMENT OF AGRICULTURE, FORESTRY AND FISHERIES	DEPARTMENT OF HIGHER EDUCATION AND TRAINING	NON-PUBLIC TRAINING INITIATIVES
Food Security and Agrarian Reform Branch[ii] through the Directorate of Sector Education & Training, as well as the Directorate of Sectorial Colleges (Headed by the same Director). Historically, extension services resided within the Directorate of Sector Education and Training, but this has been moved to the separate directorates of National Extension Support and National Extension Reform. At present these directorates are not involved in the actual provision of services but are rather occupied with the development of an overarching extension policy framework for the sector. The role of these directorates after the completion of this process is uncertain. The actual provision of extension services currently resides under the respective provincial departments with the support of the sectoral colleges.	SETA Directorate within the Skills Development Branch through AgriSETA. Universities and Branch Universities. AgriSETA interacts with most of the other AET stakeholders, both public and private. This is mainly through the provision of bursaries for tertiary education, the funding of internships[iii] (Work Integrated Learning), graduate placements[iv], learnerships[v] and short courses. AgriSETA also plays an important role in ensuring the quality of training provided through the accreditation of public and private short courses, learnerships and other training initiatives. Through this role it interacts with a vast number of stakeholders, especially private training providers and in-house training initiatives by companies. Within this role it also interacts with various agri-commodity structures.	Very little is known about these non-formal degrees or diplomas, which are mostly private initiatives. It is therefore advised that private training initiatives should be unpacked by further research due to their importance and extent. It must be noted that some private training initiatives are not accredited through Agriculture SETA (AgriSETA).

Source: Based on Greyling et al. (2014)

From the map which follows in Fig. 3.1, it is clear that universities and sectoral colleges have substantial interaction with the other stakeholders. It seems, however, that this is not necessarily the case with the respective universities of technology and public further education and training (FET) colleges. AgriSETA interacts with some of institutions within this grouping but it seems that these institutions are somewhat outside the focus of the mainstream stakeholders.

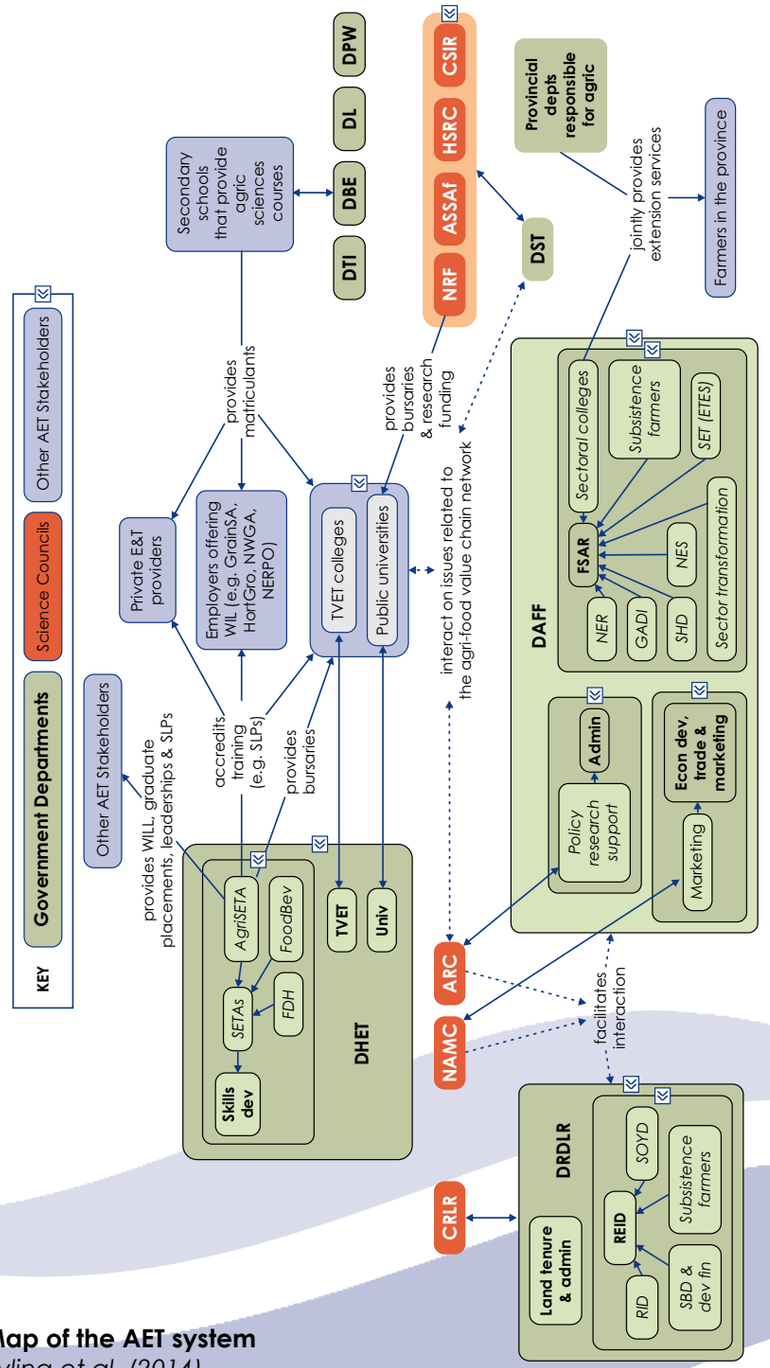

Figure 3.1: Map of the AET system
Source: Greyling et al. (2014)

Admin	Administration	DTI	Department of Trade & Industry	RID	Rural Industrial Development
AgriSETA	Agriculture SETA				
CRLR	Commission on Restitution of Land Right	E&T	Education & Training	SBD	Small Business Development
		Econ	Economic	SET	Sector Education & Training
DAFF	Department of Agriculture, Forestry & Fisheries	ETES	Education, Training & Extension Services	SETA	Sector Education & Training Authority
DBE	Department of Basic Education	Fin	Finance		
		FoodBev	Food & Beverages Manufacturing Industry SETA	SHD	Smallholder Development
Dept Dev	Department Development			SLP	Short Learning Programme (Short Course)
DHET	Department of Higher Education & Training	GADI	Grootfontein Agricultural Development Institute		
				SOYD	Social Organisation & Youth Development
DL	Department of Labour	NAMC	National Agricultural Marketing Council		
DPW	Department of Public Works			TVET	Technical & Vocational Education & Training
DRDLR	Department of Rural Development & Land Reform	NER	National Extension Reform		
		NES	National Extension Support	WIL	Work-integrated Learning (Internships)
DST	Department of Science & Technology	REID	Rural Enterprise & Industrial Development		

National Directorates with Current, Former or Potential Linkages to AET

The complexity of the AET system is further reflected by the number of government ministries which are linked to, or have clear alignment with DAFF and DHET who currently hold the primary mandate for the delivery of AET. These departments and their linkage are expanded on in Table 3.3.

Table 3.3: Government departments responsible for delivery of AET

RURAL DEVELOPMENT AND LAND REFORM	SCIENCE AND TECHNOLOGY	LABOUR	BASIC EDUCATION	PUBLIC WORKS
The Department of Rural Development and Land Reform (DRDLR) was created in 2009 and for the first time in its history, the country had a ministry dedicated to the development of rural South Africa. Government's plan for developing rural areas, the Comprehensive Rural Development Programme (CRDP) is aimed specifically at addressing the blight of poverty by the creation of vibrant, equitable and sustainable rural communities.	The Department of Science and Technology is not directly involved with AET as such, but entities within interact with universities and the ARC on issues related to the agri-food value chain. These entities also provide a significant number of bursaries etc. that enable agricultural education and provide internships and graduate placements.	The Department of Labour used to play an important role in AET as custodian of the SETAs, most notably AgriSETA. The transfer of the SETAs to DHET has resulted in greatly reducing the non-existent role of the DoL since no direct involvement was identified during this mapping study.	The Department of Basic Education (DBE) interacts with the DHET through high schools that provide agricultural sciences courses; this includes both agricultural and some non-agricultural schools.	The Department of Public Works plays an important enabling role in AET even though it is not directly involved therein. This is through the provision, maintenance and expansion of the facilities used for agricultural education and training such as the sectorial colleges, Departments of Agriculture, and research centres.

Source: Based on Greyling et al. (2014)

During stakeholder meetings, it became apparent that the Department of Rural Development and Land Reform (DRDLR) has limited interaction with DAFF, with some viewing the interaction between the departments as constrained. Interestingly, the National Agricultural Marketing Council (NAMC) facilitates interaction between DAFF and DRDLR, not intentionally so, but rather by default, due to overlapping interests on projects by the council. The lack of cooperation is reflected in the duplication of directorates; examples include the directorates of Subsistence Farmers both in DRDLR and DAFF. Another is that of the directorates of Small Holder Development in DAFF, Small Business Development and Development Finance in DRDLR and Small Medium Micro Enterprise (SMME) development in the dti.

The dti has no clear interaction with any other AET stakeholder; scope exists however for a more integrated process related to issues pertinent to agri-food value chains and networks – processing, beneficiation, trade, etc. Furthermore, the explicit emphasis in the NDP which calls for the engagement of industry with AET signals a particular opportunity for closer linkages.

Provincial Mapping Study (CS3)

Through an extensive series of provincial workshops in all nine provinces, the mapping of the AET system at provincial level explored the AET system in terms of educational institutions and other public and private stakeholders with an interest in AET, including professional associations, unions and other appropriate bodies.

This study was comprehensive in its approach, targeting stakeholders in all nine provinces. The feedback and findings from the study confirmed many common-sense notions about the AET system, as well the insights gleaned from various other commissioned studies. Reference to these studies is noted where relevant in the discussion around the findings of the provincial mapping exercise.

The provincial mapping study covered the following thematic areas: school level education, governance relationships, career pathways, funding and the use of ICT and social media. Several key similarities were noted across all provinces within each of these thematic areas. These findings are elaborated on below.

Agriculture is not a career of first choice

This creates challenges for effective sourcing of high-quality students for post-school studies. The complexities of this are discussed in greater detail in the section on the shape and size of the schooling system in South Africa (Page 66).

Lack of funding limits the quality of AET

Funding for education is a highly contested issue across institutions in South Africa. The need for greater funding was raised at all stakeholder workshops, particularly to enable institutions to provide practical vocationally relevant training. The capacity of schools to effectively deliver agricultural science as a subject is limited by a lack of funding and the absence of appropriate infrastructure for practical training. Funds which are available are not efficiently distributed or effectively managed.

Quality and availability of educators is of grave concern

The quality of educators, as well as the number of teachers appropriately trained to teach agriculture at school level is of serious concern. The complexity of this issue is discussed further on page 73.

ICTs and social media are not leveraged adequately

Across all provinces and level of education there was little evidence for the use of social media in education and extension despite the numerous opportunities it presents.

Articulation into higher education is limited

There is minimal structure in the articulated pathways from high school and college into higher education. This is exacerbated by the lack of structured governance relationships between role players in the relevant systems.

Career pathways are perceived to be limited

Within higher education there are very clearly articulated career pathways within academia. There is however limited understanding or awareness of the vast number of agri-business/entrepreneurship careers that exist along the entire food and nutrition value chain. This lack of awareness is evident at both school and higher education level.

Governance and structural relationships

Governance and structural reform pose major challenges to the AET system, as was noted in the national mapping exercise.

Relationships between colleges and higher education are not structured or regulated and rely primarily on individual relationships among institutional leaders. There is no legal framework to encourage or require systemic relations between universities and colleges of agriculture. The lack of clarity and progress around the agricultural colleges and their positioning within DHET (as opposed to DAFF) has significant ripple effects on the quality of educational provision and the coordination of the stakeholders within the AET system. There is also very little connection or collaboration between private and public education providers.

Linkages in research–teaching–extension nexus are poor, and there is a need for better coordination between the research and development, and extension systems. Challenges in this "knowledge triangle" are discussed at length in the section entitled A knowledge triangle for innovation in the agro-food value chain (Page 63).

Building on what works well

Through the provincial case studies, a few good practice examples were identified.

- Excellent linkages between agriculture high schools and farming enterprises were identified in Limpopo.
- The North-West College of Agriculture is an exemplar with regards to the articulation of curricula.
- Two examples of effective governance relationships between colleges and universities were found in the Western Cape (Elsenburg/SU) and in the Eastern Cape (University of Fort Hare (UFH)/Fort Cox College).
- Working partnerships between public and private Extension Systems were found in the Sugar Industry in KwaZulu-Natal (KZN) and in Mpumalanga.

The panel recommends that these case studies be followed up in greater detail to understand the mechanisms and pathways which enable their functioning and to identify critical success factors. Greater understanding of these cases can contribute to the design and implementation of similar initiatives in other provinces.

Knowledge Triangle for Innovation in the Agro-Food Value Chain

Skills for the agricultural supply chain are drawn from all levels of the system and not just from the university sector, and they come from a wider range of disciplines than the specific agricultural-focused qualifications. Like any other economic sector, agriculture requires a range of managerial, financial, marketing and a wide array of technical skills that are not agriculture specific – logistics, refrigeration, diesel mechanics, genetics, veterinary sciences, hydrology and numerous others. Depending on where one draws the boundary of agriculture there are myriad qualifications and courses that have a bearing on the field. The importance of this agro-food value chain approach has been highlighted in the discussions thus far; a shift in focus which is confirmed by various commissioned studies discussed in this section. AET thus needs to focus on strengthening capacities not only for production, but to equip a broad range of professionals and practitioners to engage across multiple 'points' in the value chain.

The circle widens even further. An effective value chain approach not only considers the role of education and training in isolation, but also takes into consideration the agricultural innovation system, and the transformative role that research and development play in stimulating and realising innovative solutions for the challenges that the agricultural sector will be increasingly expected to solve. The research–teaching nexus must therefore receive attention, as AET is training the future scientists who will help solve the pressing challenges, but is also educating practitioners and professionals who need to be cognisant of and connected to the most recent scientific breakthroughs to inform their work.

Navigating the modern-day world of work requires of both students and educators to become accustomed to and familiar with a broad range of skills – training and education requires the development of the so-called T-shaped skills where depth in discipline-specific knowledge is balanced by a breadth of soft skills – including communication, management and financial skills. Taking into consideration the important role that entrepreneurship is expected to play in South African economic development, T-shaped skills are positioned as essential supplements to disciplinary knowledge – rather than add on components.

International evidence suggests that fostering agricultural innovation through enhanced research support and entrepreneurship can become a key driver of development.

However, this cannot be realised without effective innovation transfer, diffusion and uptake. In the context of AET, this process is facilitated in a very large part by extension and rural advisory services, and will increasingly look towards smart ICT solutions to catalyse this process.

Persons engaged in the extension and rural advisory services component of the sector are influenced by AET in multiple ways – they are beneficiaries of AET through the training they receive, but then themselves become educators and facilitators of knowledge. For this reason, the training of extension workers should receive substantial focus as they have the potential to be the primary agents through which innovation is translated from the laboratory into practice. Training the trainers requires considered attention. The same is true of those who are being trained to teach at school, colleges and universities. Collectively this group of trainers represents a key opportunity for transforming the practice of AET.

For reasons stated above, a situation analysis is presented in the following sections which cover education, research and extension, also known as the agricultural knowledge triangle (Fig. 3.2 below).

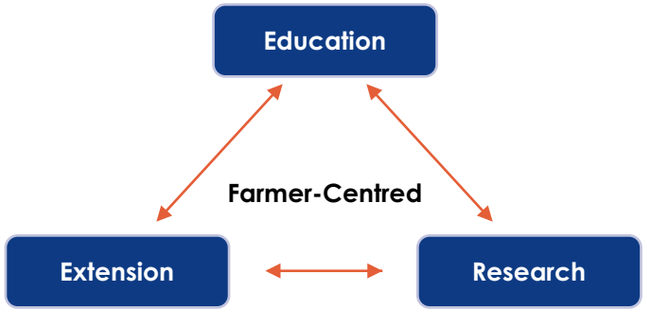

Figure 3.2: Agricultural knowledge triangle

Within this knowledge triangle, the roles of each of the actors are intersectional, and extend beyond the actions of what each actor does in isolation. The role of researchers is to design curricula for discovery learning which enable farmers and extension workers to engage in conscious learning. Researchers also partner with farmers, specialists and extension workers to develop new ideas and technologies. Extension workers focus on helping farmers learn to become experts on their own farms and to become researchers in their own right and help farmers cultivate capacity to learn through deliberate efforts and a facilitated learning agenda. In this process, farmers build capacity to command the factors influencing the sustainability of their livelihoods; they acquire the sense of equal partnership in the learning process and build their own capacities to learn.

Although the links between research, teaching and extension are important, various challenges remain in effectively integrating these, including lack of skills and contextual understanding on the part of each of the actors on how to engage effectively with farmers (Christoplos, 2010).

It is within this context that the discussions in this section will:

- Provide a situation analysis of South African AET.
- Identify the challenges faced at each of these levels.
- Assess the relevance of curricula to current global challenges.
- Provide recommendations to address these challenges and to enhance the attractiveness of agricultural education and training.

The Educational Context (CS4)

The literature on agricultural education tends to focus on a limited number of dedicated agricultural training institutions and faculties of agriculture. However, agricultural education needs to be understood **as being nested within a wider education system** that shapes, enables and constrains agricultural education and training.

Transformation and Reform in Education

The history of apartheid education is well documented and the effects of this history remain very present in the education system today (Soudien, 2007). Since the first democratic government took office in 1994, South Africa has attempted to break from the apartheid past by reforming the system. A series of ambitious and radical reforms have been introduced that have **tried to modernise and integrate the system**. These reforms have affected all levels of the system, from early childhood education through to university programmes and from adult literacy to special needs.

> "Education reform has been a priority in South Africa since the establishment of the Government of National Unity in 1994 and has played a key role in redressing the injustices of apartheid."
> (OECD, 2008)

A comprehensive review of all the reforms and the policies which informed them is not possible here, and so only the key moments will be described. The **Constitution of South Africa enshrines the right to education** and guarantees ten years of free and compulsory education. The constitution also describes **education (other than universities) as a concurrent competence**, meaning that it is a shared responsibility between the central national government and the provincial government. Until recently, provincial education departments had responsibility for technical and vocational education and training (TVET) colleges along with the entire schooling system and adult education. There have been recent changes, but this provincial responsibility has had a significant effect on the system in that there are marked differences between various provinces.

The system is highly fluid at present, with an emphasis on responsiveness and expansion in the context of the NDP. Vocational training is afforded a high priority.

One of the earliest pieces of legislation passed by the new parliament was the South African Qualifications Authority (SAQA) Act (*No 58 of 1995*) which established SAQA as the

custodian of the National Qualifications Framework (NQF). The adoption of the NQF has had profound consequences for the education system (Allais, 2007), **most centrally the attempt to integrate all forms of education in one framework**. Qualifications frameworks were developed primarily with occupational qualifications in mind, but South Africa included general education and higher education qualifications in the same framework as short courses and certificates – with varying levels of success (Harley and Wedekind, 2003; Jansen and Christie, 1999).

The NQF divides the education system into **three bands (General Education and Training (GET); Further Education and Training (FET) and Higher Education (HE))** with initially eight, and later ten levels. The first ten years of schooling as well as some basic adult education is pegged at level one, and the remaining nine levels are spread across the Further and Higher Education bands. It is in these two bands that the bulk of AET takes place. However, because the FET and HE bands build on the GET band, problems in the foundations have an impact on the tertiary part of the system.

An overview presented in Table 3.4 summarises in a general manner the broad thrust of education and training reform since the advent of democracy. Much has been achieved in transforming a highly segmented system into a national system, and there has been significant progress in terms of access at all levels. Unfortunately, the quality of the expansion has at times been poor, and most critically the foundations have not been strengthened.

Table 3.4: Education and training reform since 1994

GENERAL EDUCATION AND TRAINING (GET)	FURTHER EDUCATION AND TRAINING (FET)	HIGHER EDUCATION (HE)
Grades R–9	Grades 10–12 (through school, college or workplace)	Post-school qualifications
Number of curriculum reforms. Curriculum 2005 combined outcomes-based education (OBE) with learner-centred pedagogy and the integration of knowledge (Harley and Wedekind, 2004).	The reform of the FET band's curriculum followed the introduction of Curriculum 2005 and some of the early lessons from that reform were not repeated. The Senior Certificate was replaced with the National Senior Certificate. The key shift from the old Senior Certificate to the new National Senior Certificate was the inclusion of either mathematics or mathematical literacy as a compulsory subject for all learners, and the addition of a seventh, albeit half weighted, subject called life orientation.	Reforms were radical, but focused initially more on structure than content. Technical colleges were merged and rebranded as further education and training colleges (FETC), while universities were merged and technikons transformed into universities of technology.
Subjects combined into learning areas. Of relevance to this study – science, biology and physical geography were combined into natural science.	The traditional subject boundaries were retained, but the rules of combination were altered. The changes focused on the modernisation of subjects and subject content, removal of many smaller subjects, the elimination of a three-tiered graded curriculum and assessment structure (lower, standard and higher) and discontinuing a combination mechanism that enabled pupils to combine subjects from the technical college curriculum with school subjects to achieve a Senior Certificate.	Universities reluctantly re-curriculated along outcomes-based lines to comply with the NQF.
Wide criticism, hence review commissioned. The review committee recommended significant changes, including tighter specification of content and the reduction in the number of learning areas covered (Chisholm *et al.*, 2005). Most of their recommendations were accepted.	There have been subsequent changes to the curriculum at high school level but broadly speaking this structure remains intact.	
More recently the curriculum has been revised again and new Subject Assessment Guidelines produced that specify very tightly what is to be assessed.	In 2007, a new set of qualifications was introduced into the FET colleges. The National Certificate (Vocational) or NCV as it has become known sought to refocus the colleges on full time students at post-compulsory level (i.e. beyond Grade 9) rather than offering an out of date curriculum geared at an apprenticed student.	

Source: Based on Wedekind (2016)

Although drastic reform was necessary, what is clear is that the public education and training system has been in a state of fairly constant reform since 1994 – an evolution which has not fully realised its potential to integrate the system and provide quality education. The next two-subsections focus on first, the post-school system and second,

the school system. The purpose of these sections is to give an overview of the structure, shape and size of each system, as well as an overview of the AET-related qualifications within each .

The Post-School System

The tertiary or post-school system is the core of the AET system. The establishment of the DHET in 2009 resulted in the definition of a public post-school system integrated with universities, further education and training colleges and adult education colleges, with the department becoming moreover responsible for skills development. The Further Education and Training Colleges Amendment Act (*No 3 of 2012*) declared these colleges a national competency now under the jurisdiction of the DHET.

The White Paper for Post-School Education and Training (DHET, 2013) gave conceptual expression to the notion of the post-school education and training system now integrated with universities, TVET colleges and community colleges. As indicated in the White Paper, the new configuration of the DHET opened up enormous possibilities for co-operation among post-secondary institutions and other national stakeholders, in line with the vision of the third National Skills Development Strategy (DHET, 2013).

South Africa's post-school system is described as an inverted triangle with respect to the programme and institutional types. Too many institutions focus on academic programmes and too few prepare people for the intermediate and lower levels of skills. Currently, there are just over a million students enrolled in university-level programmes and fewer than that in technical and vocational programmes. While both systems have grown, the largest growth has been in the TVET colleges, where over the past five years the student numbers have doubled.

National targets set by the DHET and also the National Planning Commission propose a growth in universities to 1.5 million students while the vocational system is expected to quadruple to 4 million. This will result in a very different post-school system.

The top of the inverted triangle consists of the 26 public universities (offering qualifications primarily in the HE band). These are divided into three categories: traditional universities with a strong research focus that offer a largely academic track with undergraduate and postgraduate degrees. Universities of technology evolved from the technikon system and are strongly vocational, offer certificates, diplomas and degrees and have a stronger applied research orientation. Comprehensive universities offer both types of programmes. There are a large number of private higher education institutions which variously focus on one programme or field or may offer a limited selection of programmes. With a few exceptions, these private institutions have a limited research profile. The university landscape is discussed in further detail on page 70.

There are 50 public multi-campus TVET colleges that offer a range of certificate, higher certificate and skills programmes across a range of occupational categories. The major programmes offered are the National Certificate Vocational (NCV) in a range of specialisations at Level 4 and the old National Accredited Technical Education Diploma (NATED) curriculum leading to a national diploma. There are over 500 private colleges registered with the DHET that offer programmes at these levels. It is estimated that there may be as many as 200 000 students enrolled in these colleges, although the data are very uneven. The TVET colleges, and the types of qualifications offered are discussed in greater detail on page 77.

Formal qualifications in South Africa have to be registered with SAQA and listed on the NQF. Qualifications can be registered by the specific provider that is offering the qualification (for example a specific university) or they can be registered by an examining body (for example the DHET) or other structure and be offered by any accredited institution such as a college. **There is no shortage of registered qualifications in the field of agriculture on the NQF.** A search of the SAQA database for qualifications with the word 'agriculture' or 'agricultural' in the title revealed that there are 282 currently registered qualifications. These range from adult basic education and training (ABET) certificates in primary agriculture through to Masters degrees. This search would not have included explicit agricultural-related programmes which do not have the term in the title, such as Bachelor of Science in Food Security Studies or a Diploma in Extension. **There are thus well over 300 qualifications available on the NQF.** Whether these qualifications are in fact all being offered is a different matter entirely.

