Department of Agriculture

NATIONAL AGRICULTURAL RESEARCH & DEVELOPMENT STRATEGY

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ABBREVIATIONS AND ACRONYMS

AAS:	African Academy for Sciences
AGIS:	Agricultural Geo-referenced Information System
AIMS:	Agricultural Information Management System.
AIS:	Agricultural Innovation System
ASTI:	Agricultural Science and Technology Indicators
AU:	African Union
CAADP:	Comprehensive Africa Agricultural Development Programme
CGIAR:	Consultative Group for International Agricultural Research
DBSA:	Development Bank of Southern Africa
DoA:	Department of Agriculture
DoE:	Department of Education
DEAT:	Department of Environmental Affairs and Tourism
DST:	Department of Science and Technology, formerly the Department of Arts, Culture Science and Technology (DACST)
FANR:	SADC's Food, Agriculture and Natural Resources directorate
FANRPAN:	Food, Agriculture and Natural Resources Policy Analysis Network
FAO:	United Nations Food and Agriculture Organisation
FARA:	Forum for Agricultural Research in Africa
GDP:	Gross Domestic Product
GERD:	Gross Expenditure for Research and Development
GFAR	Global Forum for Agricultural Research
HEMIS:	Higher Education Management Information System
IA:	Impact Assessment
IDRC:	International Development Research Centre
IFS:	International Foundation for Science
IHDP:	International Human Dimensions Programme on global environmental change
IKS:	Indigenous Knowledge Systems
ISNAR	International Service for National Agricultural Research
IUCN:	World Conservation Union
JICA:	Japan International Cooperation Agency
M&E:	Monitoring and Evaluation
NARF	National Agricultural Research Forum
NARS:	National Agricultural Research System
NEPAD:	New Partnership for Africa's Development
NWGA:	National Wool Growers' Association of South Africa
OECD:	Organisation for Economic Cooperation and Development
PDA:	Provincial Department of Agriculture
R&D:	Research and Development
RTD:	Research and Technology Directorate of the Department of Agriculture
SADC:	Southern Africa Development Community
SAKSS:	Strategic Agricultural Knowledge Support System
S&T:	Science and Technology
TWAS:	Third World Academy of Sciences
TWOS:	Third World Organisation for Women in Science
WOCAT:	World Overview of Conservation Approaches and Technologies

1. INTRODUCTION

1.1 Background

Following the advent of democracy in South Africa, a number of significant actions related to policy initiatives concerning agriculture were launched. Historical dualism characterised the nature of the agricultural sector. To redress the problems this created the Department of Agriculture embarked on a strategic framework to broaden access and participation in agriculture through the Broadening Access to Agriculture Thrust (BATAT) process. This process identified, among others, the following research and development (R&D) related constraints:

- Lack of policy and long-term strategic management in research and the linkage mechanisms between agricultural research institutions and their clients.
- Lack of clarity on how linkages should be strengthened to improve the farmer-extension-researcher linkages.
- The need to design and establish suitable institutional linkages to support effective co-ordination and prioritization of research needs at all levels.

In addition, the then Department of Arts, Culture, Science and Technology undertook a number of initiatives, including the National Technology Foresight Project (1997) with a view to anticipating the future drivers of the South African science and technology (S&T) system; improving quality of life, competitiveness and a shared democratic culture for all South Africans.

For the agricultural sector the mandate of the Foresight study was to ensure that research and technology would address the social and economic challenges with regards to the performance of agriculture and the agro-processing sector. The Foresight study identified potential, and recommended the concentration of efforts, in the following areas: Agro-production systems, biotechnology, natural resource management, market development, processing, novel technologies as well as technology transfer together with an enabling the culture of innovation in agriculture, strategic funding in agriculture, infrastructure and the establishment of a National Agricultural Research System (NARS).

The White Paper on Science and Technology (1996) established a policy framework for S&T based on the concept of a National System of Innovation (NSI) that seeks to enable innovation through the mutually reinforcing activities of the main roleplayers – government, business and Higher Education. This set the tone for a paradigm shift in R&D thinking and further informed the SA National R&D strategy (2002) which is based on three pillars namely: Innovation; Science Engineering and Technology (SE&T) human resources and transformation; and creating an effective S&T system.

A further significant action was the response to the State President's invitation to industry (Agri-SA and NAFU) to join government in developing a common agricultural perspective. This led to the Strategic Plan for South African

Agriculture (2001) with a vision which calls for a united, and prosperous agricultural sector based on three core strategies namely, access and participation; competitiveness and profitability; and sustainable resource management. These are underpinned by the complementary strategies on good governance, integrated and sustainable rural development, knowledge and innovation, international cooperation and safety and security, all of which require research and scientific interventions having significance in the development of a R&D Strategy.

1.2 Current status of the National Agricultural Research System

An agricultural research system consists of a number of elements such as organisations, funders, service providers and clients. For the South African National Agricultural Research System (NARS), the key categories include government (national and provincial), statutory bodies and science councils, higher education and development institutes, private/business sector, farmer organisations, civil society and financial institutions. Their differentiated roles are summarised below:

Table 1. Current stakeholders in the Agricultural R&D System.

Categories	Roles and responsibilities
Government	Development and implementation of policy and legislation on agriculture, environment, biodiversity, agro-forestry, water, science and technology and the promotion of innovation.
Parastatals/Statutory bodies/Science Councils	Scientific research, technology generation and transfer (or promotion of the application of knowledge and innovation) in agriculture, bio-diversity, agro-processing, socio-economic development and impacts.
Higher Education and Development Institutions	Curriculum development, training, research (pure and adaptive) and technology transfer.
Organised Agriculture	Technology transfer; cooperatives provide a commercial base for procurement, policy advocacy, priority setting, facilitate resource allocation, articulating the needs of the 2nd economy.
Civil Society/community based organisations	Development, training, capacity strengthening, adaptive research, technology transfer, support services.
Financial Institutions	Lending and mortgages, Socio-Economic research and general financing to the agricultural sector.

Within the agricultural sector, a number of prominent issues need addressing and these include ducal economy and related socio-technological issues (empowerment, land tenure); integrated natural resource management (soil, water, biodiversity, veld and natural pastures); competitiveness (value-chain addition, post harvest processing and storage, profitability, food safety, crop and animal health)' cross-sectoral issues (health, energy, education, transport); production systems; risk management and climate change; policy

and institutional issues; globalisation; human resource capacity for agricultural R&D and protection of the environment.

The current NARS arrangement is, however, largely incapable of addressing these issues in a coherent manner. In particular, a number of weaknesses, challenges and opportunities are have been identified. These include lack of a coordinating mechanism at national level; inadequate mechanisms to establish priorities; lack of a national system to allocate resources to priorities; lack of institutionalised monitoring, evaluation and impact and impact assessments; erosion and lack of R&D capacity; lack of an IPR Management system; poor partnerships (public-private, public-public, private-private); ineffective linkages among knowledge and information generators and users; inadequate linkages internationally; lack of participation of the second economy in the formal System of Innovation, Low level of investment in agricultural research; overlapping mandates of role players and lack of clarification of the role and responsibilities of different role-players; poor access to information, weak or inadequate value-addition technologies; biased approach towards technology-driven research *versus* policy and socio-economic research; insufficient resources for maintenance of national asses and infrastructure; lack of trust among stakeholders; declining science and technology capacity and negative perception of agriculture as being 'rural', associated with unskilled labour and poverty, the latter makes agriculture unattractive to youth and potential students whom may contribute to the broader research and development.

The contribution of the agricultural sector to the accelerated and shared growth initiative will require focused efforts on tackling and responding to identified challenges and opportunities. These will include core of competent researchers that needs to be optimised; political commitment and support for agricultural research and development; comparative and competitive advantage; strong higher education institutions (HEIs); good basic research infrastructure; potential or opportunity for innovative funding mechanisms; potential to strengthen existing international linkages; identification and equitable exploitation of indigenous technologies; strengthened and sustainable linkages between research institutions and tertiary education. Input to the *curricula* of primary and secondary education must be provided from this level in order to lay a better foundation for the importance of agriculture and its products in livelihoods and the economy, strengthening of links between researchers and extension services; understanding the second economy and their needs within the poverty framework and promoting agriculture at school level and providing incentives for teachers in maths and science, and in particular agriculture.

The set of challenges, weaknesses and opportunities identified within the agricultural research system provide a compelling basis for developing an effective and well-supported agricultural research and development strategy for South Africa.

1.3 Need for the National Agricultural Research and Development Strategy

As South Africa embarks on its second decade of democracy, agricultural research in South Africa is again at a cross-road where urgent and quick action is needed to decide on an appropriate, effective and sustainable National Agricultural Research System (NARS) and to promote an Agricultural Innovation System (AIS) that would simultaneously be able to address the objectives of poverty alleviation and food security on the one hand and increased competitiveness and profitability on the other. Following the recent implementation of the new governance framework for science and technology, science councils are transferred back to the full administrative responsibility of the relevant line function departments. In view of this development, the Department of Agriculture (DoA) is repositioning itself for this responsibility and as such intends to explore alternative options for effective coordination, resourcing, development and oversight for the NARS. It now presents the DoA with the opportunity to address the issues relating to limited resources, insufficient national coordination as well as institutional framework.

Recent developments in the context of agricultural R&D present certain challenges to agricultural research and innovation in developing countries. These include:

1.3.1 Confronting new priorities in a rapidly changing world (e.g. stronger demand for competitive and quality-conscious agriculture) and adapting to changes within a more complex innovation systems framework where there are a greater number of actors and linkages to consider.

1.3.2 Redefining the role of government in agricultural research and service provision and defining the role of the private sector, civil society and end users.

1.3.3 Strengthening the demand side of agricultural research and services to ensure that programmes are more responsive and accountable to end users, but also anticipating demand as new and emerging technologies dominate the landscape.

1.3.4 Developing a clear understanding of the institutional structures needed at the national, regional and sub-regional levels for agricultural research and service provision and of whether, and how, this understanding would imply changes in the current structures present at national, regional and global levels.

1.3.5 Developing a clear understanding of the institutional structures needed at every level for agricultural education within the emerging food and agricultural innovation systems. This includes strengthening the capacity and re-focussing the mandates of Colleges of Agriculture.

1.3.6 Ensuring stakeholder participation and developing local, regional and global partnerships and alliances.

1.3.7 Facilitating development of innovative funding instruments that make public institutions more sustainable, reduce donor dependence and encourage co-financing by end users and others.

1.3.8 Assisting in developing mechanisms through which internal and external support for food and agricultural innovation systems in developing countries are better coordinated.

1.3.9 Strengthening system linkages and coordination, including linkages between agricultural research policy and wider policies for science and technology.

1.3.10 Addressing climate change and issues related to emerging technologies, especially bio-technology and information communication technology.

One of the objectives of agricultural development must be to attain a cadre of qualified, experienced and motivated world-class agricultural research and development specialists, managers and policy makers to lead South Africa towards achieving the long-term goals, food security and poverty alleviation, international competitiveness in agriculture and enhancement and sustainability of natural resource base.

A Sectoral (agriculture) analysis of the State of the Nation Address (SONA, 2006) suggests a number of priority areas in response to the challenges posed by the President. These include generation of knowledge to achieve sustainable natural resource utilization, management and biodiversity conservation; developing sustainable cost-effective interventions in support of the needs of the 2nd economy and to accelerate the progress with regard to the 1st economy to achieve higher levels of economic growth and development; crop estimate models/forecasting models; developing risk-management strategies for agricultural production to address natural disaster, climate change, and disease and pest outbreaks; improving production systems, post-harvest and processing technologies to enhance nutrition, food security and safety; enhancing competitiveness of the SA agricultural sector to enable it to access existing and new markets and be viable against imports; identifying, protecting and commercialising agri-indigenous knowledge systems (IKS), to enhance the benefits to the agricultural sector and applying biotechnology to create new opportunities and overcome constraints in crop and animal production through the use of marker technologies, fingerprinting etc.

Given the sweeping reforms that are taking place, R&D systems are facing a transition period in which they will need to restructure themselves, confront new demands and adjust to new political, scientific, institutional and economic environments. As South Africa enters a new phase of policy development under the accelerated and shared growth initiative, giving effect to the

implementation of the reconstruction and development programme as supported by sound macro-economic policies, the agricultural research system must clearly articulate its role in contributing to economic growth. It is against this background and rationale that the agricultural research and development strategy is being developed.

2. STRATEGIC OBJECTIVES

2.1 Vision, mission and goals

The implementation of the agricultural research and development strategy will be guided by the **vision** of the sector plan, namely ***a united and prosperous agricultural*** sector in order to achieve the strategic goal of the sector.

The **mission** of this research strategy is to guide and direct the generation, adaptation and application of knowledge and innovation for sustainable agricultural development to benefit society.

In pursuit of the vision and mission, the **goal** of the research strategy is to enhance the contribution of agricultural research towards attaining a 6% economic growth through sustainable agricultural productivity, sustained competitiveness to ensure food security and eradication of poverty in South Africa. The implementation of this strategy should improve the efficiency and profitability of the sector; and improve business opportunities; ensure social upliftment and improvement of the quality of life for all the citizens of South Africa.

2.2 Objectives of the Agricultural R&D Strategy

The main objectives of the agricultural research and development strategy are to:

2.2.1 Guide the Agricultural Research and Innovation System in the formation and operation of national agricultural research and development programmes;

2.2.2 Mobilise resources and enhance their effective use for sustainable agricultural research and development;

2.2.3 Guide the generation of knowledge and information in the agricultural sector;

2.2.4 Provide a framework for developing research capacity and expertise, funding for agricultural research and innovation, focussing national efforts to strategic priorities and areas of comparative advantage; and ensuring effective technology transfer, information sharing and communication to the entire spectrum of the farming community;

2.2.5 Provide an institutional framework to enhance participation of all stakeholders in agricultural research and development; and to

2.2.6 Engender a culture of learning and innovation through human resource development and management.

2.3 Guiding principles

The implementation of this strategy will be guided by the following principles:

2.3.1 Responsibility

To adopt the principle of responsibility whereby all R&D programmes and activities are at levels where they can be best handled within the NARS.

2.3.2 Integrity and Trust

To broaden stakeholder participation in R&D activities and to ensure reliability and integrity in the decision-making processes within the NARS. This will promote trust among partners, and ensure integrity of the governance and decision making process within the agricultural research system.