In addition to the registered qualifications, there are also part-qualifications. In terms of the current approach of SAQA and the Quality Council for Trades and Occupations (QCTO), a part-qualification is "an assessed unit of learning that is registered as part of a qualification" (SAQA, n.d.). For example, a part-qualification can be a module, or a unit standard. All occupational qualifications must include a work integrated learning component. However, because workplaces are not always available to all students enrolled in occupational programmes (either because employers are reluctant to make the places available or because there are not enough places) there is the possibility of awarding a part-qualification. In the main, part-qualifications refer to modules or unit standards that carry a certain number of credits and are pitched at a specific level of the NQF, and are often offered as stand-alone short courses. **Much like whole qualifications, there is a wide array of part qualifications and unit standards that are registered on the NQF. There are currently 1 425 unit standards registered in the Learning Field Agriculture and Nature Conservation and 73 unit standards with agriculture or agricultural in their title.** Once again, this is by no means a full complement of relevant unit standards as unit standards that apply to agriculture could come from practically any of the 12 learning fields[vi]. There is a large variation in terms of credits and levels from 20 credit units at NQF Level 5 to 2 credit units at Level 1.

The nature of unit standards are highly outcomes-based modules that can be coupled together to lead to a qualification. There has been much critical debate about whether this competence-based training does indeed lead to sustained learning and pathways to better job opportunities or further study (Allais, 2012). Much like the qualifications, the fact that these units are registered does not imply that they are necessarily being offered, but approved providers could offer them. The providers are more diverse than with full qualifications, with public TVET colleges being one possibility, but more frequently private training companies take this on.

Currently the least understood component of the post-school landscape is the category of colleges that are designated as HE colleges. This term is defined in the Higher Education Act and refers to institutions such as agricultural colleges, nursing colleges, police and traffic police colleges and so forth. **These colleges have usually been administered and governed by the relevant line department or provincial department, and have not been formally part of the higher education system.** This is being revised, with some colleges being moved directly to the DHET and others remaining but falling under the quality assurance system. This has significant implications for AET, and has proven to be a challenging process, which is yet to be finalised and concluded. A JTTT has been appointed to study the situation in detail and make relevant recommendations in this regard. This matter is discussed in greater depth in the section on Agricultural Colleges: Where to now? (Page 79).

The newest component of the post-school landscape is the community colleges. This new institutional structure is discussed in the section Community Colleges: Opportunity for AET to expand its reach? on page 81.

Rivera and Alex (2008) conclude that "agricultural education and training, especially at the post-secondary level, are significant for advancing agricultural productivity and the processes that move agriculture from farm-gate to markets".

The University Sector – An Overview

The university sector has a wide array of agricultural and agriculturally-focused programmes and most universities and universities of technology have some agricultural programmes on offer. Several well-established agricultural faculties, schools or departments have strong national and international reputations.

AET in the university sector faces many challenges, many of which are not unique to AET. Some of the most salient challenges in the sector are discussed in brief, and linked specifically to the implications for AET.

South Africa needs to increase its participation rate in tertiary education to drive economic development in a knowledge-based economy. This presents tangible and not insignificant challenges to a sector which is already under strain.

Although the demographic profile of students in universities has shifted significantly since 1994, the proportion of black students per capita in the sector is grossly unrepresentative of the population demographics in the country. This is in essence an issue of access – which is complicated by a number of factors including financial affordability. The controversial #feesmustfall campaign launched nation-wide in 2015 has highlighted pertinently the plight of low-income students seeking to enter the university environment.

On the other hand, there is a limit to the carrying capacity at South Africa's public higher education institutions, whose enrolments have been increasing year on year. Although

five new universities were announced in the White Paper for Post-School Education and Training (DHET, 2013), and three have been established, it will take time for these new institutions to grow into their role within the higher education landscape.

Admission requirements and the academic preparedness of students entering higher education has been a topic of extensive debate and remains a challenge for institutions. There has been much made of the apparent pass requirement of 30% in order to achieve a senior certificate pass (Wedekind, 2013). The suggestion is that standards have dropped and that a 30% aggregate is sufficient. This perception needs clarification. Even for the lowest category of pass (higher certificate pass), three subjects including the home language must be passed with a 40% minimum. For progression into higher education qualifications the requirements are significantly higher and exceed the requirements of the old system under apartheid. A recent Ministerial Committee review has proposed further tightening of the requirements around language of learning and teaching, which shifts the aggregate requirement closer to 50% (Ministerial Committee on the National Senior Certificate, 2014). However, actual percentages tell very little about whether the students have the requisite competencies. Evidence suggests there is cause for concern. The National Benchmark Test results have illustrated that less than a third and a tenth of students entering higher education have the requisite language and numeracy skills respectively to cope with the demands of higher education without additional academic support.

In response to the situation, higher education institutions set their own entry requirements on top of the minimum requirements set down in policy. This is based on a points system allocated to subjects based on marks and in some cases, subject choice. Certain subjects are excluded from this formula and there may be minimum requirements for specific subjects in some fields, most notably mathematics. These entry requirements mean that there is a smaller proportion of students who meet the criteria to enter the system. Post-school AET is further affected by these lower than desired translation rates because it is competing for the pool of students with access to high-profile fields of study such as medicine or accounting.

Higher education is also plagued by low graduation rates and high levels of degree non-completion. A troublingly low figure of only 54% of students graduate within a six-year period of enrolling in a three-year degree qualification, and 60% graduate from four-year degree programmes. Although graduations from agricultural three-year degrees are slightly higher than the average (59%), the absolute number of enrolments in agriculture remains among the bottom five subject-area enrolments. Agricultural graduations from four-year degrees are on par with national averages (59%), but enrolments are comparatively low (CHE, 2016).

AET in the University Sector

The traditional universities generally focus on training scientists and practitioners for the commercial agricultural sector. In South Africa, there are ten universities offering AET programmes from a first degree level to PhD qualifications. Degrees focus on disciplines such as agricultural economics, agronomy, soil science, plant science and animal science, and these can be pursued through to Masters and doctoral level. The location of these disciplines in science-focused faculties at universities has resulted in the focus being

primarily on science and research and there has been a lesser focus on the human and social dimensions of agriculture. Increasingly, however, there are more management and community development-focused programmes and some universities have reoriented their programmes to include issues such as food security, land reform and to focus on the socio-economic complexities of the multi-functionality of agriculture.

Practically all universities of technology have agricultural programmes on offer. Many of these programmes are offered through life sciences departments or faculties but there is also a strong management focus to the diplomas and BTech degrees that are offered. There are four universities of technology offering AET from NQF levels 6–10 namely: Cape Peninsula University of Technology (CPUT), Central University of Technology (CUT), Mangosuthu University of Technology (MUT), and Tshwane University of Technology (TUT). Nelson Mandela Metropolitan University (NMMU), a comprehensive university, also offers programmes of this nature.

The South African Agricultural and Life Sciences Deans' Association (SAALSDA) was formed in 2014 by the NRF with the aim, *inter alia*, to improve perceptions of agriculture, create awareness around the science of agriculture as well as link agricultural faculties to one another within South Africa and across the continent. The association also links South Africa to key continental and international bodies and platforms through RUFORUM and the Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA).

Agricultural sciences are covered by one CESM code, CESM 010 (DOE, 2008). CESM code 010 excludes agricultural engineering and veterinary medicine (covered in Engineering and Health Professions and Related Clinical Sciences, respectively). Table 3.5 indicates the subcategories of CESM 010.

Table 3.5: Sub-categories of agricultural sciences CESM code 010

Agricultural Business and Management	Animal Sciences
Agricultural Mechanisation	Food Science and Technology
Agricultural Production Operations	Plant Sciences
Applied Horticulture and Horticultural Business Services	Soil Sciences
International Agriculture	Forestry and Wood Sciences
Agriculture, Agricultural Operations and Related Sciences, Other	

Source: Based on DoE (2008)

The CESM codes were reclassified in 2009 and thus the 2005–2009 data are not comparable with the post-2009 data. Colleges of agriculture are currently excluded from HEMIS. The following section provides a profile of the number of AET teaching and research staff by degree, gender, discipline, race, age and by field and university; as well as the number of students registered and graduated by degree, gender, discipline, race and by field and university (CS5), focusing on agricultural sciences. Life sciences were excluded because of the many fields not directly related to agriculture. It was also not possible to obtain data for agricultural engineering. Also, Unisa was excluded from the data analysis below.

Profile of Staff in Agricultural Sciences

As is illustrated Table 3.6, compared to national statistics, the proportion of staff in agricultural sciences with a PhD qualification was relatively high at 56% in 2014 – an increase from the 50% in 2010.

Table 3.6: Staff in agricultural sciences by qualification level

	Agricultural Sciences	
	2010	*2014*
Total FTEs	389	448
Share of		
PhD	50%	56%
MSc	27%	26%
BSc	15%	10%
Other	8%	7%

Source: Based on HEMIS data (2016)

However, closer examination of these statistics (Table 3.7) shows that the over-representation of white and male academics in agricultural sciences is still prevalent. The highest level skills are concentrated at four institutions namely: SU, UKZN, UP, and University of the Free State (UFS), which combined accounted for 57% and 25% of total staff with doctorate and Masters degrees in 2014, respectively.

The profile of academics in terms of race remains predominantly white, with at least five out of ten academics with a PhD in both science fields being white in 2014. However, the share of whites has decreased during 2010–2014. Initiatives to enable and support black academics to pursue their PhD in these fields thus remain a high priority.

Table 3.7: Profile of academics in agricultural sciences by race and qualification level

	White		Black, Coloured, Indian	
	2010	*2014*	*2010*	*2014*
PhD	63%	55%	33%	35%
MSc	62%	37%	36%	60%
BSc	66%	52%	34%	48%
Other	59%	57%	41%	41%

Note: Shares do not add up to 100% because for a number of staff their race was unknown.
Source: Based on HEMIS data (2016)

There are also distinct gender gaps in the agricultural sciences, with significantly lower numbers of female staff in this group, with women holding only about 30% of the doctoral qualifications in 2014. The gender disparity is smaller for other qualification levels and the share of female staff has in general increased over the period 2010 to 2014. This trend is illustrated in Fig. 3.3.

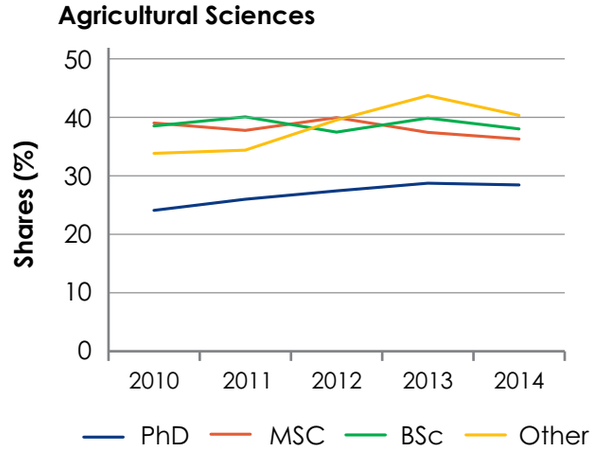

Figure 3.3: Share of female staff in agricultural sciences by qualification level, 2010–2014
Source: Based on HEMIS data (2016)

Much has been written about the age profile of academics, and the importance of preparing the next-generation. In 2014, 43% of staff with PhD qualifications in agricultural sciences, were older than 50 (Fig. 3.4). The share of PhD-qualified staff over 50 years has declined somewhat. Surprising is that the share of staff with BSc qualifications were also relatively older than those with MSc or other qualifications.

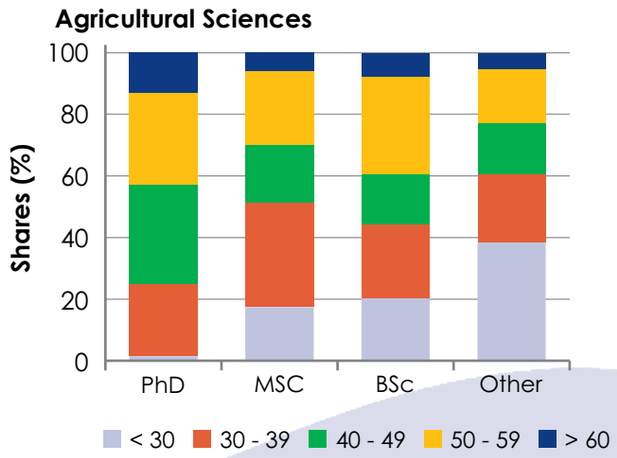

Figure 3.4: Share of staff in agricultural sciences by age and qualification level, 2014
Source: Based on HEMIS data (2016)

Profile of Students in Agricultural Science

The majority of the agricultural science students were pursuing a degree in agricultural business and management (27% of the overall total, as well as of the doctorate students), whilst other popular fields were animal sciences, agricultural production operations, food science and technology, and plant sciences. The total number of enrolments and graduations are reflected in Table 3.8.

Table 3.8: Total number of enrolments in agricultural science by qualification level

	Enrolments		Graduations	
	2010	*2014*	*2010*	*2014*
Total	10 775	14 173	2 465	3 278
Share of				
PhD	4%	5%	3%	2%
MSc	12%	11%	10%	10%
BSc	41%	44%	51%	54%
Other	43%	40%	36%	34%

Source: Based on HEMIS data (2016)

As illustrated in Tables 3.9 and 3.10, neither the profile of enrolments nor graduates has shifted over the period 2010–2014. In 2014, 44% and 40% of the students in the agricultural sciences continue to be enrolled in BSc and certificate/diploma level qualifications, respectively.

In 2014, white students accounted for only 34% of the total enrolled students in agricultural sciences. Their shares declined at all qualification levels during 2010–2014.

Table 3.9: Students enrolled in agricultural sciences by race and qualification level

	White		Black, Indian and Coloured	
	2010	*2014*	*2010*	*2014*
PhD	34%	24%	66%	76%
MSc	29%	27%	71%	73%
BSc	28%	25%	72%	75%
Other	19%	13%	81%	87%

Table 3.10: Graduated agricultural science students by race and qualification level

	White Students		Black, White and Coloured	
	2010	*2014*	*2010*	*2014*
PhD	39%	20%	61%	72%
MSc	40%	32%	59%	68%
BSc	34%	25%	66%	75%
Other	22%	15%	78%	85%

Note: Shares do not add up to 100% because for several students their race was unknown.
Source: Based on HEMIS data (2016)

The enrolment and graduation figures are disaggregated by gender in the graphs below (Figs. 3.5 and 3.6). In contrast to the profile of staff, the proportion of female students enrolled in the agricultural sciences equals the proportion of male students, whilst graduation of female students exceeds male students, albeit slightly, in 2014.

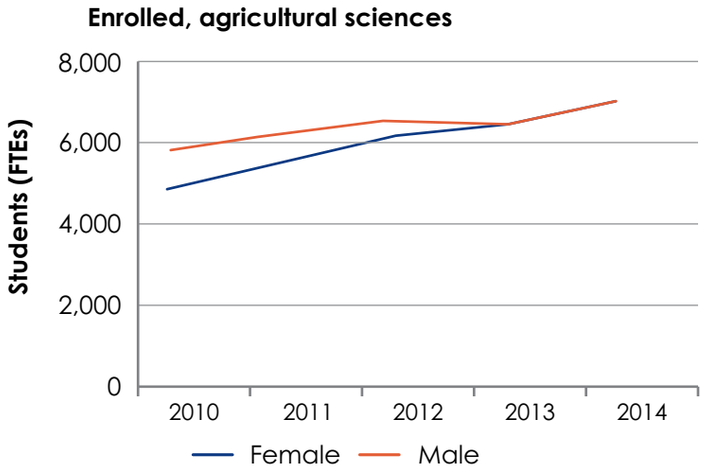

Figure 3.5: Enrolled agricultural science students by gender
Source: Based on HEMIS data (2016)

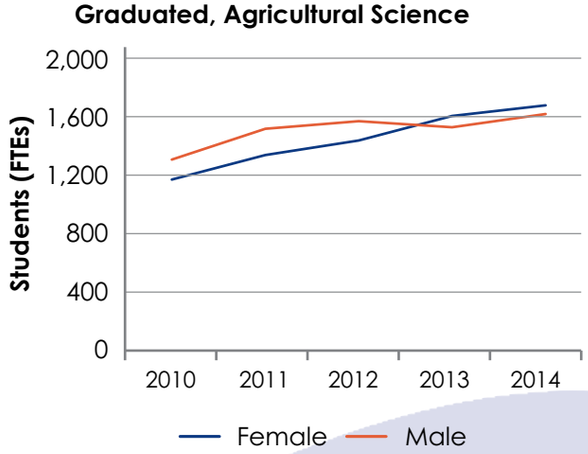

Figure 3.6: Graduated agricultural science students by gender
Source: Based on HEMIS data (2016)

In 2014, female PhDs constituted 42% and 40% of all PhD enrolments and graduations, respectively, in agricultural sciences.

Unsurprisingly, most of the doctoral students in agricultural sciences were enrolled at SU, UKZN, UP, or the UFS. Combined, they accounted for 65% of the PhD student population, 56% of the total students pursuing a MSc degree and 42% for those enrolled in BSc degree programmes.

Technical and Vocational Education and Training (TVET)

Public TVET colleges are the result of a series of reforms and mergers that were outlined in the first part of this chapter. There is a range of offerings and the quality of delivery varies. Colleges have some degree of autonomy, with college councils controlling the budget. However, staff members are now employed directly by the DHET and almost 90% of the income is from direct grants or conditional grants (Wedekind, 2016). A few colleges can bring in third-stream income through contracts with industry or via SETA grants.

Theoretically, these institutions should be playing an important role in the post-secondary landscape as the sector continues to expand. Significant growth in enrolments and high-quality graduates is required in the TVET colleges for South Africa to 'flip' its inverted triangle and train adequate numbers of graduates in vocational programmes as is intended in the NDP. Regrettably the performance of these institutions has been poor.

International examples, such as Germany, illustrate clearly the potential of vocational training to contribute to education, skills development and employment. Vocational education tends to result in a faster transition into the workplace, and countries which have prioritised vocational training – such as Germany, Switzerland, Austria and the Netherlands – have been successful in maintaining low youth unemployment rates (Subrahmanyam, 2014).

Intentional and systematic collaboration between TVET colleges and SETAs can amplify the impact even further (Tsamela, 2016).

There are approximately 50 TVET colleges in South Africa – of which only 13 currently offer agricultural programmes. Curricula offered are vocational in nature and extend from the FET band, N1 to N6. Public TVET colleges in South Africa offer three types of programmes in agriculture specifically (Table 3.11) and indirectly through occupations that support the agricultural sector or its downstream beneficiation of agricultural products (Wedekind, 2016).

In total, there are no more than 1 500 students across the public TVET system registered in agricultural-related qualifications (Wedekind, 2016).

Table 3.11: Agriculture qualifications offered by public TVET colleges

NATIONAL CERTIFICATE VOCATIONAL IN PRIMARY AGRICULTURE	NATIONAL DIPLOMA: FARMING MANAGEMENT	SKILLS PROGRAMMES IN RESPONSE TO REQUESTS FROM EMPLOYERS OR SETAs
NQF Levels 2, 3 & 4 (three-year programme).	This is an old qualification at N4-N6 level.	The AgriSETA has partnered with many colleges to offer a range of short courses and part qualifications.

NATIONAL CERTIFICATE VOCATIONAL IN PRIMARY AGRICULTURE	NATIONAL DIPLOMA: FARMING MANAGEMENT	SKILLS PROGRAMMES IN RESPONSE TO REQUESTS FROM EMPLOYERS OR SETAs
Aims to equip learners with the necessary skills to enter a mixed farming situation.	Focuses on farm managers, extension officers, consultants, inspectors and other bureaucrats.	The AgriSETA has also registered adult basic education and training qualifications on the NQF such as the General Education and Training Certificate (ABET) Applied Agriculture and Agricultural Sciences. These qualifications would probably be offered through community colleges in future (Page 81).
Fundamental subjects are compulsory and taken across the years: • Life Orientation • Language (usually English) • Mathematics or Mathematical Literacy The remainder of the curriculum: • Agribusiness (across all three years) • Animal Production (across all three years) • Plant Production (across all three years) • Soil Science (at Levels 2 and 3) • Farm Planning and Mechanisation (Level 4)	• Management (3 semesters) • Data Management (4 semesters) • Maintenance Management (2 semesters) • Financial Management (3 semesters) • Human Resource Management (1 semester) • Dairy Production (2 semesters) • Vine Production (2 semesters) • Fruit Production (1 semester) • Mutton Production (1 semester) • Plant Nutrition (1 semester) • Applied Farming Techniques (1 semester)	

Source: Based on Wedekind (2016)

The NCV is a Level-4 qualification that is theoretically equivalent to the National Senior Certificate, but it has been difficult for students with this qualification to access post-school programmes. Some universities of technology have started addressing this blockage, but one commonly reported difficulty is the fact that the qualification has only one language and thus does not meet normal entry requirements. To date, there have been only 170 graduates, with a completion rate of less than 32%. Clearly, in the case of AET, the TVET system will need to undergo significant transformation to increase the number of students who are successfully graduated in agricultural-related qualifications. This transformation will require urgent attention to various problems including, first, the lack of practical training and equipment and second, the limited number of appropriately qualified educators.

Agricultural Colleges: Where to Now?

Agricultural colleges are well known within the agricultural sector given their specialised focus. However, because they have fallen outside the purview of the wider education system they are not widely understood and there is almost no research literature on the colleges.

Agricultural colleges have historically had a direct line function to DAFF and its forebears. This has meant that the colleges have not been funded out of the education budget but rather out of the agriculture budget. However, the qualifications offered by colleges need to comply with the SAQA and quality assurance processes. This process has only recently been completed for all colleges and programmes are now aligned to the NQF.

Table 3.12 outlines the broad areas of focus at the various public agricultural colleges in South Africa.

Table 3.12: Focus areas at public agricultural colleges

Eastern Cape	Fort Cox	Crop and Animal Production; Animal Health; Agribusiness; Marketing and Forestry
	Grootfontein Agricultural Development Institute (ADI)	Animal Production; Agricultural Management; Pastures and Crops; Agricultural Technical Services
	Tsolo	Animal Production; Crop Production
Free State	Glen	Animal Production; Agricultural Management; Crop Production; Agribusiness
KwaZulu-Natal	Cedara	Crop Production; Animal Health; Mechanical Engineering; Animal Production; Agricultural Economics; Soil Science; Ecology
	Owen Sithole	Crop Production; Animal Health; Mechanical Engineering; Animal Production; Agricultural Economics; Soil Science; Ecology
Limpopo	Madzivhandila	Animal Production; Plant Production and Mixed Farming; Irrigation Management; Agribusiness
	Tompi Seleka	Animal Production; Plant Production
Mpumalanga	Lowveld (Nelspruit & Marapynane)*	Water Management; Crop Production; Soil Science; Forestry; Agricultural Management

North West	Taung	Agricultural Management; Plant Production; Animal Production and Irrigation; Engineering
	Potchefstroom	Agricultural Management; Plant and Animal Production
Western Cape	Elsenburg	Resource Management; Research and Technology; Veterinary Services; Plant and Animal Production.

* Now integrated into the University of Mpumalanga
Source: IGroDeal (n.d.)

The colleges generally offer diplomas at NQF Level 6. In many cases these diplomas have been offered in partnership with technikons (now universities of technology). However, the curriculum space is more fluid, with some colleges offering their own programmes through direct accreditation with the HEQC, while others are still collaborating with universities. In a case like Cedara College, the partnership with UKZN has been extended to include the offering of a Bachelor of Agriculture on the college campus.

Saasveld College which focused on forestry was incorporated into the Nelson Mandela Metropolitan University when that was established during the mergers, and Lowveld College has been incorporated into the new University of Mpumalanga and forms the core of the new university's agricultural offering.

The status of colleges is contested. When the White Paper was finalised a small section had significant implications for agricultural colleges.

> A government decision to shift responsibility for the agricultural colleges from the Department of Agriculture to the DHET will be effected in the near future. Following the transfer, the DHET will conduct an assessment of the colleges, and then develop a strategy to ensure that they function effectively and are integrated fully into the work and planning processes of the DHET. The department will also assess whether further expansion is required. In time, the agricultural colleges may be further integrated with other colleges – for example, by offering non-agricultural programmes in areas where those programmes are unavailable from another institution (DHET, 2013).

Despite this Cabinet-approved decision, there is still some uncertainty about the full implications. The DAFF released a Green Paper in 2015 that proposed the establishment of new entities that would effectively change the nature of colleges and keep them under DAFF control. Both departments have been meeting to develop a plan for the transfer of the colleges, but this process has not been finalised and there appears to be some resistance from within the agricultural sector.

As such there is no clarity and consensus on exactly what the future of the colleges is. Resolving the matter should receive immediate attention. The colleges have a clear and important role to play in the development of the South African rural economy, and there is a need to strengthen the responsiveness of the colleges to the full spectrum of skills needed in the country in relation to rural development.