2.3.3 Efficiency and Flexibility

To enhance efforts to ensure adequate flexibility in the advancement of research for technology development and technology transfer; and to promote efficient coordination and management of national resources for agricultural research and technology development.

2.3.4 Innovation

To strive for cutting edge technologies developed by a well-focused and capacitated (human resources, facilities and funding) research infrastructure. The White Paper on Science and Technology (DACST, 1996) introduced the concept of a national system of innovation to the local discourse in order to focus attention on the institutional environment. Organisations conduct R&D within institutional frameworks that ideally support innovation through interactions among the host of research and technology organizations and institutes. The strength of an Innovation System depends on the strengths of its components and the management of its linkages. Developing a clear understanding of the historical, political and institutional dimensions of the system and its components is crucial to draft national policies that not only help build capacity in individual R&D actors, but also create incentives and support mechanisms for institutional learning and partnerships that will improve the system's performance.

2.3.5 Competitiveness

To build and support, through R&D, a market-based agricultural production system that enhances and promotes competitiveness of the SA agricultural sector to enable it to access existing and new markets.

2.3.6 Equity

To strive for fair distribution of R&D generated benefits to all relevant stakeholders to ensure enhanced and equitable access and participation to agricultural opportunities.

2.3.7 Complementarity

To give recognition to the mandates and strengths of the different role players to complement rather than compete with each other in the execution of their tasks.

2.3.8 Participation and ownership

To ensure that planning is based on broad participation and consultation in order to engage as many stakeholders as possible in ensuring ownership for the output.

2.3.9 Commitment to vision, mission, goals and objectives

To direct focus in the areas identified as being of high national priority, including support for special programmes in these areas.

2.3.10 Mutual benefit

To ensure broad participation in national strategic programmes to benefit all stakeholders.

2.3.11 Accountability and impact orientation

To build accountability into investment portfolios in order to ensure effective use of resources and building quality research capacities to achieve strategic goals and objectives.

2.3.12 Decentralization

To establish bases to devolve responsibilities and the flow of funds and decentralization of research institutions to allow decision making as close to the beneficiaries as possible. However, some basic and strategic research of national importance could be centralized at national level.

2.3.13 Relevance

To ensure that targeted research is focused and guided by industry and public needs and that it meets challenges of today's agricultural environment.

2.3.14 Elimination of overlaps and duplication

To stimulate partnerships and collaboration in research and development with expertise and capacities working together.

2.3.15 Value-adding

To promote value-adding to primary agricultural production in order to make the South African agricultural sector competitive.

2.3.17 Transparency

To facilitate exchange of information with stakeholders and build a mechanism to periodically review and set priorities through a transparent and inclusive process.

3. KEY STRATEGIC AREAS AND THRUSTS

3.1 Human Capital

The National R&D Survey of 2001/02 (DST, 2004) paints a picture of an ageing and shrinking scientific population, that Higher Education sector is dominated by white males and relatively few blacks and women. The current system of education in South Africa still provides systematic and institutional barriers that contribute to the problem of few students doing mathematics and sciences, thus limiting the pool from which to train, nurture and groom future scientists. Innovative approaches such as incentives to schools excelling in these subjects, as a joint venture by the DoA and DoE, should be considered. Although there has been progress with regard to gender and race representation in agricultural science it is still inadequate. Successful resource mobilisation depends upon continued investment in professional training for scientists and in assuring the development of scientific research capacity. Therefore, targeted scientific and professional development programmes should be established in agriculture to produce, on a sustainable basis, a cadre of young science graduates, to be mentored by the more mature and retiring or retired scientists, who will feed into agricultural post-graduate training. Government (both national and provincial) should provide financial support to these programmes, in various forms, including but not limited to bursaries, study loans, fellowships and chairs. Adequate financial resources should be made available to create and maintain stability in terms of remuneration and tenure in the agricultural research system.

When dealing with the subject of human capital, the entire spectrum needs to be considered. Although the focus in this strategy is largely on human capital involved in R&D activities *per se*, extension agents, partners and beneficiaries are equally important to ensure effective transfer, uptake and implementation of innovations. Included are the farmers and farming communities across the board, from developing or emerging to first economy commercial farmers. Skilled human capital is essential for research and development, but their mere availability is not sufficient for knowledge generation. The international environment characterized by the globalization of capital markets, trade and services, free movement of people and ideas has forced new challenges upon South Africa. Mobility of scarce skills is one of the elements of globalization. There is an inclination to try to reduce mobility because of the negative consequences of brain drain. The critical significance of a national mentorship programme cannot be overstated. The steady transfer of experience to new incumbents must be carefully nurtured and protected to ensure full growth towards scientific independence.

Furthermore, developing the human resource potential involves examining the roles and needs of both men and women farmers and other household members who perform diverse duties and have differing requirements with regard to education, health, nutrition and technical knowledge. A low level of human development is characteristic of developing areas of the country. The serious negative impact of the HIV/AIDS pandemic on food security and markets for agricultural production needs to be emphasized. Measures need

to be undertaken to address the pandemic and the resulting decline in labour productivity in the agricultural sector.

The Agricultural Science and Technology Indicators (ASTI) surveys also provide comparative data on the R&D performance and support in developing and developed countries. The National R&D Survey 2004/05 shows that in South Africa there are some 56 000 full time equivalent (FTE) R&D personnel, comprising 37 000 FTE researchers, Ph.D and post-doctoral fellows, indicative of a relatively small science system. In terms of demographics, women researchers constitute 38% of the total, while white males over 45 years of age, amount to 21% of the research cadre. The aging of the research population without the influx of new researchers is not just a South African problem – it is a matter of serious concern in many OECD states.

The data indicate that the Science Councils, followed by the universities, are leading the way in committing funds to the biosciences. As a strategic position, South Africa should invest primarily in the training of agricultural scientist and engineers as a first priority, and supplement with training and production of new open-minded social scientists and researchers likely to analyse current realities and point the way organisations and communities are changing.

Information on human resources from the R&D surveys (1992 and 2004) enables the establishment of the high–level human resource requirements. These surveys indicate changes in the availability of researchers across the three major sectors over the last decade (Table 2).

Table 2: Full-time equivalent researchers per sector, 1992-2004

Sector	**1992**	**2005**
Business	3395	4411
Government	2428	2342
Higher Education	3631	3374
TOTAL	**9454**	**10127**

Sources: R&D Survey 2003/04, DNE (1993)

Indications are that the research cadre is not growing in line with the population, student or economic growth. Most worrying is that at universities, with their massive student growth, the number of researchers has fallen and this reduction is confirmed by the higher education management information system (HEMIS) data. South Africa's academics account for some 90% of academic journal output, with the bulk of the remainder coming from the government sector. Ranked by country share of the most highly cited papers and adjusting for economic size, South Africa was at position 22 in the world, on par with Poland and ahead of Greece, South Korea, Singapore, Brazil, Russia, India, Iran and China. This indicates that South Africa has an underlying scientific strength on which to build a competitive economy.

The current capacity of the NARS to perform and deliver research output has been affected by a large exodus of qualified and highly experienced research staff from the system as listed in Table 3:

Table 3. Research capacity (researchers, technicians and other support staff) within the NARS

Headcount	**2002**	**2004**
Government (National & PDAs)	1,039	869
Universities	602	571
ARC	494	467
Business	403	557
Total	**2,538**	**2,464**

However, data from 1992 to 2000 is available only for the ARC and indicates an initial growth from 693 (1992) to 749 (1997) and a moderate decline to 691 (2000). A further decline was experienced in 2002, which stabilised thereafter. Comparative figures for the highest numbers (749 in 1992) to the current level (467 in 2004) indicate a decline of 37.7 %.

A real cause for concern is the situation at school level in respect of the key subject area of mathematics at Higher Grade as indicated in the matrix for university study in S & T (Table 4).

Table 4: Mathematics HG passes, 1997-2003 (000s)

Year	1997	1998	1999	2000	2001	2002	2003
Wrote	68.5	60.3	50.1	38.5	34.9	35.5	35.4
Pass	22.8	20.3	19.9	19.3	19.5	20.5	23.4

Source: Department of Education databases

The flow is fairly static at around 20 000 passes annually, which is 5% of all those that sit the Senior Certificate examination. This is not to say that the entire mathematics HG pass cohort will go on to careers in research. The majority will most likely not go into careers in research, nor will they become teachers in areas of scarce subject skill such as physical science or mathematics. In this regard, agriculture as an attractive and rewarding career needs to be communicated widely and effectively to potential students.

To this picture must be added the consequences of migration, through which South Africa has lost large numbers of professionals, whilst being unable to attract a corresponding inflow of similarly skilled and experienced engineers, scientists, science and mathematics teachers, medical practitioners and technicians. To stop the brain drain of agricultural researchers, five basic requirements should be met: a competitive remuneration, incentives for innovation, career path and recognition, equipment and infrastructure that are on par with other competing research groups and free movement to scientific forums and conferences.

The current average cost to maintain one researcher full-time for a year is in the order of R1.5 million including labour costs, associated support staff, utilities, IT and capital equipment. To move from R10bn of R&D to the R16bn per year required by 2008, would require an additional five to six thousand researchers in the system. To satisfy this demand, the policies introduced and those already in place, need to reinforce one another. It is necessary to achieve three things simultaneously:

- Developing our own staff;
- Recruiting staff abroad;
- Nurturing staff.

The policy should focus on producing, retaining and recruiting – that is, providing adequate financial support and security of tenure to researchers and recruiting the best skills abroad. In this regard an effective HR policy needs to be in place at organisations employing agricultural researchers and should feature career pathing, opportunities for personal development, incentives and adequate funding. Recognition of community service activities and related popular publications on innovative approaches also needs attention.

The introduction of a more uniform funding structure to cover basic manpower costs would go a long way to removing incorrect assumptions about the relative costs of utilising staff from say the provinces as opposed to the parastatals. Added to this, the universities need to produce more Ph.D.s in agricultural and animal health sciences. Mentoring programmes should be established to retain retired scientists as mentors to new scientists. This implies:

- Significant state intervention that will change the face of education. It not only pushes up the state share of GERD, but also envisages researcher development taking place in the science councils, industry and universities.
- That the areas of scarce skill are addressed, for example through full-cost bursaries as well as foreign recruitment.
- That emphasis is placed on developing adequate capacity to address the new technology challenges and creation of centres of excellence.
- Providing substance to a paradigm of national renaissance through the universities that believe in the ability of the majority of students to obtain quality degrees in the allotted time.

The approach towards science is to do research to underpin the required technology developments, but also to look for opportunities to attract major global science infrastructure and resources. It is imperative for South Africa to develop the people that provide the R&D capability and capacity in order to address livestock systems development, crop diversification and protection, clean production, biomass utilization, biotechnology, ICT, remote crop management, advanced processing and storage, resource sustainability and poverty reduction.

In view of the above background, the proposed agriculture R&D strategies in regard to human capital are that:

- The DoA should make available bursaries and contractual study loans to attract top grade students to pursue studies in scarce and critical agricultural specialist fields and disciplines.
- The DoA should sponsor research fellowships and academic chairs in scarce and critical agricultural fields at universities.
- The DoA should establish and fund a Mentoring Programme wherein retiring and retired experts are contracted to mentor young agricultural researchers.

3.2 Innovation and technology transfer

Technology acquisition and transfer into the economy are central for productivity change and growth leading to raised economic productivity and living standards. There are two aspects of technology change that are important. The first is the international transfer of technology from developed to developing countries and *vice versa*, and the second is diffusion of technology both imported and locally developed from the importing or innovating company or organisation into the wider economy. In both aspects of technology transfer, the end results should ideally be that the recipient is able to use, replicate, improve on and possibly re-sell the technology. For technology transfer to contribute to sustained and equitable development, it must involve a broad and encompassing process that avoids creation and maintenance of dependency. The process must encompass all elements of origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions information.

There is no single strategy for successful transfer appropriate to all situations. The traditional mode of technology transfer, which involves the assumption that technologies developed in the north are eventually transferred to the developing countries, mostly through foreign direct investment, has not always been successful. Although deficient building of capacity to absorb, diffuse and maintain these technologies has been cited as the main reason for the failure, the problem, however, is far more complex and requires innovative approaches. The traditional linear approach of researcher-extension agent – farmer or end-user is limiting in the current South African farming systems. Other approaches, such as participatory action research and farmer-to-farmer learning are more appropriate approaches.

Recipients for technology transfer should therefore be able to identify and select technologies that are appropriate to their needs. The implementation of technology transfer in agriculture could be guided by the *Norms and Standards for Extension and Advisory Services* (2005). These provide the minimum standards (i.e. skills levels of extension agents and advisors; resources requirements at district, municipal and local offices; etc.) to be adhered to in the provision of services to farmers. In this regard, capacitating of extensionists is considered to be very important. Particular success with

effective extension has been achieved where centres of excellence around commodity groups have been created and the whole farming spectrum has been serviced. Examples of this are the South African Sugar Research Institute (SASRI), Cotton SA and National Wool Growers Association (NWGA). All appropriate avenues for effective technology transfer need to be utilised and these could include AGIS, television, radio, cell-phones, rural information centres and paper based material in local languages, with on-site demonstration of best practice technologies being top priority. The absorptive capacity of the end users is also a critical element that deserves attention.

3.3 Key Areas of Technology Development

Agriculture, being a primary industry, supports many other industries, roughly in the ratio of 1:1,6 as regards job opportunities. Apart from being a catalyst for economic growth generally, agriculture provides food, clothing, employment, tourism, contributes to the alleviation of poverty and promotes international competitiveness.

With the adoption of the NSI into the Agricultural R&D Strategy, it becomes increasingly important to identify, develop, adapt, adopt and transfer appropriate technologies to both the first and second economies. In this way the divide that persists with dualism will hopefully be bridged.

The aim in identifying new and emerging technologies in the South African context is not only to increase global competitiveness, but to ensure household food security and to assist the developing farmers in entering the mainstream. In identifying technologies, stimulating innovative solutions needs to be encouraged.

Therefore, the proposed agriculture R&D strategies in this regard are that national programmes should be developed focusing on the development of new and improved emerging technologies in the following areas sustainable natural resource management; biotechnology; information & communication technology; geographic information systems and earth observation technology; product specification; macro- and micro-economics of agriculture and value-adding processes; bio-energy; precision agriculture; animal and plant breeding and health; adaptations of crop varieties and animal breeds to climate change and indigenous food crops.