Currently, the sustainability of the agricultural colleges from an academic point of view may be at risk, and there are questions which need to be answered around ensuring the financial sustainability of the colleges during and after the proposed transition.

Attempts were made by the study panel to meet with the respective parties in order to understand fully the situation and to position the panel to make recommendations with regard to this important component of the AET system. The engagement was not sufficiently robust so as to allow for such a recommendation to be made. A JTTT has been appointed to investigate the situation in-depth. The JTTT will seek to identify an appropriate governance, academic and institutional model that provides a conceptual framework for the future functioning of the agricultural colleges. This model will inform the process and approach of transferring the function.

Although the JTTT was appointed in early 2016 significant progress had not been made at the time of finalising the study report. The panel thus strongly recommends that the activities of the JTTT be expedited and prioritised to resolve the situation, and that a member of the study panel be appointed to the JTTT to ensure that the insights from the study are taken into consideration during the task team's activities.

Community Colleges: Opportunity for AET to Expand its Reach?

Community colleges are a new institution that is proposed in the White Paper for Post-School Education and Training (DHET, 2013). The motivation in the White Paper for the establishment of community colleges focuses on the need to deal with unemployed youth, adult literacy and various other community needs that are not adequately catered for in the general expansion of the colleges and universities.

There is not much detail in the White Paper as to the institutional form or the programme and qualification mix. However, they will incorporate the former Public Adult Learning Centres (PALCs) which generally focused on the teaching of adult basic education and training certificate programmes. The new colleges will play a much wider role, offering a new 'adult matric' – the National Senior Certificate for Adults (NASCA) – which is currently under development as well as skills courses. Currently there are nine pilot colleges that have been established (one in each province) that are starting to deliver programmes. Simultaneously the DHET has a number of processes underway that are exploring different models for developing the colleges.

At least three separate committees or task teams are looking at various aspects of the new colleges such as infrastructure, funding and programmes. Key debates revolve around whether the colleges focus primarily on formal qualifications such as the National Senior Certificate for Adults (NASCA), General Education and Training. Certificate (GETC) and ABET certificates, or whether they should be more flexible and community-driven. Given current fiscal constraints it is unlikely that there will be funding for new infrastructure, meaning that the colleges are most likely to utilise schools, colleges and other infrastructure and operate virtually.

The role of community colleges in offering agricultural programmes has not been finalised, but they would be obvious vehicles for dealing with issues such as farm worker literacy, community agriculture and food security programmes and training for new and small scale farmers. There remains space for influencing the process and the possible roles that colleges could play.

The AgriSETA

AgriSETA was constituted on 1 July 2005 following the merger between the Sector Education and Training Authority for Secondary Agriculture (SETASA) and the Primary Agriculture Education and Training Authority (PAETA).

The problems confronting AgriSETA: The levy-grant scheme

South Africa currently makes use of a centrally administered uniform levy-grant scheme as the main financing mechanism for skills development and training. Employers contribute 1% of their payroll into a central fund and are eligible to claim back a portion for approved and accredited training via mandatory and discretionary grants (1999).

AgriSETA has a proven track record in serving the needs of the commercial agricultural sector in South Africa. However, the current levy system was not designed to address the needs of the informal sector, which makes up a large part of the agricultural sector of South Africa. There is a clear danger, therefore, that unless AgriSETA is able to apply its funds more strategically, the needs of neither of these two constituencies will be met.

Despite the significant potential of the AgriSETA to contribute to skills development, projects implemented to date are small in scale, piecemeal in nature and lacking in coordination and coherence. The potential of partnerships between colleges, TVETs and the private sector to create meaningful opportunities for practical training, internships and employment has been grossly underexploited.

Tracing Graduates into Employment

Currently there are no systematic, national level statistics available on where agricultural graduates (from any level of qualification) find employment. It is thus not possible to determine what proportion of students work in the production components of agriculture *versus* the proportion who work in other components of the agricultural value chain or who find employment in completely unrelated sectors. Some statistics from a limited number of institutions are available in an *ad hoc* form, but the data are scattered across databases and are not readily available. Data are also difficult to compare as they are not collected in a standard format.

Graduate tracer studies are important as they enable an accurate understanding of the extent of graduate unemployment in society. Under ideal circumstances they should be undertaken at regular intervals as part of government's routine data collection on the labour market; however, this is not the case in South Africa. The lack of tracer studies is thus not unique to the agricultural sector in South Africa. Only two large-scale national studies have been done post-1994 in South Africa (DPU, 2006; Letseka *et al*., 2010), and the data used for these studies are more than ten years old.

The Cape Higher Education Consortium (CHEC) conducted a tracer study in 2013 among graduates from institutions in the Western Cape (CHEC, 2013). The study has important insights for conducting post-qualification tracer studies that could inform the design and national level implementation of a tracer study in the agricultural sector.

The School System

The South African schooling system is large, comprising some 13 million enrolled learners and 30 500 schools. This spans both the public and private system from Grade R (Reception Year) through to Grade 12, at which point pupils write a national exit examination, popularly referred to as Matric. There are over 448 000 teachers employed in the state and private schooling system (DBE, 2016).

The curriculum structure varies across the different phases of the schooling system. Grade R has a special school readiness curriculum that focuses on basic psycho-motor skills and general socialisation in preparation for the formal schooling. The Foundation Phase has three broad areas that need to be covered – literacy, numeracy and life skills. From Grade 4 onwards until the end of the Senior Phase in Grade 9 the curriculum is common for all children. It consists of eight learning areas which were originally conceptualised as integrated cross disciplinary fields. They consist of **languages** (one main and two additional), **mathematics and mathematical literacy, social science** (history, social geography), **natural science** (biology, physical science and physical geography), **arts and culture** (music, drama and art), **economics and management sciences, technology**, and **life orientation** (physical education, guidance and counselling). While the overarching structure of this curriculum has been retained, the various reforms and revisions discussed earlier have resulted in the strengthening of some of the boundaries between subjects within a learning area (for example, most schools teach history and geography and art and drama separately) and also a relative weighting of time in favour of languages and mathematics over subjects such as technology and life orientation.

In the FET Phase (Grade 10–12), the selection of subjects increases and pupils need to select combinations of subjects. A learner is required to select two South African languages (one of which must be the language of learning and teaching of the school), must do either mathematics or mathematical literacy, and must take life orientation (half the credits of the other subjects). The remaining three subjects are choices selected from what is available at a specific school. There is a large selection of languages available in the curriculum at three levels: home language, 1st additional language and 2nd additional language. These include all eleven official languages as well as many foreign languages from Asia and Europe, including Latin.

Table 3.13 shows a non-exhaustive list of subjects offered. There are several other subjects that are officially recognised by the department and offered at public schools or privately. These include various music subjects, maritime and nautical studies, and in the agricultural field, equine studies.

One of the concerns with the range of subjects available at the FET level is the lack of foundation in some of those subjects that is developed in the GET phase. For example, if a learner wishes to take engineering graphics and design, they would need to have developed skills in technical drawing that far exceed what is covered in the technology learning area. This also applies to the agricultural subjects, particularly those that are not science-based. This means that schools that offer those subjects must make extra provision for laying those foundations at lower levels, either through private tuition or through adjustments to the timetable and deviation from the gazetted norms. Very few schools have the resources or the confidence to do this and so many of the subjects

are offered primarily at private or high-fee state schools. This means that the curriculum choice for the clear majority of secondary schoolchildren is very restricted, with choices focused largely on a limited set: business studies, life sciences, history, geography and so forth.

South African secondary schools can currently offer four specifically agricultural subjects. These are highlighted in orange in Table 3.13. They are agricultural management practices, agricultural science, agricultural technology and equine studies. Of these, only agricultural science is offered outside of the specifically designated agricultural high schools, as the other three require access to farms and equipment, which most schools do not have. There is also no agricultural subject coordinator appointed at the National Department of Basic Education.

However, it should again be noted that **not all agricultural skills and occupations require a foundation in agriculture at school level.** In fact, agricultural subjects at high school may ironically be a disadvantage to students trying to enter higher education. Only agricultural science is recognised by a few universities, while agricultural management practices and agricultural technology are not recognised.

In the agricultural sciences, the key gateway disciplines are mathematics, physical science and biology (highlighted in blue in the table). Thus, subject choice at school level does not necessarily bar young people from entering the agricultural-related occupations, but **mathematics is probably the biggest single blockage in the pipeline** as most science and commerce-related programmes, as well as vocational programmes at colleges and universities of technology require mathematics passes. For example, in 2011, about half a million Grade 12 learners sat for the National Senior Certificate (NSC) examinations. Of these, only 224 635 wrote mathematics, and only 67 541 passed it with 40% or more (2013). This is the absolute minimum requirement for progression into the so-called STEM (science, technology, engineering, and mathematics) subjects and is the first major constriction in the pipeline. Where progression requires physical science the pattern is even worse. In 2011, of the 180 585 pupils that wrote, only 61 109 passed with 40% or higher (2013). Over subsequent years the situation has not improved. There are still only 120 000 of the over 500 000 Grade 12 learners who pass mathematics at 30% or higher (2016). **For agriculture as a sector this is a major problem, as it does not share the same cachet amongst the majority of youth as fields such as medicine or commerce.** Attracting top performing students from this small pool requires active intervention in the form of bursaries and scholarships and marketing and career guidance.

Table 3.13: Subjects offered at FET level

	Taught at technical schools	Taught only at agricultural schools	Strong vocational orientation
Accounting			Yes
Agricultural Management Practices		Yes	Yes
Agricultural Science			Yes
Agricultural Technology		Yes	Yes
Business Studies			Yes
Civil Technology	Yes		Yes
Computer Applications Technology			Yes
Consumer Studies			Yes
Dance Studies			
Design Studies			Yes
Dramatic Arts		Yes	
Economics			Yes
Electrical Technology	Yes		Yes
Engineering Graphics and Design			Yes
Equine Studies		Yes	
Geography			
History			
Hospitality Studies			Yes
Information Technology			Yes
Life Orientation			
Life Sciences			
Mathematical Literacy			Yes
Mathematics			
Mechanical Technology	Yes		Yes
Music			
Physical Sciences		Yes	
Religion Studies		Yes	
Technical Mathematics (new)			Yes
Technical Science (new)			Yes
Tourism			Yes
Visual Arts	Yes		

Source: Wedekind (2016)

Profile of Agricultural Subjects in Schools

Agricultural science (which is offered outside agricultural schools) is one of the most popular subjects offered, with the tenth largest enrolment. In 2013, approximately 83 000 pupils wrote agricultural science, roughly 1 in 5 Grade 12s. The vast majority of the pupils enrolled for agricultural science are from rural provinces: the Eastern Cape, Limpopo, Mpumalanga and KwaZulu-Natal. Over 91% of schools that offer agricultural science as a subject were historically designated for black children. The majority of academic schools offering agricultural science do not have any or very few practical facilities.

Historically the pass rate in this subject was low, at or around 60%. However, in 2013 the pass rate leapt to over 80% as the first group of students came through a revised curriculum. No analysis of the curriculum or assessment of the cognitive demand has been undertaken to date, but one must surmise that the examination expectations must have been adjusted to address the low pass rate.

The other three more specialised subjects have a completely different profile. They are offered at the small number of specialised agricultural schools of which there are between 30 and 35 in the entire country. In addition, another ten schools offer a part programme in agriculture.

Currently, the DBE does not make distinctions between types of schools either in their funding formula or in the way in which the data are reported, so it is not possible to easily distinguish these schools at a systemic level, but they are a very small component of the system.

Schools with a farm and farming equipment (including farm animals) for practical training are responsible for their own funding to manage the farm, as well as the appointment of staff skilled in agriculture because posts are not allocated or are frozen. The same tendency repeats itself with the allocation of farm workers. In many cases, even if there is a farm, equipment is outdated and not effective at all.

The majority of these schools have historically tended to cater to the white farming community and have provided a form of integrated education and vocational preparation for the sons (and occasionally daughters) of farmers. Within the new policy frame of the DBE, agricultural schools are categorised as 'focus schools' alongside other schools such as maritime schools or arts schools. The intention is to develop a different funding and staffing model for these focus schools (DBE official, personal communication, 2015). This shift is welcomed by the panel as it will allow for a more nuanced approach to these schools, which should include consideration of the costs of running the schools, the most appropriate teacher-student ratios, as well as the need for a policy on the management of 'focus schools'.

The fact that very few new teachers have been trained over the past 15 years will undoubtedly result in a crisis of supply as the current ageing cohort of teachers retires. It will take time for a new generation of teachers to emerge. Most teachers offering agricultural subjects (at both academic and agricultural high schools) are often inadequately trained – both in theory but especially in terms of practical farming experience.

Curriculum Content of Agricultural Subjects

The content of the curriculum for three of the four agricultural subjects based on the Curriculum and Assessment Policy Statement 2011 is mapped out in Table 3.14. The content for equine studies was not available at the time of writing the report.

Comments and recommendations for change within each subject are noted at the bottom of the table.

Table 3.14: Curriculum content of agricultural subjects

Subject	Agricultural sciences	Agricultural management practices	Agricultural technology
	studies the relationship between soils, plants and animals in the production and processing of food, fibre, fuel and other agricultural commodities that have an economic, aesthetic and cultural value.	curriculum focuses on the study and application of production, economic and management principles that are used in the cultivation, transformation and marketing of food and other agricultural products. These principles are used to produce and add value to high-quality agricultural products so that these products have economic, aesthetic, social and cultural value. Agricultural management practices draws knowledge and skills from various disciplines. The subject is designed to provide learners with a sound practice-orientated base that integrates theoretical and practical competencies.	focuses on technology used in agriculture. The subject covers the knowledge of how processes, tools, equipment, structures and skills are utilised by farmers, to cultivate agricultural land and produce food and products, through various production processes, thus sustaining and maintaining quality of life and increasing economic, aesthetic and sound cultural values.
Primary content	• Soil Science • Plant Studies • Animal Studies • Agricultural Economics • Basic Agricultural Chemistry • Basic Genetics and Biological Concepts • Sustainable Natural Resource Utilisation • Agro-ecology	• Crop Production and Crop Management • Soil and Water Management • Product Harvesting and Quality Control • Animal Production and Animal Management Aspects • Farm Management and Evaluation • Value Adding, Processing and Producer Organisations • Agri-tourism, Business Planning and Entrepreneurship	• Safety • Structural Materials • Energy • Construction Processes • Tools and Equipment • Irrigation and Water Supply • Communication • Drawings • Measurements, Calculations and Calibrations

Comments and recommendations	Clearly, at the level of the curriculum topics this subject has the potential, if taught well, to provide school learners with a broad understanding of modern agriculture and its different branches. However, given the current makeup of the learners, from rural, former homeland areas, there might be a case for a stronger focus on sustainable and small-scale agriculture.	The specific production enterprises that are taught in practical situations should be linked to the agro-ecological region in which the school is located.	

Extension and Rural Advisory Services (CS6)

In recent years new forms of extension delivery have started to emerge. Wallace (1997) suggests that attention should be given to rationalisation, new aims and learning styles, reaching new audiences, innovations in curriculum and teaching, developing learning webs and networks, human resources development, and strengthening regional or inter-regional organisations and networks.

> Notwithstanding the concerns for cost, studies have shown that "investments in extension services have the potential to improve agricultural productivity and increase incomes especially in developing economies".
> (Anderson and Feder, 2004)

Stemming from a World Bank-funded study into the factors affecting extension in sub-Saharan Africa, three strategic challenges have been identified by Rivera (2008) based on case studies in seven countries. These are the challenges:

- to advance the dual needs for science education and agricultural demand-driven university research;
- to produce competent graduate students to take up available positions in the agricultural labour market, but also to pursue entrepreneurial ventures in agricultural business; and
- to catalyse institutions to foster national extension-type services and community development by upgrading the skills of producers, professionals and communities.

Best-fit Forward

A desktop study of international extension and advisory research revealed several challenges facing the agricultural extension advisory landscape globally. The challenges can be organised according to the 'best-fit' framework set forth by Birner *et al.* (2009) which is illustrated in Fig. 3.7. The framework clearly highlights the fact that there is no one single extension methodology suitable for all situations and for all purposes.

> It is important to realise that no single extension methodology is suitable for all situations and for all purposes. A 'one-size-fits-all' approach to sustainable extension and rural development programmes will not work. The need to develop location-specific extension approaches is essential and in line with developing situation-specific food security strategies. The best-fit approach embraces both the pluralism of approaches used today and the diversity found within agricultural innovation systems (GFRAS, 2012).

The framework for designing and analysing agricultural advisory services looks at the impact pathways and influencing factors for successful performance and impact of extension services (Fig. 3.7). It starts with the contextual factors or 'frame conditions', including the policy environment (A), the general capacity of service providers (B), and the production/farming systems and community aspects (C & D). The framework then looks at the characteristics of the advisory service system that must respond to the frame conditions. These characteristics include governance structures (E), capacity (F), management (G), and extension techniques or methods used (H). These frame conditions and characteristics then affect the performance of the service (I). Additionally, the response through capacity and decision-making of farm households (J) leads to impact (K).

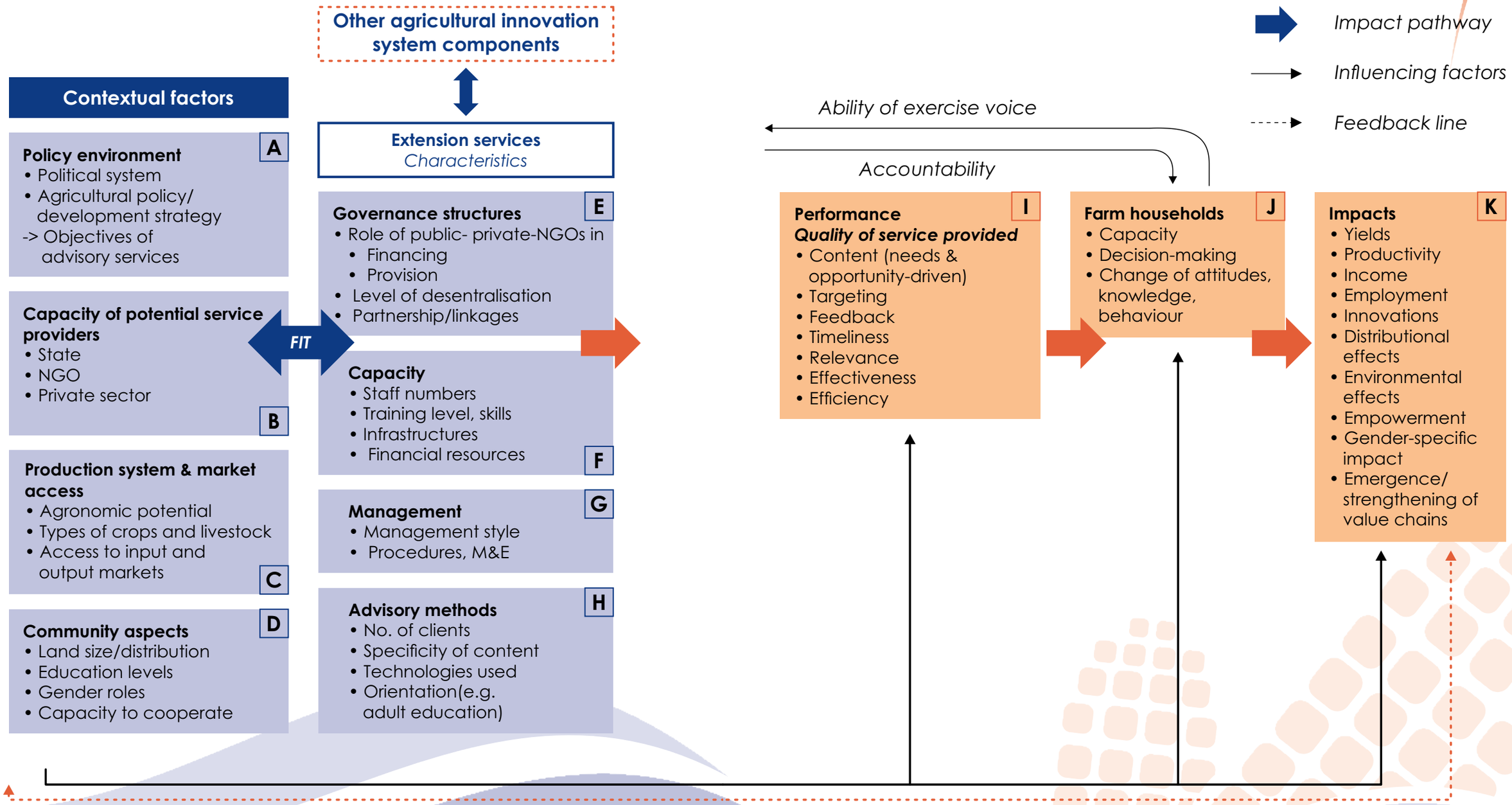

Figure 3.7: Framework for analysing advisory services
Source: Davis and Terblanché (2016)

When taking a best-fit approach, specific considerations for identifying the best-fit model for a specific context become important. Pye-Smith (2012) noted that the most successful extension approaches achieve the following: empower farmers and communities; consider local culture and tradition; and frequently target specific groups such as women and young people. The best approaches tend to be participatory and demand-led; in other words, they respond to the individual needs of farmers and communities. They also involve a constant dialogue between clientele and service deliverers, and a process of continuous learning. Knowledge sharing is critical, and extension and advisory services are a vital knowledge-sharing institution. Within this context, according to GFRAS (2012), there are a number of opportunities to mobilise the potential of extension and advisory service, each discussed briefly below.

Focusing on best-fit approaches: Best-fit approaches imply using means that suit the local conditions, as has already been introduced above.

Embracing pluralism: Pluralism is a given in modern society and extension approaches must take this into account. In principle, a pluralistic extension network aims to promote the advancement of 'mixed economies' whereby public and private sectors cooperate more closely. A pluralistic extension pattern demands that programmes/projects be jointly planned, implemented and evaluated by all service providers, in active collaboration with farmers (Rivera and Qamar, 2003). For pluralism to work, extension implementers, especially national extension services, must ensure effective operational linkages between extension and research and other key relevant institutions (Qamar, 2005).

Participatory approaches and decentralisation: Using participatory approaches for decision-making and decentralisation to lower tiers of government, allows for demand driven extension and bottom-up planning. Decentralisation is taking place in more and more countries – moving the responsibility for providing extension to lower administrative levels (it can also include political and fiscal levels) (Rivera and Sulaiman, 2005). Decentralisation, if well planned, can also increase accountability to rural people through subsidiarity – placing responsibility for activities at the frontline where extension services are closer to farmers (GFRAS, 2012). Accountability to rural people also means knowing whether a programme or organisational innovation worked or not and acting to respond to challenges (GFRAS, 2012).

Capacity strengthening: There is a need to develop capacity in such a way that will enable changing field extension staff from 'technical advisors' to more specialised teaching-learning facilitators or extension educators. In terms of delivering successful training, the focus needs to be on the learning and not only on the content of the curriculum. Extension must build the farmer's capacity to investigate, apply and share. Clearly, extension should not only provide technological answers, but should provide a learning base and skills to capacitate farmers to apply principles to new situations.

The South African Context

In South Africa, the current emphasis of public extension is on support to land reform beneficiaries almost to the exclusion of providing services to the total agricultural and related value chains. This is not enough.

The predominance of the rights issues in the land reform programme created a gap in the readiness of the agricultural extension system to deliver support services to settled communities for an extended period following 1994. Resources from the budget were allocated for the restitution and redistribution programmes early on in democracy, whereas the resources for farmer support including agricultural extension reorientation and training were only provided for in the 2004 budget year. This was further exacerbated by the fact that land reform was planned for at a national level whereas agriculture was a concurrent function requiring that the provision of farmer support services be the responsibility of provincial departments of agriculture.

It was only in the 2003 Medium-Term Expenditure Framework where there was more widespread acceptance that land restitution or redistribution without commensurate support services in agriculture would not achieve the objective of creating a viable smallholder agriculture sector. Following an expenditure review there was consideration of a dedicated allocation to farmer support services to the former National Department of Agriculture (NDA), now DAFF.

Whilst the allocation of funds was a positive development, for it to be fully effective it required institutional arrangements that pose challenges for the existing constitutional dispensation which disperses the agricultural functions across the three spheres of government. The arrangement could only be effective if there was strong leadership to drive coherence of policy and the establishment of systems coordination of delivery. This has not been the case.

Most recently, the National Extension and Advisory Service Policy (Draft, March 2014) has been developed, but is still in draft format and awaiting final approval. The policy aims to facilitate the establishment of an effective and efficient extension and advisory services to ensure knowledge transfer and skills development as the foundation for equitable, productive, competitive, profitable and sustainable agriculture, forestry and fisheries sectors in South Africa.

Policies and strategies greatly depend on government priorities and the needs of clientele. However, in formulating extension policy, and thus the roles of extension services and extension agents, it is important to note that today, for better or for worse, extension agents do more than just 'traditional' extension and technical agricultural outreach. They play a much bigger role, brokering and facilitating links and relationships within the agricultural innovation system, and thus require new strategies and capacities to perform these roles (Sulaiman and Davis, 2012).