3.3.1 Sustainable natural resource management

Degradation and loss of land, water and agro-biodiversity for agricultural use are widespread and accelerating. This poses an increasing threat to national and individual food security in many parts of South Africa. Agro-ecological systems are resilient up to a point, but subject to a collapse when degraded beyond that threshold. Whilst the current picture is not entirely clear, it suggests a close correspondence between areas experiencing significant land and water degradation, and areas troubled by high levels of rural poverty. Farmers maximize income and minimise risk in a dynamic context and often under harsh conditions and serious constraints. Research must respond to

these challenges through inclusion of technologies to address sustainable natural resource management.

This would include technologies to address conservation agriculture principles relating to soil organic matter decline, soil erosion and degradation, nutrient depletion, loss of biodiversity, prevention of invasion by alien species, maintenance of water quality and veld productivity, optimization of water use efficiency under both irrigated and rainfed conditions, capturing and storing rainwater (rainwater harvesting) and restoration or creation of new balances in biotic communities. GIS based technologies, natural resource inventories and adequate characterization and monitoring are considered essential.

Irrigated agriculture produces almost 90% of South Africa's fruit (deciduous, subtropical, citrus, etc) and vegetables. It is widely recognised that research over a wide range of disciplines and expertise (agricultural engineering, horticultural science, agronomy, viticultural science, soil science, plant pathology, entomology, etc) is needed to improve the efficiency of irrigated agriculture.

3.3.2 Biotechnology

Biotechnology (defined as a set of technologies including, but not limited to, tissue culture and recombinant DNA techniques, bioinformatics and genomics, proteomics and structural biology, and all other techniques employed for the genetic modification of living organisms, used to exploit and modify living organisms to create/produce new intellectual property, tools, goods, products and services) has the potential to make a considerable contribution to national priorities that include food security and environmental sustainability as well as the maintenance of plant and animal biodiversity and health. There are a number of societal concerns surrounding its' use that require attention. The responsible handling of bio-safety is a priority.

3.3.4 Information and communications technology

South Africa has a number of significant warehouses of information of importance to agriculture. The real challenge is to make this information available in useful and usable form for information users in well-equipped offices on the one hand and resource poor rural communities on the other. This entails the interpretation, packaging and dissemination of the information in appropriate and usable form. Modern information communication technologies (ICTs) and innovations based on the internet, digital satellite television and cellular telephones are required to facilitate access to information. *AGIS* of the DoA, the nine PDAs, the ARC and the Landbank, has gone a long way in implementing this technology, but further development is necessary.

This same technology can be utilized for obtaining information such as crop areas and crop yield estimation for agricultural statistics, national collections of pests and disease type organisms. Creative use of Global Positioning

technologies, data loggers and other portable and fixed point ICT devices for the collection of natural resource and other data offers possibilities.

3.3.5 Earth observation technologies

These include satellite imagery, airborne imagery, and *in-situ* data collection such as weather stations. Data collection and the development of agricultural applications relating to Hyper-spectral, RADAR and airborne geophysics are essential for the global competitiveness of the sector. Data fusion and refinement of model parameters can assist in obtaining meaningful stress-related interpretations, such as of soil moisture, pests and disease.

3.3.6 Geographic information systems, spatial modelling and scenario planning

The spatialisation of data, combined with remotely sensed imagery using AGIS technology, provides a powerful tool for informed decision making. Spatial technologies used in a modelling environment allow simulation far wider than when using only point data. Applications include agricultural statistics with sample frames, climate change scenarios, forecasts and advisories and natural resource inventories and monitoring.

3.3.7 Product differentiation for global competitiveness

The identification, development and optimization of niche markets for global competitiveness are essential. Three areas for R & D are identified namely: organic products (with emerging farmers in mind), indigenous products (such as Rooibos tea and Proteas) and health and homeopathic products (Devil's Claw, traditional remedies, fat branded beef and omega 3 eggs), bearing in mind IKS (Indigenous Knowledge Systems) considerations. In the global (and even local) markets crop quality is key element of competitiveness. Timing of production to strike markets when prices are at their highest is also a key factor. Research on cultivar choices and determining how far production of a crop can be stretched outside its optimum climate requirements are key research imperatives.

3.3.8 Global competitiveness and macro-economics

Role-players, including farmers, active in a global market, need an understanding of the economic dynamics of international trade. Agricultural research needs to focus on developing a strategic understanding of the macro-economic environment and relate this to micro-economic decisions required by farmers.

3.3.9 Systems improvements and value-addition

Agricultural production is increasingly practiced in a system relationship. This implies optimizing the entire production chain from primary production systems, through post- harvesting, storage and preservation, transport and marketing to value addition, both on and off farm.

3.3.10 Bio-energy and bio-fuels

Energy drives all economic activity. Mineral fuels are limited and the agricultural production of bio-fuels is becoming increasingly viable and desirable. The following research priorities have been identified: identification of suitable crops for bio-fuel production; development of engineering plants of different capacities: adaptation of farm implements; environmental impacts of using bio-fuel and the economics thereof; value addition to the protein-rich residues for the feed and food markets.

3.3.11 Precision agriculture

Internationally, there is considerable interest in precision farming research. Optimizing production inputs and outputs makes both economic sense and is environmentally more responsible and sustainable. R&D in this field should focus on remote sensing, instrumentation, software development and image processing to be able to manage production system variability on a real time basis.

3.3.12 Animal and plant health

In order to continue national and international trade in animal and plant products, effective phytosanitary and animal health regimes must be maintained. These should rely on research to improve and develop new vaccines, diagnostic products, surveys and epidemiological studies. This is the context in which an Agriculture R&D Strategy needs to provide a selection of areas of the research and technology frontier on which to focus, including effects that climate change might have. In order for new and emerging technologies to be adequately researched and adopted, it is essential that an enabling environment be established and nurtured. This would include capacity (human, institutional and financial), private/public partnerships and networks, adequate resourcing and infrastructure maintenance, knowledge maintenance and technology sharing and uptake. Scientists need to maintain international status and participate in global thrusts through support for international protocols.

3.3.13 Indigenous food crops

The importance of indigenous food crops is increasingly being recognised, especially as vegetables in healthy diets and their ability to fight common diseases. These include not only novel local crops, but also indigenous cultivars of normal crops like maize and pumpkins that are preferred due to specific advantages. Extremely little agronomic research has been done on these crops and it is urgently needed to optimise their production.

3.3.14 Production (crop and livestock) efficiency under extreme climate conditions

Research to improve the production efficiency and profitability in crop and livestock farming is of key importance. Field level eco-physiological research on various crops, livestock and rangelands is urgently required in anticipation of the possible effects of global warming and climate change. New crop varieties and animal breeds capable of high yields under extreme climatic conditions must be developed.

3.4 Collaboration and partnerships

Agriculture is inherently international in character. South Africa shares the global agricultural arena by exporting and importing agricultural products; by shared research interest, activities, education and training; and by complying to the increasingly effective and complex set of international standards and rules governing nearly every aspect of agricultural products. South Africa has relatively strong internationally competitive universities and research institutions playing a critical role in national, international, continental and regional capacity building.