Taking a best-fit approach, and considering the opportunities in pluralism, participatory approaches, decentralisation and the need for a new 'type' of extension worker, the new policy will require a multidisciplinary approach for the capacity development of extension professionals. This will require that policymakers, extension managers, and training institutions:

- review and develop multidisciplinary training curricula for extension practitioners;
- ensure continuous professional development; and
- contribute to the knowledge support system of government, offering accredited in-service training to extension practitioners.

This is however not the reality; several disconnects remain pervasive across the system. In terms of training, there is an over-emphasis on learning about technology and remembering facts (in a complex and dynamic environment) and insufficient emphasis on understanding the fundamental principles of production and ecology in real world contexts.

The shortage of trained and experienced agricultural extensionists in South Africa has been the subject of much debate in recent years. The DAFF has taken active steps to address the shortage of extensionists in the country through the development and roll-out of its Agricultural Extension Recovery Plan in all nine provinces.

Professionalising Extension Services

In 2005, the Standards Generating Body (SGB) for Agricultural Extension, through a process of consultation and workshops, developed an Agricultural Extension Landscape. The landscape indicated specific extension concepts, study fields and essential skills and knowledge areas that every extension worker needs to successfully fulfil his/her task in a professional manner. Along with qualifications come norms and standards. The Norms and Standards for Agricultural Extension and Advisory Services in South Africa (2005) document was a culmination of protracted discussions within the sector on the status of extension services in South Africa, and a need to improve the system. The document covers the competencies and skills required in extension's human resources.

> "It is therefore expected of every individual who performs the duties of agricultural extension and advisory services to demonstrate professionalism."
>
> All providers must accordingly be competent in the following areas: client orientation and customer focus, communication, project management, knowledge management, service delivery innovation, problem solving and analysis, honesty and integrity, people management and empowerment. (DoA, 2005)

DAFF proposed that agricultural extension be formally recognised as a profession, governed by a legal framework and requiring formal registration and continuous professional development. DAFF requested the South African Society for Agricultural Extension (SASAE) to undertake a study on the feasibility of establishing a professional body for the registration of agricultural extensionists and advisors (Terblanché and Koch, 2012). The study focused on the pros and cons of establishing a new professional council under the auspices of DAFF or pursuing registration under the South African Council for Natural Scientific Professions (SACNASP). Furthermore, it focused on the best practices regarding establishing and managing a professional council. The study drew on experiences of other professional bodies and aimed to:

- determine the levels for professional registration;
- identify specific qualifications at each level necessary for registration; and
- determine essential elements of continuous professional development (CPD) and mentorship.

The purpose of the Natural Scientific Professions Act (2003) was the establishment of the SACNASP and the registration of professional, candidate, certificated, and associated natural scientists (Terblanché and Koch, 2012). According to Schedule 1 of the Act, no one may practise in any of the 21 listed fields of practice unless he/she is registered in a category of the schedule. The latest fields of practice published under *Government Gazette* Notice 36 of 2014 by the Minister of Science and Technology includes extension science as a field of practice.

Thus, only registered persons may practise in a consulting, and extension/advisory capacity. There are certain requirements for registration. The extension science category requirements for South Africa are displayed in Table 3.15. The process of professional registration of extensionists with SACNASP was launched in the second half of 2014. At the end of August 2015, SACNASP had received 2 778 applications from the nine provinces (Davis and Terblanché, 2016).

The Act also calls for continuous professional development (CPD). Under this, persons registered as professionals are required by their code of conduct to practise strictly within their area of competence and to maintain and enhance this competence. They therefore have the responsibility to keep abreast of developments and knowledge in their areas of expertise to maintain their competence. In addition, to maintaining their own competence, they should strive to contribute to the advancement of the body of knowledge with which they practise, and to the profession in general. A committee has been established to develop CPD for extensionists and the roll out of the process.

Table 3.15: Extension science professional registration category requirements

Category and Designation	Requirements
Professional Extension Scientist (Pr.Ext.Sc.)	4-year degree; 120 extension credits at Honours degree level; 5 years' work experience
Candidate Extension Scientist (Cand.Ext.Sc.)	4-year degree; 120 extension credits at Honours level Less than 5 years' work experience
Extension Technologist Level A (Ext.Tech.A)	Recognised extension qualification: 60-120 extension credits; 5 years' work experience
Candidate Extension Technologist Level A (Cand.Ext.Tech.A.)	Recognised extension qualification: 60-120 extension credits; Less than 5 years' work experience
Extension Technologist Level B (Ext.Tech.B)	Recognised extension qualification: 10-59 extension credits; 5 years' work experience
Candidate Extension Technologist Level B (Cand.Ext.Tech.B)	Recognised extension qualification: 10-59 extension credits; Less than 5 years' work experience
Associate Extension Technician (Assoc.Ext.Tech.)	At least 10 years' work, lacks appropriate training 2 credible independent witnesses

Source: Davis and Terblanché (2016)

Research Context (CS7)

The ARC is a century-old institution which was amalgamated into its current formation in 1990. The council has 11 institutes throughout South Africa employing 2 588 people, including 823 scientists (ARC, 2014).

The ARC has the following four key divisions: Livestock; Crops; Agricultural Innovation Systems (including climate and water, engineering, natural resources and biotechnology); and Agricultural Economics and Capacity Development.

The animal sciences are concentrated at the Animal Production Institute (API) and the Onderstepoort Veterinary Institute (OVI). These institutes are recognised as of strategic value in animal agriculture and related industries.

The ARC also provides diagnostic and analytical services through high throughput genome sequencing, embryo transfer, biological safety level (BSL) three laboratories for highly infectious agents, and satellite imagery for climate monitoring and Geographic Information System (GIS) mapping.

The key points informing the discussion below are drawn from the five-year institutional review conducted in 2015 (Rukuni, 2015).

Strengths of the ARC

ARC is still relevant for both large scale and smallholder agriculture, although the council is losing positioning with large-scale commercial agriculture and it is gaining ground with smallholder agriculture.

ARC is still indispensable as a result of the fact that some of its services cannot be easily provided by alternative sources: breeding; diagnostics and analytical laboratories and some research facilities. In other words, without the presence of the ARC in the last ten years there would have been a negative impact on the economy especially the indispensable role in diagnostic and analytical laboratories, smallholder agriculture and breeding.

The ARC is thus still a critical component of the AIS in South Africa and the region, and the ARC is still a productive research and development (R&D) system even though an innovation culture is not fully embedded in the organisation.

Plant breeding is a success story of the ARC with many excellent varieties being introduced over the past five years. According to industry players, the most important and valued contribution the ARC has and continues to make is in the field of plant breeding. Furthermore, overall, animal sciences are engaging in innovative science, producing highly valued vaccines, diagnostics and animal performance evaluations, and having impact within selected food commodities value chains, e.g. meat.

Challenges

The ARC is however facing severe challenges that threaten its mandate and gains, and the council is not perceived to be leader in the agricultural sectors despite recognition of research quality.

The main threats include an imminent retirement of several key senior scientists in the absence of successors; a depreciated and poorly maintained research infrastructure; poor working relations with some key stakeholders; a declining financial base; and a culture that detracts from a climate of innovative science.

Partnerships have improved with provincial governments resulting in several success stories with impact; however, there are poor relationships and partnerships with DAFF and other key science entities – for example the NRF. Although the ARC is increasingly positioning and engaging with the provinces, this could be more strategic and could avoid overlap with extension. Industry was of the opinion that the ARC does not engage sufficiently with them.

The scientific culture can do more to enable innovation and transformation, and overall the ARC lacks capacity for strategic and foresight analysis. The review analysed the ARC as an agricultural innovation system and to start with identified that innovation is not explicit in the value proposition. There is lack of clarity and understanding across the ARC of the agricultural innovation systems concept.

It was found that the R&D processes within the ARC still largely focus on knowledge/technology generation and validation rather than the entire spectrum of the knowledge value chain.

Climate change is arguably the biggest issue that South African agriculture will face in the next century. At a programmatic level, the quality of science is poor and fragmented for natural resources management, especially in the priority aspects of climate change and the environment. Under the existing organisational structure of the ARC, it is difficult for cross-cutting themes to gain the prominence and resources these issues merit. Currently, the climate and environment programmes and initiatives in the ARC enjoy low priority, are not well coordinated and lack visibility in and outside of ARC.

Recommendations

The following strategic recommendations were highlighted as an outcome of the review process.

There is a need to **review and develop governance policies to address relationships within the ARC, as well as between the ARC and its key stakeholders.** The ARC should collaborate with its strategic partners in the formulation and articulation of an innovation system and in the process address issues of co-ordination, communication and information management system, reward sharing mechanisms as well as a framework for organisational capacity building of the different actors.

Strategy, governance, executive management. The current financial model is inadequate to meet current and future needs for research, innovation and technology transfer.

The ARC board and executive should actively engage regularly with key stakeholders especially the shareholders to ensure alignment of strategy and actions to existing agriculture, science and technology, environment, water and relevant health policy frameworks of government and the Science Agenda for Agriculture in Africa within the context of a systematic, multi-level, institutional strategic and business planning approach.

The ARC executive management, supported by the board, should re-position itself to take up research funding opportunities that exist in all relevant commodity groups, government departments, private companies and international research and donor organisations.

Steps are needed to create and promote a scientific climate that is more conducive to interdisciplinary research within the ARC and with strategic partners. The review found ARC deficient as an active 'learning' organisation. The review recommended that the ARC creates a planning group to identify climate and environment priorities and strategies and to ensure that there is coordination of on-going initiatives. This planning group should include strategic partners to ensure that a coherent and integrated approach to issues related to climate and environment is developed that can provide useful guidance to South Africans as the effects of climate change become more pronounced and to prevent expensive duplication in data collection.

Continue to nurture the key flagship research programmes and focus areas that the ARC is known for, i.e. innovative production technologies, plant breeding, diagnostics, management of alien invasive plants, maintenance of national assets (biosystematics) and pest and disease clinics.

The ARC must invest in human capital and ensure effective succession and retention planning, mentoring programmes and enable excellence. The review also recommends that it is important to retain and grow the identities of key research and diagnostic entities such as the API and OVI. The API and OVI have maintained a high level of science output, but risk losing credibility through loss of capacity. The recommendation is that the ARC considers ways and means to encourage scientists and veterinarians to join and remain with the ARC, especially persons who know the local agricultural and academic landscape and can communicate with farmers, academics and industry.

Following the review, the ARC established a Strategy Board Committee inclusive of the executive, selected board members and external experts. The purpose of the committee was to develop a vision and strategy to take the ARC forward. The strategy document – Vision 2050 – is near finalisation and will be submitted to the newly-appointed board for approval during 2017.

There is need to maintain, upgrade, expand and extensively invest in physical facilities and infrastructure including equipment, laboratories, greenhouses and the experimental farms.

Envisioning Agriculture (CS1)

Various frameworks for strategic thinking were considered as a basis for developing a vision statement for the AET study panel. Ideally, the use of scenario (planning) option analysis and or market future analysis could have been more accurate in terms of creating a vision for the future of AET in South Africa as it is a complex challenge that has been the subject of numerous reviews over the past two decades.

However, in the light of the time and resource constraints, envisioning draws on the knowledge, experience and perspectives of the panel members, invited experts, a literature review and a SWOT analysis that included consultative workshops with the critical stakeholders.

> In "solving real world strategic problems, one must find not merely novelty, but novelty in the context of constraints, trade-offs and uncertainty, and that solution must be useful".
> (Loehle, 1996)

At its inaugural meeting, the ASSAf study panel on AET considered a range of preliminary guiding principles for a future AET system that included (but are not limited to) the following:

- **The vision should be aligned with agricultural, scientific and other socio-economic policies** in South Africa, the SADC region and with the AU's Comprehensive African Agricultural Development Programme.
- **A new vision should be forward looking, inspiring, attractive to and resonate with young people** and all the components of an integrative AET system.
- The **future AET system should be responsive to the needs of intended users and beneficiaries of the system** and be quick to react to the social, economic and environmental and technological changes on an ongoing basis thus building balance, predictability and resilience in all its components.
- **There should be a managed transition from the current institutional arrangements** to a system that is comprehensive, inclusive, professional, entrepreneurial, impactful and accountable.

> At the core of a new AET system is a focus on human capital development, innovative delivery, monitoring and controlling systems supported by autonomous yet inter-connected institutions.

Beyond a new vision, mission, goals and objectives for the sector, an AET strategy will need to be definitive about what needs to be done, by whom and by when.

A starting point in developing a vision for a future AET system was to reflect on the critical elements of policy and practice that potentially impact on the existing system. A number of key questions were considered in the envisioning exercise, most pertinently the following:

- How could effective working relationships between agricultural training colleges be established?
- How could issues of articulation between colleges and universities be addressed most effectively and efficiently?
- What is the feasibility of the establishment of a dedicated agricultural university?
- To what extent and in what quantities should an AET system be producing PhD-level specialists in the agricultural and life sciences in the context of growing the knowledge economy?

In order to frame the future vision of the AET system, the National Department of Agriculture vision statement for the agricultural sector was considered, "A united and prosperous agriculture". Whilst simple in its articulation, the statement captures the desired end state and resonates with the ambition of the NDP 2030, as well as the AU Agenda 2063.

Within this broader vision for the sector, a vision for AET can be articulated, as **'Accessible, responsive, quality education and training for agriculture and rural development'**. This broad vision is not linked to specific time frames, and emphasises the requirement to support land reform along with the continued support for the agri-food value chain.

The study panel proposed a vision for South African AET. By 2030, South Africa's AET system should be:

AN INTEGRATED, AGILE SYSTEM
DELIVERING EXCELLENCE
IN PURSUIT OF AGRICULTURAL GROWTH AND PROSPERITY

The AET system will be:

- A vibrant, cohesive, connected proficient and robust AET system re-enforcing agricultural prosperity, socio-economic development and well-being.
- Inclusive of farmers' organisations, related education and training institutions, agri-business firms, research organisations, consumer organisations.
- Purposefully integrated, coordinated and co-competitive.
- Adequately funded with high-performing institutions of higher education and training.

Opportunities for Supporting the Science Agenda (CS8)

Post-democracy it has been asserted that South African AET and agricultural science should play an important role in the SADC region. This position has been considered by the panel, and it is agreed that whilst South Africa has a role to play in the SADC region, it also has a role to play in the continental agenda, articulated in Agenda 2063. As noted earlier, over the next ten years, the agricultural agenda within Agenda 2063 will be primarily driven by the **CAADP** and the **Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods.**

African solidarity for science, which is articulated in the Science Agenda for African Agriculture (S3A), has been ratified as the main framework for driving science and technology in the CAADP process. The S3A provides a collective vision for science in agriculture in Africa, through a framework and set of guidelines to shape immediate priority setting for implementing CAADP.

The core of the agenda is to connect science with end users in a more effective way for the benefit of society. The three primary strategies for operationalising S3A are: a) integrating science (AET, AEAS, local partnerships; state and non-state actors); b) connecting science (with farmers, producers, entrepreneurs, consumers); c) strengthening sciences (basic sciences; skills, facilities and policy environments; and capacity to address new and evolving challenges).

The following need to be enabled for the S3A to be operationalised and successfully implemented.

Strengthened institutional systems of science for agriculture. In principle, effective national systems are the building blocks for regional, continental and global partnerships which are required to achieve the S3A goals. Sustaining basic science capacity at the national level is thus the basis upon which the strategy can be achieved.

Each country needs its own strategy that defines its needs for science and agricultural research. The poor linkages between research, extension, agricultural education and the end-users of innovations need to be addressed by all countries – as in many cases there is a tendency to consider these as separate stand-alone entities. Well-integrated systems of education research and advisory services are ultimately the universal solution.

Strengthened partnerships for operationalising S3A collaboration for shared gains. It is acknowledged that African science and education are chronically under-resourced. Sharing knowledge and research facilities amongst countries will better address common challenges, thus increasing African agricultural competitiveness. Africa's partnerships in science should be based on the principles of mutual benefit, mutual responsibility and mutual accountability.

Increased investments in public agricultural R&D. Investments in agriculture research have increased by 20 per cent between 2001 and 2008 albeit from a rather narrow base, following two decades of almost stagnant growth. This growth, however, was observed in a few large countries and investment efforts in many African countries appear to be inadequate and highly dependent on donors. It can be assumed that African countries have domestic resources that could be mobilised and more funding for S3A should be mobilised from the private sector. Countries should explore several nonconventional sources of funding for science.

A reform agenda for Tertiary Agricultural Education and Training. Many efforts in this regard are currently underway, including the work of Tertiary Education for Agriculture

Mechanism in Africa (TEAM-Africa) and the Agriculture Technical and Vocational Education and Training (ATVET) initiative to develop the AESIF.

AET has been an integral part of national strategies in countries such as India, Brazil, Malaysia, Chile, and the Philippines which have successfully developed their agricultural sectors. The AET system in Africa therefore needs reforms and strengthening, particularly as it relates to the lack of staff with PhDs, the aging academic workforce, the limited number of researchers, and curricula that are obsolete.

From the above, it is evident that there are many opportunities for the South African AET system to be responsive and contribute to the S3A. There are also potential partnerships with continental institutions and actors that could enhance and strengthen potential impacts.

One of the most promising potential partners on the continent is RUFORUM, who are currently playing a leading role in dual spheres of capacity development and policy influence. The 5th Biennial RUFORUM Conference was held in Cape Town in October 2016. At the conference the collaboration between RUFORUM and the African Union Commission to increase investment in higher education was formalised. Ten African heads of state and government have been constituted into a committee to champion higher education, science and technology in Africa, as part of the efforts to strengthen the role of science and technology to enhance the realisation of economic growth on the continent. A meeting with these heads of state and higher education partners will be held in Mauritius during 2017. The meeting will explore the role of the private sector in funding and supporting higher education.

There are several South African AET institutions with sufficient convening power to network and support collaborative activities to assist with enabling the Science Agenda. Specific opportunities for contribution are identified below.

1 **Supporting capacity development at the national level.** South African institutions have experiences to share in terms of reforms and developments that craft a well-integrated, self-productive, self-regenerating, system of education, research, advisory services. AET in Africa need to better understand the special role of AET in 'reproducing' the innovation system.

2 **Promoting postgraduate training especially PhD level to invigorate research.** Capacity building of agricultural stakeholders and access to information through improved training and extension, intensified agricultural research, and the use of science and technology.

3 **Promoting reform models for integrating higher agricultural education with research and extension.** The current consensus study is an exemplar in the respect that it reflects candidly on the system and envisions a transformed future. The very process of conducting the consensus study can serve as a learning opportunity for other countries seeking to undertake similar processes.

4 **Seeking solutions for sustainable financing**. South African role players are called upon to assist in the design and establishment of the African Solidarity in Science Fund that promotes science mobility, sharing technologies, information, facilities, staff, and engaging Africans in the diaspora.

South African AET institutions can gather lessons on how South Africa finances the sciences including gleaning of best practices in competitive research management. This includes sourcing and managing funding from public and private sources, as well as public-private partnerships.

5 **Collaboration for mutual benefit.** South African institutions can do more to support and engage with regional centres of excellence to share knowledge and facilities. This includes strengthening sub-regional research cooperation through sub-regional groupings such as the West and Central African Council for Agricultural Research and Development (CORAF), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA).

South African institutions need to play a bigger role in partnerships at national and regional level and are called upon to support the establishment of innovation platforms aligned with CAADP.

6 **Enabling environments.** South African AET institutions should seek ways to enable more open flow of people, knowledge and resources among other African countries.

7 **Foresight studies and policy research.** South African AET institutions have the capacity to generate the agricultural research policy research and analysis needed for creating a favourable policy environment for science. It is time this role evolved from International Food Policy Research Institute (IFPRI) to African research institutions with greater efforts from South African institutions.

As local and external pressures exert themselves on Africa, mega trends and challenges for agriculture (such as population growth, urbanisation, climate change, variability adaptation and mitigation, market access and trade) are some of the key areas that African science needs to negotiate. This cuts across themes such as sustainable intensification, modern genetics and genomics, and workforce development. South African AET institutions have greater capacity for strategic and foresight analysis in this regard, and these skills need to be developed for every region on the continent.

Areas Where South African AET Could Learn from Other African Experiences

The following are areas in which the AET institutions in South Africa could learn lessons from the African experience:

- Promoting AET alignment with smallholder farmers through curricula reform and improved linkages with agribusiness.
- Seeking more inclusive growth models for agriculture and rural development.
- Skills and models for community-based natural resources management.
- Reforming the science system to respond to needs of smallholder agriculture.
- Integration within sub-regional research entities such as CORAF, ASARECA and CCARDESA.

Governance and Reform: An International Perspective (CS9)

Ensuring that the knowledge and educational needs of the food systems are met poses organisational and structural questions across the globe. Making cutting-edge research results available to practitioners, educators and entrepreneurs is a necessary, but not easy, task. Engaging community members and university students in education programmes that are relevant to current issues and responsive to ever-changing conditions is complex, but imperative.

Various successful models have been identified and applied internationally to address these challenges. Three outstanding international examples were examined as potential models for application in South Africa – namely the US, Brazil and India.

These countries have been selected for several reasons:

- Each has made distinctive contributions to the organisation and delivery of food system research and education and each faces problems similar to those of South Africa and has relevant experiences from which South Africa can benefit.
- India, Brazil, the US and South Africa are culturally and economically diverse countries that face problems of inequality and discrimination, but have strong commitments to democracy, inclusive development and improved livelihoods for all citizens.
- All four countries have experienced marked failures and impressive successes in generating knowledge and providing information to ensure that the food system contributes to the economic, environmental and human health of these nations.

The goal of this component of the study is to explore how the agricultural knowledge system, including formal and community education, and research can be structured to deliver a safe, adequate and affordable food supply, while simultaneously providing strong environmental stewardship and good livelihoods for those working in food production, processing and marketing.

The comparative analysis is not intended to 'shoe-horn' South African institutions into an agricultural education framework that evolved elsewhere, but rather to analyse the successes and failures of several education, research and outreach systems to assess what might be most appropriate for the South African context and goals through asking the following critical questions:

- Are there historical lessons to be learned?
- What models have worked in other parts of the world?
- Do the approaches outlined in the case studies align with South African goals?

The goal is to promote discussion within South Africa on the strengths and weaknesses of the current system and to develop a vision of what food system education and research should look like 20 years from now.

Taken together these case studies sought to answer the question, how can the South African agricultural research and education system realise the benefits of integration without institutional disruption and new legislation.

The discussion is divided into four broad sections. The first section will provide a brief description of the land-grant system of the US and of the social environments that led to its creation and evolution. Studies comparing the land-grant system to other systems too often focus only on the reporting relationships of ministries, university faculties, research institutes and extension organisations, without considering why the institutions were created and their underlying goals. The enabling conditions and social contexts which stimulated these changes were much more important to their success and long-term impacts than reporting hierarchies and curricula details.

The second section will involve the case study of India, which made a significant effort to implement the land-grant model starting in the early 1950s. Third, the development and successes of *Empresa Brasileira de Pesquisa Agropecuária* (the Brazilian Corporation of Agricultural Research)(EMBRAPA), a publically-owned parastatal, in Brazil which transformed the Cerrado from a semi-arid wasteland to one of the most productive soya-bean growing areas in the world will be explored.

Finally, there will be a discussion of what aspects of the case study systems should be considered for inclusion in a forward-looking South African system that will provide new knowledge and innovations, as well as a skilled work force for the food system of the future, 20 or 30 years from now.

The United States Land-Grant System

The land-grant system in the US, which now includes 106 universities with mandates for undergraduate and graduate education, research and extension, developed in the middle of the 19th century, a time of rapid expansion westward and industrialisation in the US. The legislation to create the land-grant system was passed during the middle of the US Civil War when Abraham Lincoln was president (Pell, 2016).

The economy was in turmoil: the textile industry on which both the North and South were economically dependent was severely disrupted. Many young men were in the military, leaving women largely responsible for agricultural production. Slavery was hotly contested and soon would be illegal, creating social upheaval and opportunity. Within a few months of passage of the Morrill Act of 1862, which created the land-grant system, two other very important bills also were signed into law by congress: the Emancipation Proclamation, which freed the slaves, and the Homestead Act which gave settlers title to 65 hectares of land at no or minimal cost if they tilled the granted land for five years.

These three laws were transformative: they provided freedom to the slaves, made sweeping changes in land access and tenure, and greatly expanded educational relevance and opportunity. It is hard to believe that this was accomplished in the middle of a bloody civil war, the outcome of which was very uncertain. Although much racial discrimination persisted after the Emancipation Proclamation both legally and in practice, the Homestead Act permitted grants of land to both freed slaves and women. These social, economic and historical contexts strongly affected the evolution of the land-grant system and influenced its goals, as well as traditional educational considerations like organisational structure and curriculum. The parallels between this tumultuous period in American history and South Africa's transition to a democratic inclusive government are evident: there was no alternative to significant social change to provide freedom, political voice, equitable land tenure, educational access and economic development. Both countries also had the benefit of charismatic and visionary leadership.