It is no longer possible to attempt to develop and maintain advanced scientific capacities in all areas of agricultural research and development. Agricultural productivity is increasingly dependent on innovation and knowledge. The innovation system consists of a network of organizations directly involved in the development, diffusion and use of scientific and technological knowledge. Innovation is interactive, non-linear and applicable at various levels. Research and development is, therefore, not exclusively the business of specialized research institutions, but the business of the entire value-chain and network of participating institutions.

Collaboration and partnerships amongst the national and international research organisations are important. Internationally, continentally (Africa) and regionally (southern Africa) there is an array of actors and potential players in agricultural research and development, each with their own purposes, strengths, weaknesses and capacities. These can be broadly classified as global and regional networks of organizations; organizations supporting research including international and regional organizations, international research organizations, international and regional private firms and international and regional NGOs; national institutions; investors; and non-traditional research partnerships with sectors such as the environment and public health.

The promotion of partnerships and collaborations with international, continental and sub-regional organisations should be guided and sustained by the following principles:

- Support and encouragement by government to foster and develop strong global, continental and regional partnerships;

- A minimum of direct bureaucratic control as it might inhibit scientific cooperation;
- Facilitation and fostering of a wide variety of arrangements for collaboration;
- Strong and effective participation in international, continental and regional networks and programmes of high priority to the country;
- Development of clear agreements and protocols for collaboration including the protection of intellectual property rights, equity and transparency among partners as clear mutual benefits are necessary for successful long-term partnerships;
- Adequate financial resources to act as incentive for producing good scientific innovations that benefit partners;
- Capacity building, including human resources and institutional arrangements that promote the effective use of human resources and innovativeness. One of the methods is to continue to host foreign students and to sponsor local students to study across the country's borders. Such exchanges build life-long professional relationships and generate new ideas enhancing scientific research outcomes.

The proposed agriculture R&D strategy in this regard is that the process and framework for developing and implementing international collaboration and partnerships should involve the following actions:

- Conducting a thorough investigation of the best forms of international collaboration and determining the role, cost and benefits of participation in various international networks and in exchanging university-level students;
- Establishing incentives, programmes and rules for scientists' international collaboration;
- Identifying and securing medium to long-term financial resources and potential supplementary sources required for international partnerships;
- Developing a competitive, matching grant system to promote innovative partnerships. The grant system should be a component of the national competitive funding arrangements of the agricultural R&D strategy;
- Developing and implementing training programmes in collaborative research for both scientists and research managers to ensure skills development in building and managing collaborative and complex partnerships.

4. GOVERNANCE AND INSTITUTIONAL ARRANGEMENTS

The key role-players in the agricultural system of innovation (Table 1) have overlapping mandates, roles and responsibilities. The challenge is to create multi-level, multi-stakeholder approaches that enhance inter-linkages and cooperation in participatory governance processes. Therefore, new and innovative multi-level organisational arrangements (both horizontal and vertical) among government and government agencies, parliamentary assemblies, business, intergovernmental organisations, international agencies, NGOs and civil society groups offer promising possibilities for mobilising effective, collective action in addressing the nutritional needs of vulnerable people and for potentially eradicating poverty and hunger.

Within the agricultural sector, a number of R&D institutions and organisations would need re-alignment to operate in the wider context of policies for research and development, higher education, trade and investment, financial management, labour relations, modes of production, intellectual property rights and skills development. Sustained action is required across sectors and among various actors in the R&D system to put in place the governance mechanisms, processes, institutions, rules, guidelines, policies and normative structures to lead to improved performance of the agricultural sector in eradicating poverty and hunger and in developing a prosperous agricultural sector. Despite public pronouncement about *good governance,* much still remains to be learned about getting governance right, that is, establishing the proper and most effective mix of institutions, rules, policies and actors (i.e. public sector, private sector and civil society) to enhance food security at the local, national and regional levels. Reinforcing mechanisms need to be in place at each level for ensuring accountability, effective implementation, monitoring, evaluation and responsive democratic governance.

The agricultural R&D governance model (Figure 1) is proposed to foster and achieve the following:

- An enabling institutional and policy environment that encourages collective action, learning and capacity building that leads to positive agricultural and rural development outcomes;
- Accountability mechanisms to ensure that key institutions, policies and stakeholders effectively address poverty and food and nutrition security;
- Efficient planning and effective coordination of national programs;
- Integrity and transparency in decision making process and resource allocation;
- Accountability in the management of national resources for research and technology generation;
- Collaborative research work among R&D stakeholders;
- Optimising the utilization of available and existing resources (i.e. research farms, personnel, equipment, etc) for implementing national research agenda and priorities.

The NARS institutional framework shall encompass public, private and civil society organisations in order to promote both horizontal and vertical linkages in the implementation of the agricultural research and development strategy.

The Department of Agriculture's Research and Technology Division (RTD) will perform central coordination functions for the NARS to ensure, through appropriate means, identification and generation of the national agricultural research agenda and priorities; and the creation of the national agricultural research and technology fund to support national activities under the competitive and matching grants, innovation and centres of excellence, Agricultural Technology & Human Resources Programme(ATHRP), and adaptive research, technology transfer and extension services. The National Agricultural Research Forum (NARF) should be strengthened within the DoA to provide seamless secretariat services to the entire NARS and the efforts of the DoA in managing the national processes of priority setting to develop the agricultural research agenda.

The capacity of the Agricultural Research Council (ARC) to perform its core research mandate and maintenance of national assets and infrastructure as well as the provision of national services to the agricultural sector should be strengthened and sustained.