Since 1862, massive technological changes in agriculture and industry have reduced the proportion of the US work force involved in production agriculture from about 64% to less than 2% (New York Times, 1988; US Bureau of Labour Statistics, 2012). The original land grant institutions of the mid-19th century bear little resemblance to those same institutions today. However, today's 106 land-grant universities educate about 60% of undergraduates in the US (Glossner, 2012) and retain their **original mission that universities must serve societal needs as well as educating the next generation.** The initial vision and structure of the land-grant system envisioned in the 19th century was sufficiently robust to permit its evolution to meet the needs of today's very different society.

In the US land-grant system, undergraduate and graduate education, extension and most research are integral parts of the university system. By including these three functions under one administrative structure, cross-agency rivalries and budget battles are minimised. In addition, research results are more likely to get into the hands of practitioners and students are more likely to acquire a good balance between theoretical knowledge and practical skills needed to succeed. An important consequence of strong links between researchers and practitioners is that scientists are more likely to ask pertinent research questions that result in information that is relevant to farmers and others in the food system. With strong communication between academics and those involved food production, processing and marketing, the problems of isolation and irrelevance of research and education programmes are greatly reduced.

The 1862 Morrill Act profoundly affected the funding, access and curriculum of American higher education with long-term consequences. Because the 1862 Morrill Act was passed during wartime, funds to establish the land-grant institutions were unavailable. Congress mandated that each state would be granted 30 000 acres of land (12 188 hectares) that could be sold to fund the new universities, hence the title "land grant" (Wright, 2012). These lands often were not in the same state as the land grant university: the land for New York's land grant institution was in Wisconsin. Over time, additional laws were passed that established research and extension funding, which provided additional Federal support to the new institutions. Until the middle of the 19th century, most universities in the US were private, most with religious affiliations but some secular. One of the consequences of the Morrill Act was to make it easier for states to create state-supported universities.

Prior to the Morrill Act, most colleges focused on the classics and theology, not on soil science and dairy production, but the Morrill Act explicitly mandated that the land-grant institutions were to focus on practical subjects such as agriculture, science, military science and engineering without exclusion of classical studies (Abramson *et al.*, 2014; Wright, 2012). The stage was set for the evolution of the land-grant institutions into comprehensive universities.

The stark contrast between the goals of the old and young American colleges is reflected in their mottos: the Latin mottos of two of the oldest American universities, Veritas (Truth, Harvard) and *Lux et Veritas* (Light and Truth, Yale) are quite different from Cornell's English maxim "Any Person, Any Study".

Similar differences were evident in their curriculum and student bodies. However, it would be incorrect to conclude that faculty members at some of the older colleges also were not involved in research with agricultural importance.

While the university curriculum was changing, so was the student body. Enrolments increased and access for lower-income students improved. The original Morrill Act was explicit that people from all economic backgrounds should have access to the new institutions, but this did not extend to race. It was not until 1890 that the second Morrill Act was passed, which required each state to demonstrate either that race was not a criterion for admission or to create a separate land-grant institution for people of colour, an acceptance of a separate but equal doctrine that was in effect until it was overturned by the Supreme Court in 1954.

In 1994, a third Morrill Act was passed to provide support for colleges with land-grant mandates for native Americans. To ensure that technical education and research were broadly available in fields other than agriculture, sea grant, urban grant, space grant and sun-grant institutions have been established.

As we consider the attributes of the land-grant system that might be relevant for South African institutions, it is important to recognise that in the US, the national department of education does not control university curriculum. Curriculum is the domain of the faculty, state departments of education, and regional accreditation and certification boards. **The result is a heterogeneous system with different requirements and standards, which has permitted states to develop institutions that meet local needs.**

Remarkably, despite the decentralised system, students are able to transfer credits to universities across the country because of accreditation and articulation agreements. Fig. 4.1 shows a simplified organisational chart for Iowa State University, the first land-grant university created in 1862. The board of regents is the governing board for the public universities in Iowa (the University of Iowa, Iowa State University and the University of Northern Iowa, as well as a couple of specialised post-secondary programmes). Needless to say, there has been considerable social and economic change in the ensuing 150 years.

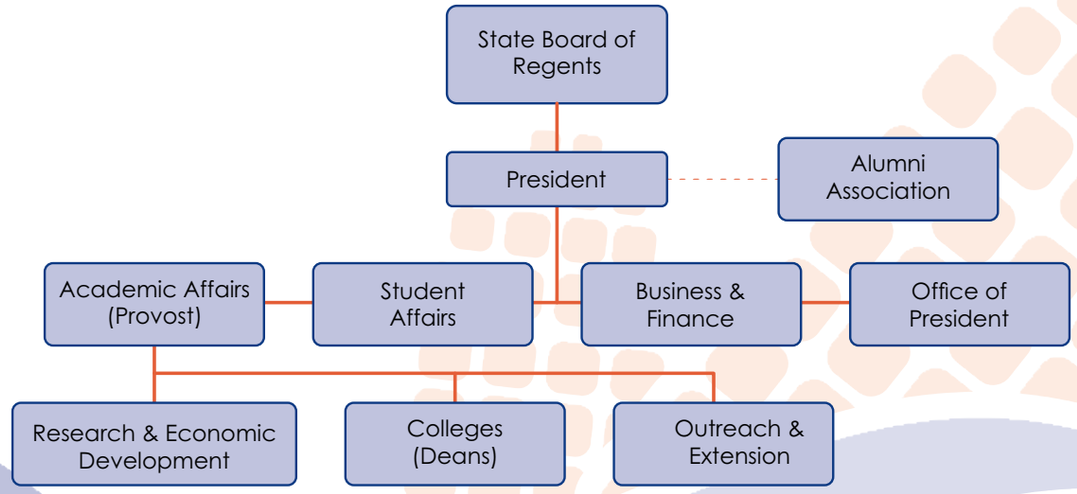

Figure 4.1: Simplified organisational chart of Iowa State University
Source: Based on Iowa State University (n.d.)

The board of regents, whose members are nominated by the governor and approved by the state senate, has responsibilities that are analogous to a board of trustees. The state legislature approves an appropriation to the university which, coupled with tuition, external funding, and donations, comprises the university budget. Although there have been some prominent exceptions, generally the state legislatures do not meddle in the day-to-day running of the universities. These university-government relationships differ considerably from many African models in which the national government, through the ministry of education or higher education, exerts considerably more direct control over curriculum, academic programmes and management.

Under the American system, funding is the primary mechanism by which the national government can influence academic programming at universities. However, this financial influence is tempered because public universities receive most of their budgets from state funds, tuition and external sources, not from the federal government. Although the federal government provides considerable support for financial aid, research, extension and infrastructure, these funds are administered by separate government agencies with limited coordination.

With the state legislatures working through quasi-independent boards of regents and the national government influencing universities indirectly through funding, it is reasonable to ask who is minding the store to ensure quality. The answer is that the regional higher education accreditation boards, which are private, non-profit corporations, with strong emphasis on self-regulations and peer review, play an important role. They coordinate accreditation review teams, composed of faculty from similar institutions and assist in articulation between secondary schools and higher education. In most countries, the role of the accreditation boards is assumed by the Ministry of Education. Reliance on the independent accreditation process is another example of American wariness about government meddling in higher education and academic freedom. Accreditation reviews are required every ten years, unless a review is required sooner due to previously identified problems. Failure to gain accreditation has serious consequences on institutional credibility and the ability of the university to attract students and external funding.

The organisational chart of Iowa State University (Fig. 4.1) also shows a second important aspect of the land grant system. The Provost, who also is the Vice-President of Academic Affairs at Iowa State, directly oversees research and economic development, the colleges and academic programmes, and outreach and extension. This arrangement makes integration of the three core missions of the university much easier than if these functions were located in separate government ministries with several intervening layers of oversight between the relevant players.

A third benefit of the organisation of land-grant system is that county or local extension staff are integral to university outreach programmes. Originally, each county had an extension office with staff with skills needed to promote agriculture and economic development for the region and a local advisory board to provide guidance on programming. As budgets have become more constrained and the number of farmers has declined, mergers between county associations have been common, leading to the creation of multi-county consortia. The county agents' salaries are paid by funds both from the university and from local government, putting pressure on extension agents to meet the expectations of both local and state constituents. This state-local connection improves communication, which in turn improves the quality of both the local education programmes and applied research at the university.

One of the primary strengths of the land-grant system is that it fosters bi-directional communication between educators, researchers and practitioners. These interactions ensure that community educators are familiar with new technologies and their applications, while students and researchers are knowledgeable about field problems that require research or educational attention. As is the case in many parts of the world, community education programmes in the US often are under-funded, with serious consequences for small-scale farm operations. Producers now rely heavily on the internet and on regional workshops for technical information and phone consultations with either extension staff or with agribusiness personnel and veterinarians to solutions of immediate problems. Today's extension workers are more specialised and technically oriented than their predecessors, but many US farmers have university degrees and considerable computer savvy, both of which are essential for this evolving model to succeed.

Fifty years ago, most land-grant research focused on solving problems directly related to agricultural production such as management of plant and animal diseases, soil degradation and selection of varieties. Today's applied research focuses more on issues of the commons: management of water supply and quality, climate change and land-use planning. These environmental and development problems have much broader constituencies than the production-focused concerns of the past and often embroil the research and education system in controversial issues. Procuring funding for support of these contentious issues that affect most of the population, but often have no clearly defined constituency, presents funding challenges, especially at the local level. These "problems of the commons" are not unique to the US: they manifest themselves somewhat differently in South Africa, India and Brazil.

The Indian Land-Grant Experience

The case of India, which developed its own land-grant system, closely following the US model, provides evidence of aspects of the land-grant system which have worked and failed in an emerging economy.

When considering the Indian case study, it is important to note that the US and Indian relationships between the national and state governments differ significantly.

The national ministries and institutions like the Indian Council of Agricultural Research (ICAR) have considerably more academic, administrative and financial influence over the Indian agricultural universities, than do the national departments of education and agriculture over the land-grant universities in the US. The consequences of this political reality were not considered carefully during the planning of the Indian land-grant system.

India, like the US in the mid-19th century and today's South Africa, is undergoing profound social and economic change. Because of definitional and methodological differences, estimates of the Indian population dependent on agriculture vary from 30% to 75%. World Bank (2015) data indicate that the percentage of the Indian population employed in agriculture declined from 59.9% in 2000-2 to 47.2% in 2010-2, which underscores India's rapid urbanisation and possibly explains some of the wide variation in estimates of Indians engaged in agriculture.

Other important changes in Indian agriculture also are underway. The proportion of women in agriculture increased from 11.7% in 2005-6 to 12.8% in 2010-1, while the size

of operational farm holdings decreased from 0.07 ha to 1.16 ha over the same period (Dhar, 2012). When the land holding area from 1970 (2.22 ha) is compared to the 2011-2 information, we find that today's farmers have about half as much land to till as the farmers of 40 years ago. Changes in the Indian diet and an increasing demand for food mean that India's food security will depend on changes in many aspects of the food system, including the agricultural research and education institutions.

From approximately 1952-1972, India started to develop state agricultural colleges with responsibility for education, research and outreach modelled directly on American land grant universities. Initially, eight state agricultural universities (SAUs) were founded, but eventually 28 institutions were created. During this period, there was extensive interaction between Indian and American academics. In 1972, political differences led to an abrupt halt to the US-Indian collaboration, but the Indians continued development of the new system.

Busch (1988) and Herdt (2006) examined the successes and failures of this full-scale importation of an educational approach from North America to South Asia. First, it is important to note that predictably, the Indian land-grant system differs in many respects from the American model, but all the SAUs have responsibility for education, research and outreach.

The Indian land-grant accomplishments over the first three decades were impressive: 1) India developed a postgraduate education system that enabled them to meet their manpower needs in agriculture, 2) there have been increases in productivity of many commodities including dairy, wheat, rice, sorghum, millets, and pulses, and 3) dissemination of new technologies like artificial insemination improved (Busch, 1988). Within a single generation, the Indian agricultural education and research system met many of its initial goals.

However, there also are areas where the SAUs have fared less well: they have not been able to adjust nimbly to meeting new challenges. Debates on the success of the Indian land grant system often have focused on whether a semester system is preferable to trimesters, rather than on whether the system was appropriate for India and what adjustments were needed (Busch, 1998).

Developing programmes on sustainable agriculture, globalisation of agricultural markets and the need to use new educational technologies and approaches in programmes for community members and university students has proved challenging in India. Moving from commodity-based technical extension programmes to integrated interdisciplinary initiatives that include crop management, environmental conservation, marketing and entrepreneurship has been difficult (Busch, 1988).

Inadequate funding, lack of strategic planning, limited communication and collaboration among SAUs and slow adoption of student-centred education for community practitioners and university students are some of the reasons for slow progress in addressing complex issues. Top-down lecture-based instruction has prevailed so too often research and outreach programmes that are irrelevant to the needs of those involved in food production, processing and distribution. This problem is compounded by the lack of agricultural experience of many undergraduates at the SAUs (Busch, 1988). Incoming students often lack essential agricultural field experience and the SAU practical course offerings are insufficient to make up the deficit.

> Creating institutions with integrated organisational charts that link undergraduate and graduate instruction, research and extension programmes is not sufficient to overcome poor communication and management: an enabling environment, leadership and good policy also are essential.

As has been the case in the US and many other countries, the SAUs have been under-funded, forcing choices between research, undergraduate instruction and extension, with community education often bearing the brunt of the lack of resources.

Development of cost-effective models for community education or extension has been challenging in India, especially because, until recently, there was heavy reliance on the 'local office-visiting agent' model. In the SAU system, because of limited budgets, field-based agents still had tenuous linkages to researchers and educators, and did not have the resources to reach enough potential beneficiaries to effect significant change. This problem becomes especially severe when the needs of the smallholder farmers differ appreciably from those who have access to more resources and better markets.

With limited government resources, stagnating extension budgets and rapid urbanisation, development of new approaches to getting information to all farmers regardless of scale is necessary. New virtual learning technologies hold great promise for providing needed agricultural education to all groups of farmers. For example, Digital Green, an international non-governmental organisation that works in South Asia and sub-Saharan Africa (http://www.digitalgreen.org/) has taught farmers how to make short, low-cost videos to permit sharing of effective and adoptable technologies among producers. The Digital Green model combines social learning with technology in ways that are accessible to those in need of a specific technology or knowledge.

> If Massive Open Online Courses (MOOCs) can attract hundreds of thousands of students and Wikipedia can render hard-copy encyclopaedias obsolete in a decade, it is reasonable to assume that in the next 20 years, farmers and others in the food system will get needed information very differently from today.

The Brazilian Experience

Brazil's agricultural transformation since the early 1970s when the *Empresa Brasileira de Pesquisa Agropecuária* (the Brazilian Corporation of Agricultural Research or EMBRAPA) was founded, has been impressive. The transformation of the Cerrado from a semi-arid wasteland to one of the most productive soya-bean growing areas in the world has been remarkable.

EMBRAPA, which has been at the forefront of Brazil's agricultural development, is differently organised and managed from the SAU system in India and the land grant approach in the US. **The mission of EMBRAPA, which is a publicly-owned parastatal housed within the Ministry of Agriculture**, is to "[p]rovide feasible solutions to the sustainable development of Brazilian agribusiness through knowledge and technology generation and transfer" (Correa and Schmidt, 1999). Approximately 95% of EMBRAPA's budget is from the federal government, but EMBRAPA has a decentralised structure with 54 units to ensure that EMBRAPA can meet the diverse needs of Brazilian agriculture from temperate Santa Catarina in the south, to the hot-dry Cerrado in central Brazil and Manaus in the steamy Amazon basin.

EMBRAPA is responsible for both research and extension, but not education. The universities are under a different ministry with national and state oversight and separate funding, an arrangement that might lead to poor communication and lack of cooperation. The opposite has been the case: relationships between the universities and EMBRAPA are very good. The government has mandated that funds and personnel from both entities are essential for project approval.

At the highest levels of the Brazilian government, support for EMBRAPA has been strong. During the 1990s when the Brazilian economy was growing rapidly, the government invested 1% of Brazil's agricultural GDP in EMBRAPA, which is comparable to the investments made by Australia (0.8%) and Canada (1.2%) (Correa and Schmidt, 1999). The current budget deficits in Brazil have led to threats of inflation and a budget freeze. Cuts to EMBRAPA and most other Brazilian government programmes, including pensions and unemployment insurance, are very likely (The Economist, 5 June 2015a), even though agriculture has been exemplary in its adoption of a technologically-based and market-driven approach to agribusiness.

The agribusiness sector is projected to grow by 2.5% in 2015, while the rest of the Brazilian economy is predicted to contract (*The Economist*, 27 June 2015b). Agribusiness would not be growing during Brazil's current economic downturn without the careful planning and technology-based approach that EMBRAPA has fostered over the past 40 years.

EMBRAPA recognised from the outset that they required a strong media presence to succeed and that new approaches to community education were required. They invested in getting their information out through television, radio, the internet and print media much more heavily than comparable institutions. The result is that stakeholders are familiar with EMBRAPA and its programmes. Because these programmes focus on local problems, the information that is aired is relevant to and appreciated by their intended audience. The result is widespread adoption of EMBRAPA technologies like transformation of the Cerrado and use of precision agriculture (Correa and Schmidt, 1998; *The Economist*, 2015a).

Although technically EMBRAPA is a parastatal within the Ministry of Agriculture, careful planning and policy development took place early in EMBRAPA's history to ensure that they did not encounter the administrative and relevance problems that other parastatals have encountered elsewhere. The EMBRAPA administration included agriculturalists and business people who were familiar with the ecological and economic constraints that they were working under and who were committed to a comprehensive planning process. They recognised the importance of functioning markets and the need for appropriate policies and functional institutions to support research and extension. They knew that they had to develop an organisation that worked administratively and that each unit had to have a critical mass so that it could meet the combined research and community education agenda. EMBRAPA has been managed well and avoided the pitfalls encountered by many other parastatals.

Which Options Should South Africa Consider?

Revising institutional arrangements to achieve direct reporting of those responsible for research, education and extension is difficult to achieve in many African countries, including South Africa. It likely would involve parliamentary action, with divisive and complex politics in budget-constrained environments.

Focusing on why the institutions are dysfunctional and brainstorming various solutions is likely a better approach to developing an innovative, competitive food system. As Brazil and Kenya have demonstrated, different organisational structures are workable, if steps are taken to ensure that needed communication, transparency and trust are in place.

Recent experiences of Kenya may be useful in developing a way forward in addressing some of the difficult political issues inherent in food system reform.

In Kenya, through the writing of the new constitution and the Vision 2030 strategic planning process, efforts are underway to improve institutional efficiency and cross-agency communication. Some bold steps have been taken to change both organisational structures and the missions of the new institutions. The merger of the Ministry of Education with the Ministry of Higher Education, Science and Technology has created the Ministry of Education, Science and Technology with a mandate for all levels of education from pre-primary to postdoctoral and adult continuing education. The old Kenya Agricultural Research Institute (KARI) has become the Kenya Agriculture and Livestock Research Organisation (KALRO) with a broader mandate to make policy, establish research priorities, monitor on-going agricultural research and oversee research centres. The goal is that KALRO's new structure will enable it to administer Kenya's agricultural research and make needed linkages with education and training. The Ministry of Agriculture, Livestock and Fisheries also is undergoing similar reorganisation.

Although the extension system and the universities still are housed in different ministries, their collaboration is stronger than in the past. Key to their success have been:

- Commitment of leadership in the ministries and in the highest levels of government to effective collaboration.
- Funding of programmes that mandated planning and collaboration among groups involved in research, education, and extension.
- The Kenyan ministries and universities have been given more latitude in raising funds, but have also assumed greater fiscal accountability.

These reforms are in the early implementation stages so it is premature to evaluate them, but these considerable efforts coupled with Kenya's long history of investment in education and research likely will result in a system that is more responsive and able to provide integrated responses stakeholders' needs.

All the case studies, including Kenya, underscore the need to act: planning to plan the next stage of the planning changes nothing. After thoughtful consideration of the best

options, decisions must be taken and disruptive changes made. This involves leadership: having vision and the will to act, involving and listening to others to develop a joint vision and strategy with strong support for implementation, and being willing to evaluate progress honestly and admit mistakes all are essential. **Whether it is Abraham Lincoln, Nelson Mandela, or those responsible for the development of the SAUs in India or EMBRAPA in Brazil, leadership matters and lack of leadership often has serious consequences.** Social and economic context also matter. The changes to education, land tenure and the emancipation of the slaves during the US civil war occurred because the existing situation was untenable, as was the case in South Africa's transformation. Continuing on the same road was not an option in either the US or the South African case. In the EMBRAPA situation, the situation was less dire, but strong and committed leaders with the desire and vision to realise Brazil's tremendous agricultural potential were willing to step up and engage in the creation of an effective, well-managed system to manage agricultural research and education. The benefits of this approach are evident as the Brazilian economy is slowing down: agriculture is flourishing. The EMBRAPA example is not unlike the South Africa's position as it reimagines its food system research and education system. The opportunity to develop the agricultural sector with the production of high value products is clear – critical decisions must be taken in order to move the system forward.

Imagining Innovation at an Institutional Level

Across the world, including in Africa, innovative models of delivering education at the institutional level are emerging and demonstrating impressive success. A few of these examples are discussed below to illustrate the range of innovative models which can be adopted at an institutional level.

EARTH University

In Costa Rica, EARTH University was created in 1990 to reach out to students with high potential and motivation, but who would typically be excluded from educational opportunities at the tertiary level (https://www.earth.ac.cr/en).

EARTH University is a non-profit, private, international university dedicated to contributing to sustainable development through education in the agricultural sciences and natural resource management. Its objective is, through innovative academic, research and outreach programmes, to develop the new designers and implementers of solutions that promote improvements in the quality of life globally.

The four-year programme is demanding but focused, aimed at developing agents of change. It integrates technical and scientific skills, develops social awareness and commitment, purposefully cultivates effective leadership, and develops entrepreneurship capacities (Zaglul, 2016).

EARTH University is unique in several ways; in the context of this consensus study two key features of the EARTH model are of particular relevance – a focus on experiential learning and an inclusive admission policy.

Focusing on Student-Centred, Experiential Learning

Experiential learning focuses on process rather than content, making it particularly well suited to agriculture. The learner, not the teacher or the discipline, is the focus of the student-centred approach that EARTH University takes.

The study programme at EARTH is based on the principles of experiential learning and there are extended periods of 'hands on' learning where students work on EARTH's 3 300 hectare farm gradually enhancing their skills. In the third year of study, students work directly with smallholder farmers through attachments.

All students also participate in a three-year Entrepreneurial Projects Programme where they work in small groups to develop and sustain an enterprise.

Before they graduate, each student will complete a fifteen-week internship in a real-world context.

Broadening Access through Innovative Selection

EARTH recruits promising young people of limited resources from remote and marginalised regions who show potential as future agents of change.

An extensive system of scholarships enables students who would not normally have access to tertiary education to enter the institution. Approximately 80% of its annual intake of over 100 students receives some level of support (Sherrard, 2014).

The second process to widen access is to enrol students who show a clear commitment to rural development. At EARTH, motivation and commitment are core attributes in the selection process – regardless of the academic background of the student. Although traditional test scores are taken into account, the potential of the student to become a change agent plays a vital role (Sherrard, 2014).

This dual approach of providing financial support and selecting based on commitment has paid off - EARTH has an above-average retention rate of 86% (Zaglul, 2016).

> A generation of leaders in agriculture has to be cultivated. This requires a focus on entrepreneurship, viewing and treating agriculture and the environment as interdependent and compatible, constructing knowledge and experience in the learning environment instead of passively acquiring it, and accessing information based on inter and multidisciplinary approaches (Sherrard, 2014).

The core principle from EARTH that is of critical importance in South Africa is ensuring that fair access to the AET resources of knowledge and learning are made accessible to motivated and committed students who have strong potential to become tomorrow's change agents.

The transformation of South African AET would be enhanced by learning from, enhancing, and institutionalising the experiential learning initiatives pioneered by EARTH University.

Towards an Ideal AET System (CS10)

It has been generally accepted that agriculture will remain a fundamental instrument for poverty reduction, economic growth, and environmental sustainability for Africa in the 21st century.

Appropriate and adequate education and training, at all levels and in many spheres, are essential for a revitalised agriculture sector.

This section describing an ideal AET system borrows from a chapter in the recently published book *Towards Impact and Resilience: Transformative Change in and Through Agricultural Education and Training in Sub-Saharan Africa* edited by Swanepoel, Ofir and Stroebel (2014).

Tackling Transformative Change

The many positive and negative influences on and challenges to the AET system, as well as its singular position in the AIS, appear to be well understood. Importantly, the need for transformative change for success in the AET system is clearly recognised and is being increasingly called for. Many mechanisms are proposed with various forms of linkages across the AIS system; capacity-strengthening initiatives are at the centre of most.

As a result of its strategic position within the larger system, transformative change in AET will in turn ripple across the AIS (Fig. 4.2). The results will be felt in all parts of the system. Given the state of the agriculture sector, such changes are urgently needed.

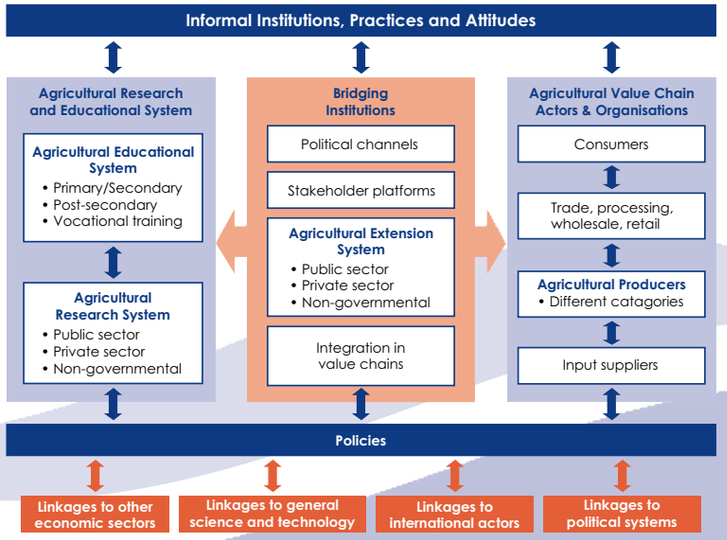

Figure 4.2: The AET system embedded in the Agricultural Innovation System
Source: Birner and Spielman (2007)

The needed transformation can be achieved through grand plans, as well as incremental change, as long as key levers or potential tipping points are identified. Interventions can then be structured around these strategic areas. Amidst a plethora of proposed interventions, it will be crucial to focus on what can activate the system to undergo change that is radical and comprehensive enough to be transformative.

Defining Transformative Change. First, it is necessary to understand what is meant by 'transformative change'. Transformative change is seen as profound, fundamental, and irreversible. It is based on breakthroughs, on fundamental shifts in individual, group, institutional, or societal values and perspectives. Such shifts involve changes in viewpoint, vision, paradigm, life purpose, organisational direction, or socio-political reforms, which in turn seed fundamental shifts in behaviour or performance. These shifts bring regenerative moments and lead to radical redirections of efforts across a system (Hannum *et al.*, 2006).

Transformative change is usually more or less unexpected, often achieved through key 'levers' and sometimes through hard-to-predict tipping points. It is always more profound in consequence than developmental or episodic change. It tends toward the multidisciplinary and holistic, integrating a range of strategies that focus on people's beliefs, values, and attitudes. Strategies may also focus upon individual behaviours, as well as the institutional and social systems and structures in which individuals operate.

A system can be transformed over time through a series of incremental changes; transformation may also come about as the result of a shock or strong pressure on the system. The transformation process can be accelerated by understanding what might be 'transformative' and by seeking to promote interventions that have a good chance of bringing about fundamental change.

Activating Transformative Change. It is necessary to consider on the one hand the balance between drivers and enablers (catalysts of change) and existing strengths in the AET system, and on the other hand, drivers of vulnerabilities and constraints that act as impediments to change. This balance will differ by context – that is, by province, institution, or set of institutions.

Significant or transformative change may come if the combined effect of the positive influences is more powerful and effective than the vulnerabilities and constraints in the system. If change is to happen, these two types of forces on and within the system should not be in equilibrium. Just a few strategic interventions over time may overcome the constraining forces. Therefore, it is important to try to recognise which interventions might be transformative for the whole system.

An understanding of what could shift the balance in critical parts of the AET system will help determine the strategies needed to bring about the desired transformative change. The challenge is to identify those factors and interventions likely to be most pivotal for this purpose and those that might be poised to result in tipping points leading to transformation. The interventions have to be combined and sequenced well for best effect and to prevent disequilibrium. If the process is not properly managed, the whole system might become ineffective or even disintegrate.

There is also a need for 'best fit' solutions, i.e. solutions tailor-made for a specific set of circumstances and able to evolve as the context evolves. Thus, the actual design and

implementation must be managed by leaders at all levels of the system – leaders who truly understand the context within which the changes are to take place and who are committed to working towards success over time – where necessary, in collaboration with one another.

In addition, leaders should be in a position to predict, at least to some extent, the intended and unintended effects – both positive and negative – of planned interventions and ensure that capacities are in place to make fast adjustments as needed. Trajectories towards transformation are hardly predictable, and without experimentation and advanced modelling it is almost impossible to be certain that such strategies will succeed. But informed leaders in each institution or set of institutions can at the very least establish enabling conditions to improve the chances of success and develop an AET strategy that emphasises those interventions likely to make the most effective and sustainable changes.

As noted earlier, it will also be crucial to understand which actions could be catalytic for transformation, whether through 'big plans' or incremental change. It is necessary to determine which interventions definitely need central or 'top-down design and activation through national or provincial or local policies, strategies, and funding, and which may best evolve 'bottom-up' as stakeholders' interests, capacities, exposure, and linkages with others grow. In this massive task, choices have to be carefully made.

The recommendations formulated in this study report are those which the panel has determined have high potential for positive transformative change if managed and implemented with due consideration and commitment.

Roadmap towards Transformative Change in the South African AET System

The studies commissioned by the study panel discussed several critical challenges that can be found in AET within South Africa. There are also many common drivers of vulnerabilities and drivers for change, as well as enabling and constraining factors.

Through the deliberations of the panel, and based on literature it is possible to start constructing an 'ideal' roadmap that can serve as a broad indication of which routes might lead to change (Fig. 4.3). The construction of this roadmap has been informed by Eicher (2006); Pal and Beyerlee (2006); Stroebel and Swanepoel (2008); and Stroebel *et al.* (2011).

The proposed roadmap is not intended as a blueprint. It is general by design, intended to be part of a process of rethinking, reframing, and reshaping structures and ideas to lead towards radical reform of the AET system within the framework established by the AIS.

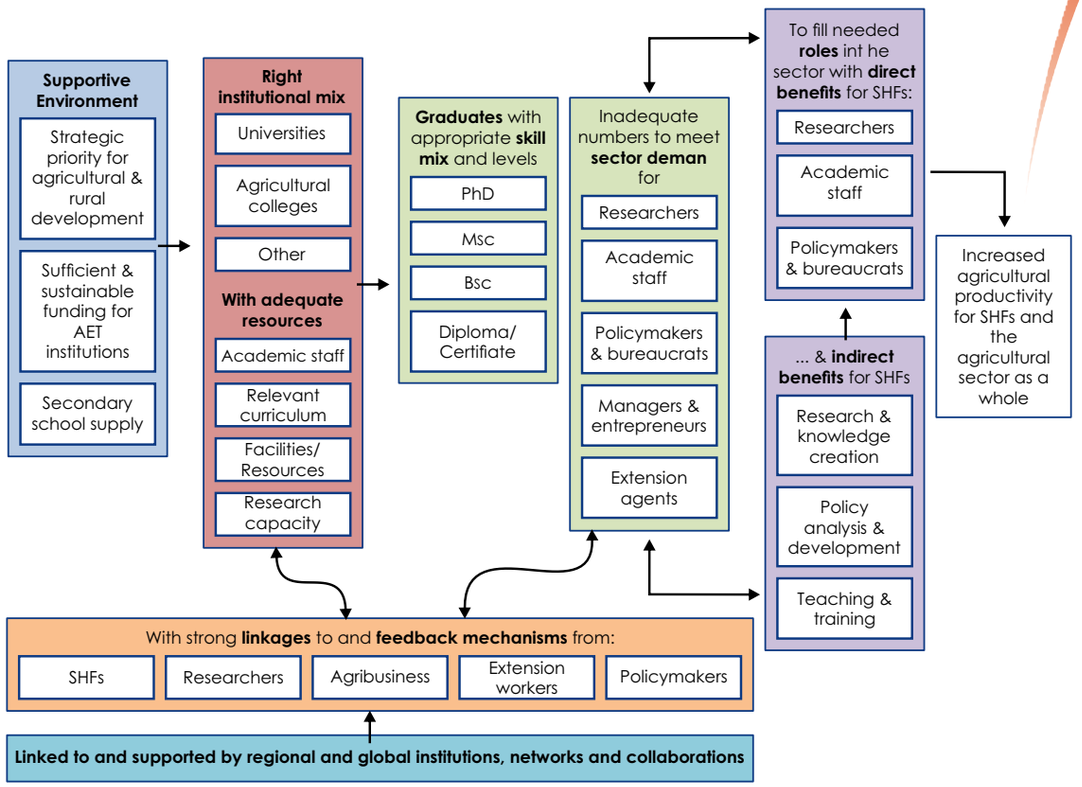

Figure 4.3: An ideal roadmap for the transformation of AET
Source: Based on Swanepoel et al. (2014)

The key components of the proposed roadmap are noted below.

The Supportive Environment

As a subsystem of the AIS, AET has particular characteristics. It is an open system, and therefore maintaining an enabling external environment is very important. The characteristics and quality of the external environment determine the level and type of support and resources available to the individuals, institutions, collaborations, and networks in the system, as well as the ease with which their work can be done.

Attention should therefore be on the economic, political, policy, sociocultural, environmental, demographic, and technological conditions that affect institutions and their inter-relationships. These conditions will reflect the balance between the opportunities and challenges that exist in the agriculture sector and beyond. It is strikingly evident that a supportive environment is lacking in the governance of AET in South Africa.

Government policies, strategies, regulations, and protocols are of particular importance for transformative change given the proliferation of actors, linkages, and markets in the agricultural innovation system. Most importantly, the real needs of smallholder farmers

should be fully included in development policies and strategies – including AET-related plans – in tandem with rather than in opposition to or as a minor component of the sector as compared to large-scale farming.

The paradigm shift from agriculture to agribusiness and entrepreneurial activity provides both opportunity and challenge. It requires policies, strategies, regulations, and protocols that will promote and catalyse the shift, while also providing protection against undue risk and exploitation. Participation in giant international agri-food value chain networks, co-existence and mutually beneficial collaboration between large-scale and smallholder agriculture, a bio-based green economy, and a focus on the agriculture–food–nutrition nexus bring new and exciting opportunities, yet are accompanied by severe power asymmetries that greatly enhance risk for the smallholder farmer.

Government must create an environment that promotes positive outcomes while guarding and protecting the agricultural sector – in particular the smallholder farmer – against any action that might hurt national, sector, or AET system interests. Institutions across the AET system are well positioned to help identify and alert governments to such opportunities and risks and should nurture relationships that will help ensure that expert opinions are sought and heard.

Policy coherence is a critical issue. AET-related policies must be aligned with national investment plans and policy regimes in the higher education, agriculture, and industry sectors. Political support will be difficult to obtain if public support for agriculture is low. Several sections of this report refer to the need to cultivate a positive public image of the agriculture sector and of the AET system. If stakeholders are convinced of the economic value of AET, they can help convince governments of the need to support it.

The government must also encourage linkages between education and training, research and development, and extension, the so-called knowledge-triangle, in order to allow the system to respond to demand.

Agricultural development is a national strategic priority, and the important role of the AET system is articulated in national development goals. Resource allocations in both the agriculture and higher education sectors, and in other relevant arenas, should reflect these priorities.

The National Mapping Study clearly showed the disconnect between the relevant ministries as being of particular concern. This disconnect diminishes policy coherence and the efficient and effective allocation of resources, demonstrating the importance of structural linkages, i.e. land-grant-style institutions, to encourage the appropriate linkages.

Agricultural education is expensive compared to many other areas, making it difficult to maintain research and training programmes and infrastructure. Therefore, it is important to explore diverse and innovative investment opportunities offered by the private sector through a programmatic rather than budget-centred approach and through South-South collaboration (Amanor, 2013).

The Right Mix of Institutions with Adequate Resources

The challenges facing institutions have been well documented throughout this study report. Fragmented and limited resources have compounded these difficulties. The increasing diversity across the AET system in terms of pedagogies, institutions, students, expectations, and missions must be dealt with and made to work in synergy – a very challenging task.

Importantly, insufficient institutional capacities continue to limit smallholder farmers' access to knowledge and technologies, hindering their efforts to thrive. Although many mechanisms exist for this purpose, institutional capacity strengthening programmes will have to be primarily based on the formal and informal connections between interrelated components within the AET system and the AIS. There is some evidence, that the knowledge triangle within the innovation system supported by land-grant-style institutional structures, where AET is closely linked to research and extension, are more successful. Such connections expose individuals to new information and knowledge and provide them with opportunities to test their own knowledge.

Funding sources are increasingly mixed, and the financing of extension training can draw from a wide variety of mechanisms outside the AET system. Catalytic and long-term investments can both be used to direct strategic priorities. There is a need for more concerted approaches and joint business plans involving donors, governments, and AET stakeholders.

Appropriately Trained Graduates

New trends and paradigms likely to influence the sector in coming decades and the resulting demands for better and new types of graduates are challenging the whole system. A new generation has to be prepared.

They have to be entrepreneurs outside of and across international and local value chains; able to work effectively in systems with and as researchers, extension agents, farmers and entrepreneurs; and adaptive enough to evolve with new demands and opportunities. Institutions therefore have a series of issues to deal with as part of the transformation of the AET system.

AET in South Africa must increase its understanding of farmers' learning strategies, approaches, and methods. Farmer study groups and learning circles are examples of valuable learning approaches which allow for farmer-centred learning.

Producing such graduates will entail most, if not all, of the following aspects:

- Reorienting graduates towards a multidisciplinary, systems approach.
- Educating them from within African contexts and with African experiences and solutions, but with international experience coupled to incentives to return to South Africa.
- Focusing on holism and generalism.
- Embedding gender, sustainability, quality assurance, and other key concepts in the underlying knowledge systems.
- Ensuring expertise to engage with old and new user communities, agribusiness, and global value chains.
- Enabling the construction of knowledge and access to information based on multidisciplinary approaches and on engendered approaches to learning, research, and work.

- Encouraging organisational and social entrepreneurship with a mind-set that favours proactive action, risk-taking, competitiveness, autonomy, and innovation.
- Cultivating the right set of values towards people and towards the complementarity between agriculture and the environment.
- Understanding smallholder farmers and the rationale for technology development and use, and being able to participate in shared impact-oriented progress assessments that promote self-reliance.
- Developing extension agents who can act as agents of change among farmers and in their relationships with other parts of the system. These agents should be catalysts – initiating learning and being conduits for knowledge resources, while respecting and activating 'agency' in the farmer.
- Institutional structures, processes and approaches need to facilitate and encourage entrepreneurial and innovative programmes and strategies. At the same time, hindrances to focusing on entrepreneurship and innovation should be removed, for example by channelling funding for systems approaches through departments as a means of stimulating such focus.

A more considered focus on all levels of education and training across the spectrum – vocational, college diploma, undergraduate, and postgraduate education and training – is critical. However, it is important ensure that postgraduate education and training is not neglected in the pursuit of developing the entire system. It is also necessary to attend to the supply pipeline – those who come through the school system as potential candidates for post-secondary studies in agricultural fields. Rapidly urbanising young people need to have the awareness and incentive to study and work in an arena that is usually seen as less attractive for a prosperous future.

> The AET system needs a specific type of leader at this juncture: innovative, inspiring, willing to take calculated risks, and most importantly, committed to working on common interests with the web of actors and institutions in an AET system embedded in a larger national system of innovation.

System-wide quality assurance and learning through appropriate and useful external and internal monitoring and evaluation, supported by an effective accreditation system, these are regarded as crucial for the regulation of the system. Importantly, quality assurance and learning provide information for strategic and operational decision-making at various levels within the system, and among those to which the various institutions in the system are accountable.

Finally, curricula need to be modernised to include:
- updated systems, in particular farming systems approaches, with a strong focus on local (social inclusion, environmental sustainability, resilience), regional, and global (trade, climate change) challenges;
- integrating multi and interdisciplinary foci, thus cultivating both specialists and generalists;
- synthesising and integrating knowledge in domains such as production, environmental integrity, social benefits, consumer requirements (health and food safety), sustainability science, and others;
- supporting interaction with farmers – providing them with feedback for evaluation, and exposing students to practical application in the field;
- emphasising the implications of global and regional and national policies and value chains, as well as the interface between political and technical issues in areas such as trade, foreign direct investment, international protocols, and controversial technologies;
- co-creating curricula to ensure gender responsiveness at all levels of the AET system and the agriculture sector;
- maintaining entrepreneurship and innovation as central tenets for working both within and outside of agricultural value chains, including work in the area of food and nutrition.

Curricula for entrepreneurship and innovation require a systems orientation, multi and interdisciplinary approaches, and experiential and work-integrated education and training. Prerequisites for success are individual and collective capabilities in innovation and entrepreneurial activities, supportive organisational cultures, external networks, and tailor-made pedagogical approaches. In practice it is hard for those who are not innovative and entrepreneurial to teach these characteristics and approaches to others.

Linkages and Collaborative Networks

Networks and collaborative ventures provide staff opportunities for participation in knowledge-sharing as well as regional staff development programmes in areas where there are otherwise not enough resources to support such opportunities – for example, small nations without the critical mass needed to support AET institutions, specialised technical fields, and emerging cross-disciplinary areas. This is further discussed below.

New mechanisms to access and share information and learning, facilitated by information and communication technologies and social media, are widely recognised as having significant potential to leapfrog poor infrastructure and enable better scholarship. Advanced ICT facilities can facilitate collaboration, for example by sharing expert scholars among institutions and drawing upon non-university experts from various spheres – government ministries, non-governmental organisations, the private sector, and think tanks – to bring their knowledge into the higher education domain.

Feedback Loops

How will we know if it has worked? There should be support offered by an adaptive management approach that can respond quickly to lessons learnt and changing contexts.

Adaptive management is facilitated by effective monitoring and evaluation as part of institutionalised quality assurance, i.e. 'balancing quantity with quality'; supporting accreditation and ensuring that information for decision-making and accountability is available in a timely manner; and ensuring that curricula and programmes evolve as sector needs change.

Impact on the AET System: Towards Resilience

The transformation foreseen in this consensus study report will also have a major impact on the AET system. If well designed and implemented, it will lead to a more effective, efficient, relevant, and respected national AET system, with the "ideal" attributes described in the proposed roadmap. The transformation should also lead in the long term to a more resilient system.

In the simplest terms, the resilience of a country, society, system, or institution depends upon its ability to be flexible and to adapt readily and effectively to slow or rapid change – or to resist such change if resistance will bring better results in the long run. Similarly, the resilience of individuals and the groups to which they belong is to a great degree determined by their ability to adapt quickly and effectively or to resist shocks or evolution in the environment.

Strategies and interventions should therefore not only transform the AET system to be more relevant, efficient, and effective in its value addition to the AIS, but also make it more respected and in the long term, more resilient.

The starting point for cultivating resilience is to identify the drivers for current vulnerabilities. Although not explicitly mentioned as such in earlier sections, several issues have emerged that can be designated as drivers of vulnerabilities in the AET system. They show that the resilience of the system is dependent not only on forces from within the system itself, but also on external forces in the agriculture, education, and other sectors, on a national, regional, and global level. This issue needs to be further explored.

Policy and decision-makers at national sector, system, and institutional levels need to understand drivers of vulnerabilities, as well as the hurdles to resilience in the AET system, and these issues should be systematically addressed as soon as resources allow. Innovation, financial strength and access to information and knowledge are crucial. Methods are needed to predict responses to interventions and possible negative consequences during transformation, and a set of solutions should be in hand to alleviate or neutralise negative effects. There should be a will to act and to invest resources in strategies with the potential to counter the risk of negative consequences and dependence on others. Cooperation – with an open platform for communication among different parts of the system and with key external actors – is crucial. All systems should move in conjunction with one another so that they can respond systematically and in synergy to any emerging risk or failure.

AET is part of the AIS and interlinked with many other open systems. Its successful transformation will therefore have impacts far beyond the system itself – on agriculture value chains, on rural development, and in the higher education sector. Eventually transformations in AET will impact society itself.

Using a 'theory of change' approach (Funnell and Rogers, 2011; Vogel, 2012), the contributions expected from changes in the AET system can be aligned with national policies and strategies. Although the contributions may be small and the impact pathways hard to trace, planning within the wider strategic frameworks helps to direct the overall approach and specific strategies towards change.

Of particular importance is the assessment and promotion of policies and strategies that can lead to mutually beneficial arrangements between smallholder and large-scale agriculture. Whether in the same value chains or existing side by side, this dual track is likely to persist. It is therefore crucial that both groups benefit from each other and those positive impacts are felt by both.

Accelerating Transformative Change

Strategies can be designed and implemented in a top-down or bottom-up manner, or a combination of both, in order to arrive at a 'best fit' solution for AET system transformation in South Africa. The approach in each case will depend on specific decision-making and governance systems, public and political interest, and institutional cultures and capacities, as well as on the strength of connections to regional efforts in this regard.

It will be difficult to address all the issues proposed in the roadmap. Difficult choices must be made, including between strategies for incremental or radical change, and top-down or bottom-up evolution. Efforts towards transformation can be facilitated through learning from the current situation, from the past, and from others' experiences, as well as through incremental learning as new strategies and interventions unfold. Such efforts can also be bolstered through using complexity science, and if resources and expertise allow, through forecasting, modelling, and experimenting with factors that could tip the balance towards the desired transformative change.

As pointed out, quality assurance at various levels is needed in order to support successful higher education programming. Monitoring and evaluation can also be valuable for other purposes and can play a crucial role in accelerating transformation processes.

Understanding Transformative Change

Monitoring and evaluation provide for strategic and operational learning. They are crucial to honing policies and strategies through incremental learning. They aid understanding of change logic and development trajectories, save time and resources by enabling quick adjustment after failures, and identify those aspects – incremental or radical – that are potentially most crucial for transformation. Monitoring and evaluation can also enhance the ability and motivation of key stakeholders to experiment, learn, assess, and rapidly scale up successful interventions.

Monitoring and evaluation will not only help assess progress during the transformation process itself, but will also provide evidence for the results (outcomes and impacts) that it delivers at crucial points in the AET system and beyond, both during and after transformation.

Planning, monitoring, and evaluation can be connected from the start of a strategy or programme, using state-of-the-art techniques to combine monitoring and evaluation with change logic or 'theory of change' (Funnell and Rogers, 2011; Vogel, 2012).

As transformation takes root, developmental evaluation – real-time monitoring of progress, performance and impacts – can be combined with special external or independent evaluation studies of progress, performance, impact, sustainability and resilience. This

adaptive management approach will assist in tracking and assessing changes as they happen and will support the evolution of transformation strategies. Importantly, such real-time learning coupled to evaluation will help identify unintended consequences of interventions in a timely manner. Where such consequences are negative, monitoring and evaluation can serve as an early warning system to help prevent ineffective action and wasted resources. Monitoring and evaluation can also be a useful instrument on the complex road towards building a more resilient AET system.

Throughout all monitoring and evaluation activities, the voices of smallholder farmers – including their different groupings in society such as men and women, cooperatives, and so forth – should be heard, respected, and used.

CHAPTER 5: Main Findings

WHERE DO WE WANT TO BE?

Envisioning AET in the Future

The study panel proposed a vision for South African AET, namely that by 2030 South Africa's AET system should be:

AN INTEGRATED, AGILE SYSTEM DELIVERING EXCELLENCE IN PURSUIT OF AGRICULTURAL GROWTH AND PROSPERITY

In order to deliver on this, the system will be:

- A vibrant, cohesive, connected proficient and robust AET system re-enforcing agricultural prosperity, socio-economic development and well-being.
- Inclusive of farmer's organisations, related education and training institutions, agri-business firms, research organisations, consumer organisations.
- Purposefully integrated, coordinated and co-competitive.
- Adequately funded with high-performing institutions of higher education and training.

WHERE ARE WE NOW?

Key Finding 1: Continued Challenges Facing AET

Agriculture is a key component of the South African economy. Although the country can maintain the ability to meet national food requirements, more than seven million citizens experience hunger, while 22.6% of households have inadequate access to food (Stats SA, 2016). In this context, South Africa's agricultural sector faces several challenges; among the primary challenges faced by the sector are the challenges experienced in the broader AET system – including in the education, extension and research components.

The NDP has a clear focus on (i) job creation through the agro-food processing value chain, (ii) an expansion in quality and provision of vocational training and (iii) training and entrepreneurship for extension workers. The value of education is also prefaced in the NDP – particularly high-level skills development is linked to the increased university enrolment, PhD graduates, and of university staff with PhD, as well as the expansion of STI. AET is thus firmly on the national agenda.

However, a key challenge in South Africa is identifying the policy objectives that should be driving the evolution of AET in the country. Early on in democracy the following imperatives were identified:

- The **need for responsiveness** of the system to the ongoing social, economic and political changes.
- The **need for rationalisation and greater integration and linkages** between the various components of the AET system – the system should be efficient, well-coordinated and integrated at all levels.

- **Equitable access and meaningful participation.**
- **More equitable funding** of programmes and institutions, and **standardisation of quality by site.**
- **Targeted training programmes enhancing the skills of the providers of extension** within the public sector.
- **Greater contribution within the continent and the SADC region in particular.**

By and large there is still a pressing need to address these issues. This must be done cognisant of the fact that the public education and training system has been in a state of fairly constant reform since 1994. Much has been achieved in transforming a highly segmented system into a national system, and there has been significant progress in terms of access at all levels. Unfortunately, the quality of the expansion has at times been poor, and most critically the foundations have not been strengthened. Now is an opportune time for transformation (not more reform for the sake of reform) as the system as it relates to AET is highly fluid.