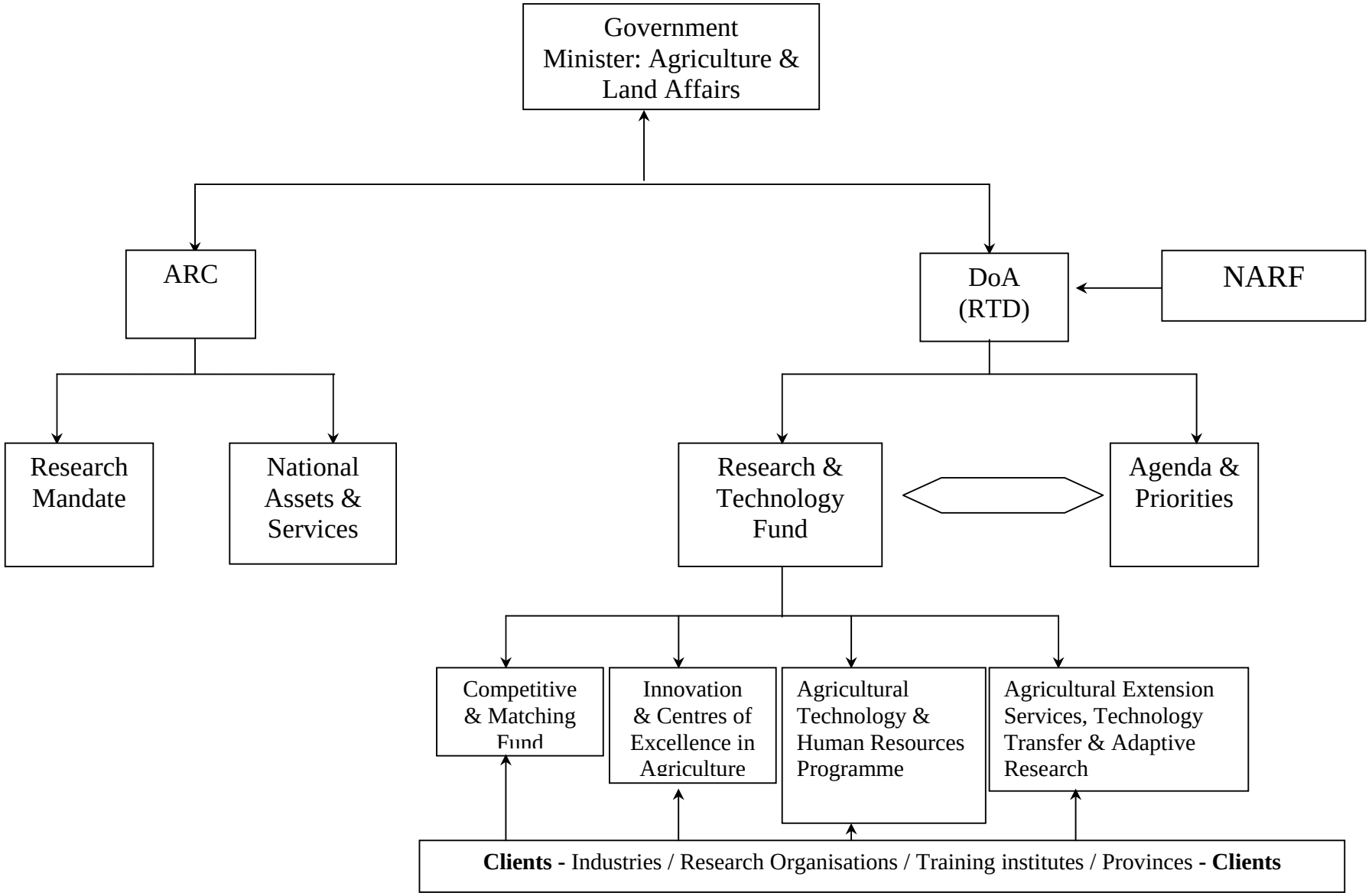

Figure 1. Institutional arrangements and lines of communication

4.1 Structures for management and coordination

The establishment of coordination mechanisms and management systems should be in tandem with the national policy setting environment. The secretariat is necessary to perform various functions including the facilitation of priority setting process and determination of national R&D agenda and mechanisms; whilst supported by and linked to a policy development division of the Department of Agriculture. Therefore, a Research and Technology Division within the Department of Agriculture, and the National Agricultural Research Forum are proposed, as elaborated below:

4.1.1 The Research and Technology Division

The Research and Technology Division of the DoA charged with the responsibility for promoting, supporting and articulation of agricultural research and development programmes, as well as resources allocation, is recommended. The division must report to the Minister of Agriculture and Land Affairs and, should provide overall strategic planning and coordination of national agricultural research priorities aligned with the Strategic Plan for South African Agriculture, ASGISA, NEPAD/CAADP, FARA, SADC (RISDP) and, in particular the implementation of the National Medium Term Investment Plan and Multi-country Agriculture Productivity Programme for South Africa. The centrality and placement of this division within the DoA should allow for transparent priority setting process for agricultural research; monitoring, evaluation and impact assessment of national research programs; and provide frameworks for addressing skills development and intellectual property rights in the sector. The Research and Technology Division will provide oversight on the efficiency of the entire NARS. The functions of the RTD should include, but not limited to:

- Development of National Agricultural Research Framework and Agenda, emanating from the National Agricultural Research and Development Strategy and its monitoring and coordination there after.

- Advocacy for public research budgetary allocation for various types of research programs to various research institutions within the country on equitable and competitive basis through the National Agricultural Research and Technology Fund.

- Impact monitoring of research projects and programs on various target groups and the agriculture sector as a whole.

- Linkage with educational systems making sure to address the identified gaps in terms of required research competency at various educational levels.

4.1.2 The National Agricultural Research Forum

The National Agricultural Research Forum (NARF) is constituted on the basis of broad representation of key R&D stakeholders in the agriculture sector under the memorandum of understanding. Its main objective is to facilitate consensus and integrate co-ordination in research, development and technology transfer to agriculture in order to enhance national economic growth, social welfare and environmental sustainability and seeks to advise government through the Minister of Agriculture and Land Affairs on all matters pertaining to agricultural research, development and technology transfer.

The NARF Secretariat should be adequately resourced to provide effective administrative support to the Research and Technology Division of the DoA.

4.2 Mandates and responsibilities

Key actors in the NARS are singled out to ensure clarity of mandates and alignment of roles and responsibilities.

4.2.1 Public Sector

4.2.1.1Department of Agriculture

With respect to research, the Department of Agriculture (DoA) shall develop a coherent approach to support research, facilitate mechanism for coordination between various role players and contribute to international research institutions and multilateral agricultural research institutions in promotion of the development and dissemination of knowledge of global significance through the development of enabling agricultural policies and legislations. In particular, the DoA's role shall include the following:

- Establishing and resourcing adequately a Research and Technology Division (RTD) to perform the functions stipulated under section 4.1.1;
- Formulating, reviewing and enactment of legislation, policies and strategies for agricultural research and technology transfer;
- Monitoring and evaluating the impacts of national agricultural research programmes to ensure conformity and compliance to national priorities;
- Soliciting and managing resources for the agricultural research and technology fund to support adaptive research, technology transfer and extension services, agriculture production inputs, processing, beneficiation and human resource development, innovation and centres of excellence in agriculture, and competitive and matching grants;
- Establish and institute a national priority setting process to solicit inputs and consensus on national research priorities and agenda;
- Approve the national agricultural strategic research plans and recommendations for resources allocations;
- Support training at Colleges of Agricultural and universities with faculties of Agriculture;

- Liaise with, and report regularly to the Minister of Agriculture and Land Affairs on national agricultural research agenda and priorities, resources allocations, outcomes and impacts of research to agricultural development.

4.2.1.2 Provincial Departments of Agriculture

The provincial departments of agriculture (PDAs) will be responsible for Identifying R&D priorities and participation in the national priority setting process led by the DoA, Mobilising, strengthening and enhancing farmers empowerment in the technology generation-adoption continuum, Providing decentralised, direct resources allocation for agricultural research; e.g. Infrastructure at Research Stations and Agricultural Colleges, financial as well as the available expertise, Implementing research findings at provincial level, based on the needs identified by its clients. e.g. Technology transfer and innovation development, Monitoring and evaluating all relevant research and development activities, Integrating agricultural research programmes and plans into the district and municipal development plans and Establish partnerships with national and international research organisations.

4.2.1.3 Department of Science and Technology

The Department of Science and Technology (DST) is responsible for overall strategic research and development in South Africa. Through a memorandum of understanding with the DoA, the DST should provide appropriate support for the maintenance of key national infrastructure required for performing agricultural research, technology generation and the provision of national services. The cooperation should also include a process of strengthening the extent of the agricultural sector's role within the national system of innovation and improve the level of collaboration within the broader research community through the development of science and technology policies and legislation. The Cooperation Agreement between the DoA and DST should be utilised to improve investments in agricultural research and technology development. The joint plan of action (JPOA) under this agreement should be revised regularly to be in line with the priorities of the NARS.