Key Finding 2: The (Dis-)Enabling Environment

Governance and Coordination (CS1&2)

The challenge of governing a system across multiple ministries and with multiple levels of institutions is well known.

The national mapping exercise highlighted the urgent need for a greater level of alignment, the removal of duplication and the removal of compartmentalised (silo) structures that do not serve a coordinated and integrated AET system. The system is in dire need of substantial governance reform directed towards greater integration, cooperation and accountability to maximise the returns on available financial, human capital and physical infrastructure.

A coherent 'vision' of the future agricultural system(s) toward which South African agriculture is needed to inform the focus and direction the future AET system and the governance thereof. All stakeholders and influential role players should contribute towards such a futures/foresight exercise, while noting the importance of accepting a wider definition of agriculture, inclusive of farming (large and small scale), agribusiness and all related functions in the value chain and supporting network i.e. the 'agri value chain-network'.

The Case of the Agricultural Colleges (CS3)

The colleges have usually been administered and governed by the relevant line department or provincial department, and have not been formally part of the higher education system. This is being revised with some colleges being moved directly to the DHET. Despite this Cabinet-approved decision, there is still uncertainty about the full implications. As such there is no clarity and consensus on exactly what the future of the colleges is. Resolving the matter should receive immediate attention. The colleges have a clear and important role to play in the development of the South African rural economy, and there is a need to strengthen the responsiveness of the colleges to the full spectrum of skills needed in the country in relation to rural development.

Attempts were made by the study panel to meet with the respective parties to understand fully the situation and to position the panel to make recommendations regarding this important component of the AET system. The engagement was not sufficiently robust to allow for such a recommendation to be made. A JTTT to investigate the matter has been appointed. The JTTT will seek to identify an appropriate governance, academic and institutional model that provides a conceptual framework for the future functioning of the agricultural colleges. This model will inform the process and approach of transferring the function.

Although the JTTT was appointed in early 2016 significant progress had not been made at the time of finalising the study report.

Key Finding 3: Relevant Institutions and Adequate Resources

Articulation and Integration (CS3–7)

Although supported in principle and allowed for within the NQF, there is very little articulation between the various components of the AET system, with key blockages hindering the realisation of a fully integrated system.

The transition from school to post-school education is a key blockage point.

Not all agricultural skills and occupations require a foundation in agriculture at school level. In fact, agricultural subjects at high school may ironically be a disadvantage to students trying to enter higher education. Only agricultural science is recognised by a few universities while agricultural management practices and agricultural technology are not recognised.

There are minimum requirements for specific subjects in some fields, most notably mathematics. These entry requirements mean that there is a smaller proportion of students who meet the criteria to enter the system. Post-school AET is further affected by these lower than desired translation rates because it is competing for the pool of students with access to high-profile fields of study, such as medicine.

One of the concerns with the range of subjects available at the FET level is the lack of foundation in some of those subjects that is developed in the GET phase. This also applies to the agricultural subjects, particularly those that are not science-based. This means that schools that offer those subjects have to make extra provision for laying those foundations at lower levels, either through private tuition or through adjustments to the timetable and deviation from the gazetted norms. Very few schools have the resources or the confidence to do this and so many of the subjects are offered primarily at private or high-fee state schools. This means that the curriculum choice for the vast majority of secondary schoolchildren is very restricted.

In the agricultural sciences, the key gateway disciplines are mathematics, physical science and biology. Subject choice at school level does not necessarily bar young people from entering into the agricultural-related occupations, but **mathematics is the biggest single blockage in the pipeline** as most science and commerce-related programmes, as well as vocational programmes at colleges and universities of technology require mathematics

passes. Agricultural curricula at school-level needs to feed into the system (mathematics and science).

Relationships between colleges and higher education are not structured or regulated and rely primarily on individual relationships among institutional leaders. There is no legal framework to encourage or require systemic relations between universities and colleges of agriculture. The lack of clarity and progress around the agricultural colleges and their positioning within DHET (as opposed to DAFF) has significant ripple effects on the quality of educational provision and the potential for enhanced articulation.

Reversing the Inverted Pyramid

South Africa's post-school inverted pyramid negatively impacts the delivery of AET in the country. Too many institutions focus on academic programmes and too few prepare people for the intermediate and lower levels of skills. This situation is unsustainable when taking into consideration the NDP targets for increased enrolments.

Vocational training should be afforded a high priority. Farm workers, as well as all worker/labourers in the agriculture and food value chains (AFVC), have become highly specialised positions due to the ever-increasing need for greater productivity and competitiveness. Significant growth in enrolments and high-quality graduates is required in the TVET colleges for South Africa to 'flip' its inverted triangle and train adequate numbers of graduates in vocational programmes as is intended in the NDP. Regrettably the performance of these institutions has been poor. In total, there are no more than 1 500 students across the public TVET system registered in agricultural-related qualifications. This is an unacceptable *status quo*, which needs to be addressed. International models, for example the vocational sector in Germany, provide frameworks and models which can be studied in-depth and contextualised for South Africa to improve the efficiency and effectiveness of the TVETs, but also to increase the impact of the AgriSETA.

The important role of the colleges and the potential role of the proposed community colleges are key levers in addressing the situation. Practical and feasible solutions, which are innovative and forward-looking, should be encouraged to address the situation. Solutions should address fundamental issues such as governance structures for TVET colleges, colleges of agriculture and community colleges; as well as articulation and mobility for students within the system.

Complex social and economic factors drive the current over-emphasis on university-level training. Proposed solutions to address the matter must focus on ensuring quality of education, exposure to cutting-edge practical training and employability of graduates to be successful. This will require innovative collaboration between the components of the AET system and the private sector.

Funding and Resource Allocation (CS3–7)

Funding for education is a highly contested issue across institutions in South Africa. The need for greater funding for AET was raised at all stakeholder workshops, particularly the need for increased funding to enable institutions to provide practical, vocationally relevant training.

The capacity of schools to effectively deliver agricultural science as a subject is limited by a lack of funding and the absence of appropriate infrastructure for practical training. Funds which are available are not efficiently distributed or effectively managed.

Funding support was identified as a major aspect to draw students into AET in post-school education. At present various entities provide bursaries for both domestic and to a limited extent for overseas studies and exchanges. It would be worthwhile, to investigate the possibility of coordinating these efforts from a single desk/entity in order minimise administration costs and ease applications due to a single contact point. This will also enable better oversight over bursars. Access to funding for students, particularly in the colleges where NSFAS are not accessible, is critical.

The AET system will need to engage in non-traditional approaches for funding for practical level training, including building linkages to industry and the private sector. In the light of the current turmoil and uncertainty with regard to funding from government the sector cannot afford to be short-sighted in this regard.

Key Finding 4: An Adequate Number of Appropriately Trained Graduates

Relevance and Responsiveness of Curricula

There is no shortage of registered qualifications in the field of agriculture on the NQF. However, to date focus has been primarily on production; yet, skills for the agricultural supply chain are drawn from all levels of the system and not just from the university sector, and they come from a wider range of disciplines than the specific agricultural-focused qualifications. Like any other economic sector, agriculture requires a range of managerial, financial, marketing and a wide array of technical skills that are not agriculture specific. AET thus needs to focus on strengthening capacities not only for production, but to equip a broad range of professionals and practitioners to engage across multiple "points" in the value chain. In other words, there is an urgent need for improved relevance in the curricula.

Linked to the need for relevance, is the need for multi and transdisciplinary approaches to curriculum that address modern day topics, to find solutions to grand challenges, such as climate change and drive economic development. Students are primarily educated for commercial agriculture, with little focus on smallholder farmers – an inappropriate bias given the context of the country. There are *notable* exceptions, for example the Postgraduate School of Agriculture and Rural Development (PGSARD) – a research and teaching unit established in 1991 within the Faculty of Natural and Agricultural Sciences at the University of Pretoria. Programmes with a similar focus and targeted at undergraduate and postgraduate level are needed. Furthermore, there is little focus on the social and human dimensions of agriculture. All the above need to be taken into consideration if the curriculum offerings are to address current needs.

Training fails to meet the needs of industry and bridge the skills-knowledge-practice gap. Navigating the modern-day world of work requires both students and educators to become accustomed to and familiar with a broad range of skills. Training and education

require the development of the so-called T-shaped skills where depth in discipline-specific knowledge is balanced by a breadth of soft skills – including communication, management and financial skills. Taking into consideration the important role that entrepreneurship is expected to play in South African economic development, T-shaped skills must be positioned as essential supplements to disciplinary knowledge – rather than add on components.

Considering the above, the importance of the development of interpersonal and soft skills should not be overlooked. A recent study evaluated the relative importance of various skill sets within a management context. Respondents in this study assigned the highest importance to interpersonal, communication, team building, conflict management and related 'soft skills' (Van Rooyen *et al.,* 2012). The need to address depth in disciplinary knowledge, as well as transferrable skills is evident across the full spectrum of qualifications, from school level to PhD level.

Industry stakeholders specifically have expressed a clear need for the inclusion of more practical exposure, internships and industry placements, the need for the development of combined skill sets and improved communication between the industry and tertiary education providers regarding AET programmes.

From industry's side the need for more practical experience is directed primarily towards university qualifications and will have to be partially addressed in future, most probably through the inclusion of compulsory internships/placement programmes within current curricula. The success of such an initiative will depend on its ability to address practical constraints, such as the availability of affordable and suitable accommodation, the administration of the programmes and the legal status of interns from a workplace insurance perspective.

In the attempt to expand opportunities for practical exposure, South African universities need to reach out actively to smallholder groups and to small and medium-sized businesses in order to engage them in the learning process. This can significantly open up opportunities for student experiential learning opportunities.

Student attachments need a formal structure, with proper feedback and follow up between universities and industry. Attachments should be formally and collaboratively assessed by both the universities and industry.

The matter of increased practical exposure demanded from the industry, specifically at university level, raises the question of the mandates of the respective institutions/ entities within the AET system. The underdeveloped college and TVET system results in greater pressure on universities to deliver more technically/practically trained graduates, a responsibility which is rather that of the (sectoral) colleges due to the greater research focus of universities. It is essential that industry (the AFVC), both individual and organised, is involved in this process of defining the respective roles and improving the relevance of the education provided by the more practically orientated institutions (See also the Key Finding raised above related to the inverted pyramid).

The AET System is in Dire Need of Quality, Qualified Educators

The quality of educators, as well as the number of teachers appropriately trained to teach agriculture at school level is of serious concern. It will become increasingly impossible to appropriately train adequate numbers of students without addressing the need to replenish and build the cadre of agricultural educators.

The need for an increase in qualified educators is not limited to any one specific component of the AET system; rather the needs for improved skills are critical across the board from school level to PhD level.

Diversity and Transformation in the Context of Access and Meaningful Participation

Within higher education, the profile of academics in terms of race remains predominantly white, with at least five out of ten academics with a PhD in both science fields being white in 2014. However, the share of whites has decreased during the period 2010 to 2014 (HEMIS, 2016). Initiatives to enable and support black academics to pursue PhDs in these fields thus remain a high priority. There are also distinct gender gaps in the agricultural sciences, with significantly lower numbers of female staff in this group, with women holding only about 30% of the doctoral qualifications in 2014. The gender disparity is smaller for other qualification levels and the share of female staff has in general increased from 2010 to 2014 (HEMIS, 2016).

As is illustrated in Table 3.8 on page 75 (See section on The Educational Context (CS4)), neither the profile of enrolments nor graduates in either fields has shifted over the period 2010-2014. In 2014, 44% and 40% of the students in the agricultural sciences continue to be enrolled in BSc and certificate/diploma-level qualifications, respectively.

In 2014, white students accounted for only 34% of the total enrolled students in agricultural sciences. Their shares declined at all qualification levels between 2010 and 2014.

In contrast to the profile of staff, the proportion of female students enrolled in the agricultural sciences has equalled the proportion of male students, whilst graduation of female students exceeds male students, albeit slightly, in 2014.

Professionalisation of Extension Work

Within the framework of the Natural Scientific Professions Act (2003), the latest fields of practice published under *Government Gazette* Notice 36 of 2014 by the Minister of Science and Technology includes extension science as a field of practice. Thus, only registered persons may practise in a consulting, extension/advisory capacity. The process of professional registration of extensionists with SACNASP was launched in the second half of 2014. The study panel welcomes this development.

The Act also calls for CPD. Under this, persons registered as professionals are required by their code of conduct to practise strictly within their area of competence and to maintain and enhance this competence. They therefore have the responsibility to keep abreast of developments and knowledge in their areas of expertise to maintain their competence.

A committee has been established to develop CPD for extensionists and the roll out of the process. The study panel views this development as a key opportunity for the sector.

Use of ICT and Social Media (CS3)

Across all provinces and levels of education there was little evidence for the use of ICTs and social media in education and extension, despite the numerous opportunities it presents.

The lack of ICT engagement at educational level translates into poor skills and engagement with these technologies in the professional workspace which is a disadvantage for students.

Agriculture as First Choice and Career Pathways

Agriculture is not a career of first choice. This creates challenges for effective sourcing of high-quality students for post-school studies.

Within higher education there are very clearly articulated career pathways. There is however, limited understanding or awareness of the vast number of agri-business/ entrepreneurship careers that exist along the entire food and nutrition value chain. This lack of awareness is evident at both school and higher education level.

Key Finding 5: Strong Linkages and Feedback Mechanisms

The Knowledge Triangle

The linkages between research–teaching–extension are poor, and there is a need for better coordination within this knowledge triangle.

Research and Research Support (CS2)

The ARC is still relevant for both large scale and smallholder agriculture, although the council is losing positioning with large-scale commercial agriculture and is gaining ground with smallholder agriculture. The ARC is thus still a critical component of the AIS in South Africa and the region, and the ARC is still a productive R&D system even though an innovation culture is not fully embedded in the organisation.

The ARC is, however, facing severe challenges that threaten its mandate and gains, and the council is not perceived to be leader in the agricultural sectors despite recognition of research quality. The main threats include an imminent retirement of several key senior scientists in the absence of successors; a depreciated and poorly maintained research infrastructure; poor working relations with some key stakeholders; a declining financial base; and a culture that detracts from a climate of innovative science.

Climate change is arguably the biggest issue that South African agriculture will face in the next century. At a programmatic level, the quality of science is poor and fragmented for natural resources management especially in the priority aspects of climate change and the environment. Under the existing organisational structure of the ARC, it is difficult for cross-cutting themes to gain the prominence and resources these issues merit.

There is a need to review and develop governance policies to address relationships within the ARC, as well as between the ARC and its key stakeholders. The ARC should collaborate with its strategic partners in the formulation and articulation of an innovation system.

Greater cooperation between the ARC and NRF is urgently needed. These organisations have a similar vision and mission with regard to human capacity development but a greater level of cooperation towards a more focused contribution to AET is required. One possibility is the creation of a dedicated Science Research Innovation Link that coordinates and integrates efforts between these institutions towards achieving the aforementioned goal.

RESEARCH AND EDUCATION TO EXTENSION

International evidence suggests that fostering agricultural innovation through enhanced research support and entrepreneurship can become a key driver of development. However, this cannot be realised without effective innovation transfer, diffusion and uptake. In the context of AET, this process is facilitated in a very large part by extension and rural advisory services.

The study panel considered the plausibility of implementing a land-grant-type model in South Africa. Several case studies in the US, Brazil, India and Kenya were considered – each case study was selected for the comparability of context to South Africa, as well as to illustrate how various adaptions of the land-grant model have been implemented globally. The goal of this component of the study was to explore how the agricultural knowledge system, including formal and community education, and research can be structured optimally in the South African context.

Key success elements of the land-grant system were identified

- a single leader directly oversees research, the academic programmes, and outreach and extension. This arrangement makes integration of the three core missions of the university much easier;
- ideally these functions are coordinated by government within a single ministry to eliminate several intervening layers of oversight between the relevant players;
- a heterogeneous system with different requirements and standards, permitting the development of institutions that meet local needs;
- students can transfer credits to universities across the country because of accreditation and articulation agreements;
- local extension staff are integral to university outreach programmes;
- bi-directional communication between educators, researchers and practitioners. These interactions ensure that community educators are familiar with new technologies and their applications, while students and researchers are knowledgeable about field problems that require research or educational attention.

Creating institutions with integrated organisational charts that link undergraduate and graduate instruction, research and extension programmes is not sufficient to overcome poor communication and management: an enabling environment, leadership and good policy also are essential.

Revising institutional arrangements at governmental level to achieve direct reporting of those responsible for research, education and extension is difficult to achieve in many African countries, including South Africa. It likely would involve parliamentary action, with divisive and complex politics in budget-constrained environments. The case of Brazil provides an alternative scenario. EMBRAPA is responsible for both research and extension, but not education. The universities are under a different ministry with national and state oversight and separate funding, an arrangement that might lead to poor communication and lack of cooperation. The opposite has been the case: relationships between the universities and EMBRAPA are very good. The government has mandated that funds and personnel from both entities are essential for project approval.

Focusing on why the institutions are dysfunctional and brainstorming various solutions likely is a better approach to developing an innovative, competitive food system. As Brazil and Kenya have demonstrated, different organisational structures are workable to achieve the same level of coordination and relevance, if steps are taken to ensure that needed communication, transparency and trust are in place.

Opportunities for Regional Partnerships and Collaboration

South African institutions have experiences to share in terms of reforms and developments that craft a well-integrated, self-productive, self-regenerating system of education, research, and advisory services. The current consensus study is an exemplar in the respect that is reflects candidly on the system and envisions a transformed future. The very process of conducting the consensus study can serve as a learning opportunity for other countries seeking to undertake similar processes.

Various opportunities for contribution and collaboration within the region were identified in the study. The most outstanding opportunities are:

- **Seeking solutions for sustainable financing of the science.** Specifically assist in the design and establishment of the African Solidarity in Science Fund that promotes science mobility, sharing technologies, information, facilities, staff, and engaging Africans in the diaspora.
- **Incentivising investment in science.** AET institutions can gather lessons on how South Africa finances the sciences including gleaning of best practices in competitive research management. This includes various public and private models. The NRF's experience with competitive funding models can be of value in this regard.
- **Policy, research and analysis.** AET institutions have capacity to establish agricultural research policy research and analysis needed for creating a favourable policy environment for science. It is time this role evolved from IFPRI to African research institutions with greater efforts from South African institutions. FANRPAN has played a leading role in this during the past ten years.
- **Collaboration for mutual benefit.** South African institutions should seek to identify ways in which they can participate in continental partnerships that can strengthen AET in the country and contribute to African development. Key role players with significant reputation and leverage should be engaged. Networks, such as RUFORUM, provide a platform for this type of highly impactful collaboration.

  South African institutions can do more to support and engage with regional centres of excellence to share knowledge and facilities. This includes strengthening sub-regional research cooperation through sub-regional groupings such as CORAF, ASARECA and CCARDESA. South African institutions need to play bigger roles in partnerships at national and regional level and should support the establishment of innovation platforms aligned with CAADP.

  South African AET institutions should seek ways to provide spaces for more open flow of people, knowledge and resources among other African countries.

- **Foresight capabilities.** South African AET institutions have great capacity for strategic and foresight analysis and these skills need to be developed for every region on the continent. As local and external pressures exert themselves on Africa, mega trends and challenges for agriculture in Africa, such as population growth, urbanisation, climate change, variability adaptation and mitigation, market access and trade and livelihood resilience are some of the key areas that African science needs to navigate.

Concluding Reflection: Challenges in the South African Innovation System

Taken from the National Advisory Council on Innovation Strategic Plan 2016–20 and Performance Plan 2016/17 (NACI, 2016)

Since the adoption of the White Paper on Science and Technology (DACST, 1996), the NSI has made progress in several areas. However, the following challenges still need to be addressed:

- The creation of a **responsive, coordinated and efficient** NSI.
- The development of robust **planning, monitoring and evaluation** capacity.
- The **expansion and transformation of human resources** for STI.
- The **commercialisation of the results** of public research and development.
- The **improvement of knowledge transfer** and diffusion.
- The provision and maintenance of **state-of-the-art STI infrastructure**.
- **Effective integrated management of the water, energy and food nexus** to ensure nutritional security.
- The **financing of the system**, especially regarding increasing private-sector investment in research, development and innovation.
- The **uptake of locally developed technologies**.

Like other national systems of innovation, South Africa's NSI must deal with the following global challenges:

- The **effects of a fiscally constrained environment on STI.**
- The need to **demonstrate how public investment in STI benefits the economy and society.**
- **Better impact indicators** and impact assessments required.
- How to **strengthen the innovation capacity of small and medium enterprises.**
- The **rapid digitisation of the world** through the development of information and communication technologies, open science and big data.
- The **globalisation and growing complexity of STI**, which requires greater and interdisciplinary cooperation.
- The role of **STI in creating sustainable and inclusive growth**.

- **Growing societal engagement with science** and technology, and the need to ensure public trust.

Each of the challenges identified by NACI in the South African NSI is relevant to the AET context, and in this respect the AET system represents a microcosm of the South African NSI. Three further points must be noted. First, agriculture is a distinct sector and should be recognised as such. The total diffusion of agriculture into related disciplines and thematic areas should be avoided; although linkages and cross-cutting work is imperative and should be encouraged. Second, sector agriculture (and the agri-food value chain) has been identified by NACI as one of the key priorities in the NSI as it relates to the water–energy–food security nexus. Working towards an efficient AET system is therefore an urgent national priority. Third, the strong overlap between the key challenges identified by the study panel and the NACI situational analysis affirms the findings of the study panel and enables prioritisation in addressing the current challenges. This is expanded upon in Chapter 6: Recommendations.

The strategic outcomes, goals and proxy indicators identified by NACI to address the challenges above are illustrated in Table 5.1.

Table 5.1: NACI strategic outcome-oriented goals

Strategic outcome-oriented goal 1	Improved efficiency and effectiveness in generating advice (proactive and reactive).	**Goal area 1 is directly related to the objective of the consensus study, i.e. to advise government on AET in South Africa**
Goal statement	To learn from previous experience to improve efficacy, relevance and ensure evidence-based, confidential and timely advice to the Minister of Science and Technology and, through the Minister, Cabinet.	
Strategic outcome-oriented goal 2	Performance of the NSI assessed.	**Recommendation 10 (Chapter 6) indicates the potential of the panel findings to contribute to Goal Area 2**
Goal statement	To contribute to the building of NSI monitoring, evaluation and learning capability in order to assess the health of the NSI and its contribution to sustainable and inclusive development.	
Strategic outcome-oriented goal 3	Governance and planning of the NSI.	**Goal Area 3 is directly related to the objectives, findings and recommendations of the study panel**
Goal statement	To contribute to the building of a well-coordinated, responsive and effective NSI.	
Strategic outcome-oriented goal 4	To transform NACI into a smart, efficient and learning organisation.	**Recommendation 10 (Chapter 6) indicates the potential of the panel findings to contribute to Goal Area 4**
Goal statement	Transforming NACI into a smart, efficient and learning organisation.	

Source: NACI (2016)

CHAPTER 6: Recommendations

Based on the key findings described in Chapter 5, these recommendations are identified as those which are deemed most likely to have a transformative impact on the AET system.

The study panel notes that Recommendations 1 and 2 are core and fundamental to the transformation of the AET system. Without the implementation of these two recommendations, change effected will be incremental, uncoordinated, and unlikely to result in the scale of change needed.

On the other hand, the panel is of the conviction that should all the recommendations be implemented the synergistic gains will be far greater than any individual effort. It therefore stands to reason that the recommendations are closely related and highly integrated.

Recommendation 1
KEY ACTORS MUST ACKNOWLEDGE THE SEVERITY OF THE CONTINUED CHALLENGES IN AET AND THE URGENT NEED FOR CHANGE IN THIS CRITICAL SECTOR

Taking into consideration the pivotal contribution of agriculture to the NSI in the water–energy–food nexus, the panel recommends that the findings of the study panel must be put forth by ASSAf to advise the Minister of Science and Technology to bring the urgent need for change to the attention of Cabinet.

The panel further recommends that the findings of the study be broadly communicated to key stakeholders in government. These include (but are not limited to) the Ministries of Science and Technology; Agriculture, Forestry and Fisheries; Higher Education and Training; Basic Education; Trade and Industry; as well as all the provincial departments of agriculture.

This is important in the context of acknowledging agriculture as a distinct sector in the NSI which is in need of focused attention, given its fundamental contribution to sustained development and growth.

Recommendation 2
ESTABLISH A MINISTERIAL AET COMMITTEE

The panel believes that it is necessary to establish a National Council for Agricultural Education and Training (NCAET) which ensures the inclusion and participation of the linked departments whose policy and programmes need to be synergised with the AET system. A similar recommendation was made in 2003, and has not been implemented – with consequences to the system. The current consensus study has highlighted the significance and importance of the establishment of the council, particularly as the overarching challenges identified in 2003 have proven pervasive and the broad national goals for the system have not shifted substantially in the interim.

However, the panel appreciates that there is currently a moratorium on establishing new statutory bodies, and therefore recommends that a Ministerial Committee for AET be established as a matter of urgency to look into the critical areas highlighted in this report.

The urgent and immediate establishment of the Ministerial Committee is timely in the light of the work of the JTTT on the agricultural colleges, the work of the NETFAFF, the findings emerging from the ARC review, the recently approved Extension Policy and the broad systemic challenges impacting the educational environment in South Africa currently.

The purpose of the committee will be to oversee activities related to AET for a period of three years, with the goal of addressing the core challenges in the system – most specifically to guide the system towards greater integration, cooperation and accountability.

The Ministerial Committee for AET will have an important role to play in coordination to ensure that the often-disparate activities are aligned. In this context, the JTTT and NETFAFF, as well as any other AET-related task teams/committees will report to the committee.

After a period of three years, an evaluation of progress should be commissioned to determine the effectiveness of the committee. If there is a lack of drastic and significant change, it may be necessary to give consideration to the establishment of the proposed NCAET.

Additional responsibilities of the Ministerial Committee for AET are outlined in the other recommendations.

Recommendation 3
EXPEDITE THE WORKING OF THE JOINT TECHNICAL TASK TEAM

The critical role of the agricultural colleges in the AET system necessitates immediate and urgent action with regard to the current structural challenges. The panel strongly recommends that the workings of the JTTT on the agricultural colleges be expedited, and that sufficient resource allocations be appropriated to enable its progress.

Relationships between colleges and higher education institutions are not structured or regulated and currently rely primarily on individual relationships among institutional leaders. The JTTT should consider this matter in its deliberations.

The JTTT will report directly to and work closely with the Ministerial Committee for AET.

Recommendation 4
COMMISSION A DETAILED STUDY ON ARTICULATION PATHWAYS AND CURRICULUM INNOVATION

Once the Ministerial Committee has proposed and approved a coordinated governance framework which clarifies the role of the colleges, a clear matrix of human capital needs and related qualifications in the context of a well-structured AET Human Capital System should be developed. An essential outcome of such a matrix will be the integration and linking of AET offerings to ensure a more coherent context and to allow greater student and professional mobility.

The study panel found that:

i Articulation is supported in principle, but not in practice (outside of a few outstanding cases).
ii Curriculum alignment between institutional types is inadequate and governance structures do not support articulation and mobility within the AET system.
iii Curriculum is focused too exclusively on agriculture, and not on the 'big issues' (for example climate change or food security). The notion that a career in agriculture only refers to farming and its direct service activities does not do justice to the wide professional networks serving the full AFVC. An expanded view would include scientists, technical artisans, knowledge workers, legal practitioners, engineers, economists, financial analysts, marketers, to just name a few. (Greyling *et al.*, 2013; Van Rooyen *et al.,* 2012).
iv Curriculum delivery fails to leverage the power of ICTs and social media.
v Due consideration has not been given to the alignment of professional requirements for registration with SACNASP for extension workers and the training curriculum.

The study panel therefore recommends that based on the human capital needs matrix, an in-depth case study on articulation pathways and curriculum innovation be commissioned to demonstrate practically how a fully articulated system, which leverages ICT innovations and a multidisciplinary conceptualisation of agriculture, could be designed.

The study should examine the following: (i) curriculum content (including relevance and professional registration requirements), (ii) curriculum delivery innovations, and (iii) alignment of content across components of the system with the aim to promote mobility and articulation. The study should consider the issue of articulation, curricula and delivery innovation from the perspective of schools, colleges, TVETs and community colleges (prospectively). Specifically, the study should focus on the ideal roles of each of the educational providers in a fully functional system.

A particular objective of the study should be to examine the potential for improved translation from school to post-school education and the proposed curriculum and structure of agricultural focus schools in line with the proposed norms and standards.

The outcome of the study will allow for a foresight and modelling exercise to be conducted which should examine alternatives for implementation and pilot testing.

Recommendation 5
INVEST IN A PILOT PROJECT TO TEST THE FEASIBILITY OF AN ADAPTED LAND GRANT MODEL WHICH EMPHASISES INNOVATIVE CURRICULUM DESIGN AND DELIVERY

Given that the educational system has been in a constant state of reform since 1994, it is neither wise nor efficient to institute widespread reforms that are unlikely to work. Careful planning, detailed case study analysis and sophisticated modelling/feasibility studies are required to inform change.

The outcome of the articulation pathways and curriculum innovation study will allow for a foresight and modelling exercise to be conducted which proposes alternatives for implementation and pilot testing of a fully articulated micro-AET system at provincial level based on an adapted land grant model. The modelling exercise should include a feasibility analysis, including full financial projections for the implementation of a pilot project.

The design and feasibility analysis of the pilot project must:

- Reflect the structural and governance relationships proposed by the Ministerial Committee.
- Address how key hindrances in the enabling environment will be taken care of (at least in principle).
- Implement an adapted land-grant-type model after in-depth and careful case study analysis of land-grant-type models internationally.
- Take on board the findings of the detailed study on articulation and curriculum innovation.
- Draw on key success stories in South Africa to date, for example,
  - i excellent linkages between agriculture high schools and farming enterprises in Limpopo;
  - ii the North-West College of Agriculture with regard to the articulation of curricula;
  - iii effective governance relationships between colleges and universities in the Western Cape (Elsenburg/SU) and in the Eastern Cape (UFH/Fort Cox College);
  - iv working partnerships between public and private extension systems in the sugar industry in KZN and Mpumalanga.

Innovative approaches to curriculum design and delivery should be piloted within this project, drawing lessons from successful international models (such as EARTH University) and using cutting-edge ICTs.

The panel recommends that the Ministerial Committee for AET (or its successor, the NCAET) be responsible for the oversight and coordination of the pilot study feasibility analysis and implementation.

Recommendation 6
STRENGTHEN THE AGRICULTURAL (FOOD VALUE CHAIN) RESEARCH ENVIRONMENT

Greater cooperation between the ARC and NRF is urgently needed. These organisations have a similar vision and mission but a greater level of cooperation towards a more focused contribution to agricultural education and training is required. The study panel recommends the establishment of a joint working group to coordinate and integrate efforts between these institutions towards achieving a strengthened agri-food value chain research environment in the capacity strengthening domain.

Increased collaboration between these two entities will enable increased investment in cross-cutting, multidisciplinary research that address challenges related to the water–energy–food security nexus. This will more optimally position research and research support entities to contribute to inclusive innovations that stimulate growth and development.

The centres of excellence and research chairs initiatives of the DST and NRF, and the ARC centres of cooperation is a specific example of where activities in the research and capacity development domains can be aligned to yield increased synergistic gains in research and capacity development.

Continued investment in doctoral education is necessary to ensure an adequately trained science workforce. Although gains in transforming the science workforce have been made, a focus on diversity and transformation should be sustained. Collaboration between the NRF and the ARC with regard to funding postgraduate education and research through the development of a resource allocation model to support AET high-level training will contribute positively towards this goal. Activities in this regard can begin immediately.

There is a need to strengthen the link between research at universities and the activities of the ARC. Increased engagement between the NRF-ARC joint working group and SAALSDA can facilitate increased collaboration on high-relevance research projects. The study panel therefore recommends that SAALSDA receive additional support to strengthen their activities.

Recommendation 7
TRAIN THE TRAINERS

The quality of educators, as well as the number of teachers appropriately trained to teach agriculture at school level, is of serious concern. Similar concerns have been raised about the availability of high-quality educators in the college and TVET sectors. Training the trainers is therefore an important priority in sustaining a strong AET system.

In addition, persons engaged in the extension and rural advisory services component of the sector are influenced by AET in multiple ways – they are beneficiaries of AET through the training they receive, but then themselves become educators and facilitators of knowledge. For this reason, the training of extension workers should receive substantial focus as they have the potential to be the primary agents through which innovation is translated from the laboratory into practice.

In this context, the study panel recommends the following:

- Establishment of a bursary fund for persons training to be educators in the AET, with an internship service component of at least two years to retain skills.
- More purposeful use of SETA funding for reskilling and upskilling extension workers in line with the professional registration and for continuous professional development.

Recommendation 8
FOSTER LINKAGES THAT INCENTIVISE COLLABORATION, PROMOTE INNOVATION AND DIVERSIFY THE FUNDING BASE

Linkages between stakeholders in the AIS are generally weak and in need of strengthening. This statement is applicable to the linkages between actors in the knowledge triangle, between AET and industry, as well as between AET and the private sector. Because of these weak linkages, innovation potential is stifled and funding flowing into and within

the system is restricted. Taking into consideration the role that the agro-food value chain is anticipated to play in the national agenda these linkages must be strengthened to promote innovation and to encourage increased funding from diverse, sustainable sources.

The study panel recommends that the Ministerial Committee constitute a special working group to investigate and propose strategies to increase the collaboration and partnership between AET and related industry and business partners to promote inclusive innovation in the agri-food value chain.

> "In simple terms, inclusive innovation is the means by which new goods and services are developed for and/or by those who have been excluded from the development mainstream." (Foster and Heeks, 2013)

These partnership agreements should consider platforms for internships and practical training opportunities for students in the AET system (Recommendation 9), and should propose an incentive-based structure for industry and business partners to increase participation. These partnership agreements should cut across all levels of AET and all levels of business – including emerging entrepreneurs, and SMMEs.

The private sector and high-net worth persons can play an important role in funding AET. Initiatives to stimulate this are gaining momentum on the continent. At the most recent RUFORUM Biennial Conference the AU Commission Chairperson and the President of the Republic of Mauritius invited RUFORUM to participate in the First Convening of African Heads of State and Government with Private Sector and Academe to be held in Mauritius during 19-21 March 2017. Opportunities of this nature should be explored and pursued in the South African context.

Recommendation 9
INCREASE THE ATTRACTIVENESS OF VOCATIONAL TRAINING THROUGH A COMBINATION OF INCENTIVE STRUCTURES

Skills-based training, particularly around high-demand skills, clearly have a fundamental role to play in economic growth, reducing (youth) unemployment, and improved livelihoods. It is therefore particularly important to consider carefully how the TVET system, the agricultural colleges and schools and the AgriSETA can be optimally aligned and restructured to meet the demands of industry and to contribute to the national development agenda. Despite recognition of the importance of vocational education, inadequate attention has been given to creating an enabling environment in which a functional vocational system can thrive.

Successful vocational systems in Europe (for example Germany and Switzerland) offer insights and models that should be studied and contextualised for South Africa, and used to propose a holistic approach to strengthening this component of AET.

The study panel recommends that the Ministerial Committee set up a task team to develop a holistic model for vocational AET that takes into consideration successful global models, as well as the governance reform required in South Africa.

Attention should be given to the following aspects:

- Establishing partnerships with the private sector and industry – including SMMEs – for the delivery of vocational training in collaboration with AET institutions. Internships and practical training are a key piece in the employment puzzle. Vocational training which focuses on the transfer of high-demand skills that lead to employment will quickly earn a reputation as a pathway into employment, increasing the attractiveness of these programmes.
- Formalising linkages between AgriSETA, TVETs and the agricultural colleges to ensure mutually beneficial collaboration and synergistic contribution to training. The role of the community colleges should also be taken into account here, and the feasibility of structured partnerships with agricultural schools.
- Addressing concerns around the quality of educational delivery in TVET colleges and investing significantly in training equipment and infrastructure.
- Identifying strategies to attract high-quality educators and creating incentives to retain their skills (for example, a bursary funding scheme with a linked internship – Recommendation 8).

The study panel notes that the vocational training sector in South Africa needs urgent, substantially increased investment and attention. Successfully facilitating transformative change in this component of the AET system has the potential to inform the transformation of vocational training more broadly. It is therefore recommended that the Ministerial Committee take cognisance of the pressing priority in this regard.

Recommendation 10
MONITORING, EVALUATION AND LEARNING FOR UNDERSTANDING TRANSFORMATIONAL CHANGE

Up-to-date information is fundamental to understanding the contribution of agricultural innovation systems to agricultural growth. Indicators derived from such information allow the performance, inputs, and outcomes of agricultural innovation systems to be measured, monitored, and benchmarked. Such data constitute a powerful resource for research managers, policymakers, donor organisations, and other stakeholders. Key indicators provide both a diagnostic tool for assessing the allocation and use of resources and an advocacy tool for increasing resources and improving the efficiency and effectiveness of resource use.

In South Africa, there is an urgent need for the development of responsive informational and monitoring data on the AET system.

The 2012 Ministerial Review Report on the South African NSI pointed out that progress in improving the functioning of the NSI was still hampered by the absence of an assigned responsibility for ensuring the availability, collation, maintenance and analysis of STI indicators (quantitative and qualitative), needed for monitoring and evaluation, and for planning and the management of the NSI as a whole. Although evidence is available from several sources for some dimensions of discrete activity in the system, there is no

comprehensive synopsis available that reflects the system in its totality, and that allows an assessment of how it might fulfil its contribution to national development. The Minister has assigned NACI the task of developing and hosting an STI data portal for the NSI, a central repository that will be important in the establishment of research and strategic intelligence.

The panel thus recommends that the Ministerial Committee for AET collaborates with NACI, as well as a monitoring and evaluation expert, to develop AET-specific indicators which feed into and align with the broader national data portal. Collaboration with the NRF's new division for Strategy, Planning and Partnerships should also be explored to enhance foresight capabilities, including strategic planning, modelling and analysis of 'critical technology needs' to support sustainable agriculture as a means of systematic analysis and interpretation of data and perspectives to better understand trends and future challenges to enhance AET.

An important component of this will be to design and conduct a national tracer study to understand graduate employment in the sector.

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APPENDIX 1: BIOGRAPHIES OF STUDY PANEL MEMBERS

Prof Frans Swanepoel, Study Chairperson

Frans Swanepoel is Professor: Future Africa at the Centre for the Advancement of Scholarship at the University of Pretoria, South Africa; and Visiting Fellow at the Institute for African Development (IAD) at Cornell University, USA. He was the former Deputy Vice-Chancellor Research and Innovation at the University of the Western Cape, Director of the African Doctoral Academy at Stellenbosch University, and Dean of Agriculture at the University of Fort Hare. He is an accomplished scientific leader in South Africa and internationally, confirmed by his election during 2010 as a Member of ASSAf, in 2016 as a Foreign Fellow of the Ugandan National Academy of Sciences, and his appointment as Senior Fulbright Fellow at Cornell University. He is a former board member of the Agricultural Research Council (ARC) of South Africa, and serves on the board of the African Women in Agricultural Research and Development (AWARD) initiative, based in Nairobi, Kenya. He was the lead consultant in the development of a continental framework for agricultural education and skills development (AESIF), under the New Partnership for Africa's Development (NEPAD) in 2015. In 2016, Prof Swanepoel was recognised for his significant contributions to capacity development in support of agricultural transformation and development in Africa during the 5th African Higher Education Week, organised by the RUFORUM, a network of 66 African universities. He has published extensively, and supervised 30 Masters and PhD students to completion. A former NRF-rated scholar, his fields of specialisation include African smallholder agriculture, research and innovation management, agricultural education and training, internationalisation of higher education, and capacity develop-ment.

Prof Adipala Ekwamu

Adipala Ekwamu is a graduate of Makerere University and Ohio State University with academic training and specialisation in plant pathology. He has successfully championed several initiatives in higher agricultural education with significant contribution to institutional and human resource capacity building efforts. He is the Executive Secretary of RUFORUM, a network of 66 universities with a mandate to strengthen postgraduate training across the African continent. Prof Adipala is passionate about generating and disseminating research information from Africa. In 2015, he founded the *African Journal of Rural Development* (www.ajrd.info), an online open access journal to enable researchers and development actors to share their research and experiences on rural development issues in Africa. He also established primary and secondary schools that are benefiting over 2 000 pupils in an otherwise impoverished and marginalised society with limited access to education.

Prof Felix Dakora

Felix Dapare Dakora is Professor and Research Chair in Agrochemurgy and Plant Symbioses at Tshwane University of Technology. He was Dean of Research at the Cape Peninsula University of Technology.

Prof Albert Modi

Albert Thembinkosi Modi is the Dean and Head of School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal. He is a crop scientist, with research interests in seed science, agronomy and sustainable agriculture. He has 20 years experience as an academic at tertiary level. He was the founding CEO of the Moses Kotane Institute of Science and Technology. From 2014 to 2016, he was the Chairperson of the South African Agriculture and Life Sciences Deans' Association (SAALSDA). The former President and Fellow of the South African Society of Crop Production and GreenMatter®, in 2015, he was awarded the Mangosuthu University of Technology Fellowship. In the same year, he received a Water Research Commission (WRC) award for Human Capacity Development. In 2016, he received the Distinguished Teacher's award of the University of KwaZulu-Natal. He has trained 41 postgraduate students, of which 12 were PhDs. He has published three books, three book chapters and 98 peer-reviewed articles.

Prof Voster Muchenje

Voster Muchenje is a Research Professor at the University of Fort Hare and the Editor-in-Chief of the *South African Journal of Animal Science*. He is a Member of ASSAf. His academic highlights include co-hosting the DST/NRF SARChI in Meat Science, a Centre of Excellence (CoE) in Food Security research associate, and a founding member of the South African Young Academy of Science (SAYAS) and its outgoing Co-Chair. He holds an NRF C1-rating and has produced 12 PhD graduates and over 100 articles. He serves on the editorial board of the Food Research International and was appointed as managing guest editor for special issues on *Food and Nutrition Security* (2014 to 2015), and *Balanced Diets and Human Health* (2016 to present). His accolades include the South African Society for Animal Science (SASAS) President's Award for exceptional contribution to animal science and the University of Fort Hare's (UFH) Vice-Chancellor's Senior and Emerging Researcher Awards. He is a member of the SASAS Council; ASSAf Scholarly Publishing Standing Committee; and Fort Cox College of Agriculture and Forestry Council.

Ms Bongiwe Njobe

Njobe is an independent consultant. She served as a Corporate Affairs Director at the South African Breweries Limited, having joined in March 2004 and was responsible for maintaining and upholding the South African Breweries' corporate reputation and for overseeing the implementation of its corporate relations activities and public policy initiatives. She served as the Director-General at the National Department of Agriculture, where she oversaw the implementation of agricultural development programmes and facilitated trade negotiations on wine and spirits with the European Union. She is a member of the board of directors of National Business Initiatives; Findevco (Pty) Limited; SAB Ltd; Kagiso Trust Investment (Pty) Limited; Pan-African Capital Holdings (Pty) Limited; Pan African Investment and Research Services (Pty) Limited; and Bigen Africa Group Holdings (Pty) Limited. She serves as the Chairman of the South African National Biodiversity Institute (SANBI). Ms Njobe served as a member of the board of directors of various private organisations, NGOs and parastatal organisations. Ms Njobe has served as an Executive Director at Tiger Brands Ltd. since August 2008. She served as Non-Executive Director of The Industrial Development Corporation of South Africa Limited. Ms Njobe has been affiliated as a Vice-Chairperson of the Forum for Agricultural Research in Africa; Commissioner for the Presidential National Commission on Information Society and Development; member of the South African Reference Group on Women in Science; and a panel member for the InterAcademy Council Study Panel on Science and Technology; Chairperson of South African National Biodiversity Institute; and a Director of Khomelela Women's Development Businesses. She holds an MSc in Agriculture, Vassil Kolarov, University of Bulgaria.

Prof Alice Pell

Alice Pell joined Cornell University's College of Agriculture and Life Sciences in 1990 and directed Cornell's International Institute for Food and Agricultural Development – a university-wide centre for sustainable agricultural and rural development in Africa, Asia and Latin America – from 2005 to 2009. She has served on panels supported by the Rockefeller Foundation, the African Academy of Sciences, the Gates Foundation, the US Academy of Science and the MacArthur Foundation. Prof Pell was a STIAS Fellow at Stellenbosch University in 2016 and is an Extraordinary Professor at the University of the Western Cape. From 2008 to 2013, she was Cornell's Vice-Provost for International Relations. She is a cum laude graduate of Harvard University, has a Masters degree in international education from Harvard, and MS and PhD degrees in animal nutrition from the University of Vermont. She has been involved in research and graduate training programmes in Botswana, Ghana, Ethiopia, Kenya, South Africa, India and Indonesia.

Dr Aldo Stroebel

Aldo Stroebel is Executive Director International Relations and Cooperation at the NRF of South Africa, and Visiting Fellow at the Institute for African Development at Cornell University, USA. He is a former President of the Southern African Research and Innovation Management Association (SARIMA), and serves as South Africa's National Contact Point for the ERC to H2020, and on the boards of the WRC and the ARC. He is a former member of the Research and Innovation Strategy Group (RISG) of Universities South Africa (USAf) (2006-2016), and holds a Ministerial appointment to the National Education and Training Forum for Agriculture, Forestry and Fisheries (NETFAFF). Education credentials: University of Pretoria (BSc and Honours degrees); University of Ghent, Belgium (Masters in International Agricultural Development); University of the Free State and Cornell University, USA (PhD); postdoctoral research at Wageningen University, The Netherlands. He is a founding member elected to the SA Young Academy of Science (SAYAS), and has published widely in smallholder livestock systems and sustainable agriculture. He has been acknowledged as a leader in the internationalisation of higher education, in research and innovation management, and partnerships and networking.

Prof Volker Wedekind

Volker Wedekind holds the Education, Training and Development Practices (ETDP) Sector Education and Training Authority (SETA)-funded Research Chair in Vocational Education and Pedagogy in the Centre for Researching Education and Labour, School of Education, University of the Witwatersrand. Prior to that he spent almost 25 years at the University of KwaZulu-Natal in various capacities, including Head of School and Deputy Dean. He holds a PhD from the University of Manchester. His research has focused on teachers, curriculum policy and most recently on vocational education. He has written numerous articles and book chapters and has produced research reports for SETAs, the South African Qualifications Authority (SAQA), Umalusi, the Department of Higher Education and Training (DHET), the Human Sciences Research Council (HSRC), the United Nations Educational, Scientific and Cultural Organisation (UNESCO), and the KwaZulu-Natal (KZN) Treasury and KZN Education Department. He has been a member of two ministerial

committees at national level, and serves on committees for the Higher Education Quality Council (HEQC), DHET, and Umalusi. He is an executive member of the South African Education Research Association.

Prof Johann Kirsten

Johann Kirsten is Professor and Director of the Bureau for Economic Research (BER) at Stellenbosch University (SU). Before taking up this position he was Professor in Agricultural Economics and Head of the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria – a position he occupied for 20 years until his resignation in July 2016. He was born in Cape Town and matriculated from Hoërskool Jan van Riebeeck in Cape Town in 1979. Subsequently he enrolled for undergraduate studies at SU and completed the BSc Agriculture degree and a BSc Agriculture Honours degree in Agricultural Economics. He started his career as an agricultural economist in the Department of Agriculture in Pretoria and also enrolled for postgraduate studies at the University of Pretoria. He obtained a Masters and PhD degree in Agricultural Economics at the University of Pretoria (UP) and joined UP as lecturer in 1992. He served as a council member of the National Agricultural Marketing Council in South Africa from 2001 to 2011 and was also appointed by the Minister of Agriculture to serve as Chair of the Food Price Committee during 2003 and 2004. He also served as the Vice-President of the International Association of Agricultural Economists for the period 2006 to 2009.

Dr Fanie Terblanché

Fanie Terblanché obtained his PhD in Agricultural Extension from UP, where he is currently a senior lecturer and researcher in Agricultural Extension. He was the President of the South African Society for Agricultural Extension, Chairperson of the Standards Generating Body (SGB) for Agricultural Extension (SAQA) and member of the Minister's executive committee, National Agricultural Education and Training. He was a member of the Southern African Development Community (SADC) Regional Food Security Training Programme representing Agriculture Colleges from 1999 until 2002. He was appointed as a member of the South African Council for Natural Scientific Professions and registered as Professional Natural Scientist in the field of extension. He is a member of the South African Society for Agricultural Extension (SASAE) and an Editor of the *South African Journal of Agricultural Extension*.

ENDNOTES

[i] STISA-2024 is a multi-functional tool and a critical enabler for achieving continental development goals. Further information available online from: https://au.int/web/en/newsevents/27635/african-union-heads-state-and-government-adopt-science-technology-and-innovation.

[ii] The map shows Grootfontein as a separate directorate. This stems from complications from the restructuring of the respective provincial departments and sectoral colleges, specifically the objective to have one sectoral college within each province. At that stage the Northern Cape did not have a sectoral college whilst the Eastern Cape had two and it was hence decided to second Grootfontein to the Northern Cape. This arrangement was not successful over the long term, however, and resulted in the current arrangement. Presently the Northern Cape does not have a provincial sectoral college.

[iii] Internship: Practical work required by tertiary institution in order to obtain the specific qualification.

[iv] Temporary employment, fully paid or subsidised by AgriSETA, intended to improve the permanent employability of a graduate after gaining practical experience.

[v] Programme that culminates in the acquiring of a NQF qualification, specified consist of 30% theoretical and 70% practical work. Theoretical work provided by public tertiary of AgriSETA accredited private training provider.

[vi] For example, there are unit standards registered that focus on financing agricultural projects from the banking sector and selling agricultural land from the estate agency sector.

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