4.2.1.4 NARF Steering Committee

In line with the provisions of the Memorandum of Understanding for the establishment of the NARF, the Steering Committee shall be responsible for:

- Providing support to the Secretariat with organisational and administration oversight for establishment and running the national priority setting process;
- Ensure NARS participation in the development and identification of the national research agenda and priorities;
- Formulate recommendations for the Department of Agriculture on the national priorities and allocations for agricultural research and technology development;
- Prepare documentation for discussion and decision making at Forum Meetings.

4.2.1.5 Agricultural Research Council

The Agricultural Research Council (ARC) is the premier national research body responsible for the technological needs in support of production, disaster management (disease outbreaks, adaptation to climate change impacts, droughts, floods, etc) and agro-processing in the agricultural sector. The ARC must be supported through a core budgetary allocation from the parliamentary grant to:

- Maintain adequate competencies (human and infrastructural) required for the competitiveness of the sector nationally, regionally and internationally;
- Undertake key national services such as diagnostics;
- Support government development agenda as defines from time to time;
- Perform such tasks and services, on behalf of government, for which the private sector will not find attractive from a commercial point of view.

4.2.1.6 Universities, colleges and development institutes

The universities with agriculture-related faculties and/or schools, agricultural colleges and the agricultural development institutes constitute a primary source of research, an activity carried out in conjunction with teaching, education and training. These institutions are therefore an important nucleus for capacity building and curriculum development in agriculture. Their roles will be to:

- Develop innovative curricula for the education and training of agricultural researchers, scientists, technicians and research managers;
- Collaborate with others in the NARS to undertake adaptive and strategic research;
- Participate in consortia or centres of excellence focused on specific themes/commodities research.

4.2.1.7 Other public institutions

There are other public institutions that participate in commissioning, coordination, impact assessment in socio-economic, socio-developmental and innovative promotion of agricultural research on a competitive basis. These include, but are not limited to the:

- Department of Environmental Affairs and Tourism for policy on environment and agro-tourism issues.
- Department of Water Affairs and Forestry for legislation and policy on water use, forestry, agro-forestry and woodlands development.
- Department of Health for food safety and control systems.
- Water Research Commission for commissioning and coordination of water related research.

- South African National Biodiversity Institute for collaborative research on management and sustainable utilisation of biodiversity, including agro-biodiversity.
- Human Sciences Research Council for socio-economic and impact assessment research.
- Council for Scientific and Industrial Research for agro-processing research and commercialisation of agriculture products.
- National Research Foundation for supporting strategic agricultural research and scientific capacity development.
- National Advisory Council on Innovation for promotion of innovation across all sectors of the economy, including agriculture.
- Perishable Product Export Control Board for quality assurance and standards for exporting and importing agricultural products.
- Medical Research Council for collaborative research on diseases that affect humans and animals.

These institutions, including any other public institution whose work is deemed pertinent and complementary to the conduct of agricultural research, will be encouraged to play a supportive/collaborative role in the implementation of this strategy as and when need arises.

4.2.2 Private Sector

The scope of the South African NARS includes private sector agencies that play a significant role in conducting agricultural research. Their participation in the implementation of this strategy is promoted, especially with regard to the following:

- Providing/offering facilities and infrastructure for conducting agricultural research within the NARS.
- Provide training to researchers and research managers in the public sector.
- Conduct research, technology demonstration and up-scaling of best bet technologies.
- Actively participate in commercialisation of R&D products and patenting of IP for the benefit of the South African society and economy.
- Market South African research and technology outputs internationally.

4.2.3 Civil Society, Farmer Organisations and Professional Associations

These organisations operate on the basis of demand and supply of agricultural research services to specific end-users and commodity groups. Their roles as key stakeholders in NARS, include policy advocacy, facilitation of resource allocation, development training, capacity strengthening, adaptive research, technology transfer and provision of support services. Their key roles in implementing this strategy will be, but will not be limited to:

- Mobilisation and capacity building for farmers to effectively participate in agricultural research;
- Lobby and advocate for increased support for agricultural research;
- Identify, articulate and prioritise research needs.
- Mobilise and manage own research funds.
- Participate in research, technology demonstration and up-scaling.
- Support industry-focussed own-interest research capacities that may participate in, or host centres of excellence within the NARS;
- Identify and prioritise problems affecting their farming systems and commodities during production, processing and marketing and seek for appropriate technological interventions.

4.3 Centres of Excellence

Improving and sustaining agricultural productivity, food security, competitiveness and profitability in the agricultural sector will require an effective network of cutting-edge institutions all dedicated to innovation and excellence in agricultural research and development. The establishment and strengthening of agricultural science and technology networks form part of the themes of the National Research and Development Strategy (DST, 2002). Scientific and technological institutions in South Africa are predominantly public, with the private sector playing a relatively small, yet important role. It is recognised that some agricultural industries have developed and operate fully fledged research and development capacities focussed on specific needs of industries, and these developments should be supported. Institutional innovations designed to strengthen the current systems should be explored with a view to providing the opportunity for the formation of centres and networks of excellence at national and regional levels, that provide for all research institutions (public and private) to participate on a equal footing.

South Africa needs a more effective agricultural research system that, through networking, defines a common research agenda, shares research tasks according to institutional comparative advantage and ensures efficient and equitable sharing of research results across the system. Centres of agricultural research excellence should be established to address strategic priorities (national and regional) and should be supported by a ring-fenced grant allocation. Wherever possible, these centres should evolve from and build upon existing national agricultural research systems, international agricultural research centres, university programmes and industry-based research centres, rather than creating another layer of institutions. International agricultural research centres with headquarters and programmes in Africa should retain their international identities. They should, however, operate in more collaborative and complementary modes with national agricultural research institutes and universities and in participatory partnerships with both farmers and consumers. These should also serve to enrich the scientific content of national training and research programmes and expose the South African Scientific Community to international experiences.

4.4 Modalities of operation

The proposed new governance regime in agricultural research should allow for accountability, responsibility, efficiency and decentralisation of the decision-making and resource allocation processes. This effort will require a new arrangement in the agricultural research system with identifiable organs that have clear mandates, roles and modalities of operation and linkages. The proposed structure should also promote objectivity and independence in the coordination and management of the national agricultural research system. It should be unbiased in its execution of its tasks; develop, nurture and retain world-class researchers and seek to promote excellence in agricultural research. The system should also protect the right to freedom of association and self determination.

4.4.1 Priority setting

With the growing pressure on public sector budgets, the potential for the NARS to use scarce resources more efficiently and effectively is widely recognised. The shrinking real research budgets have stimulated several attempts to evaluate economic benefits of agricultural research and to improve procedures for setting priorities among competing research programmes. Accordingly, many NARS have instituted formal priority setting exercises to ensure that research resources are allocated in ways that are consistent with national objectives and needs. The aim with priority setting and planning would be to foster consistency of research priorities with goals and objectives and to improve the efficiency of the research system in meeting producer and consumer needs. The priority setting process should, furthermore, address research on immediate issues as well as strategic research for anticipated concerns likely to manifest in future.

Priority setting will require intensive consultation among and between policy makers, administrators, planners, researchers and beneficiaries. Formal procedures will be required to facilitate this process since they systematise the consideration of key variables and allow an interactive process to develop. Industry specific priority setting is already conducted by the more developed industries. These industries also generally mobilise and manage their own research funding, thereby ensuring accountability to the suppliers of the funds and relieving the National system from having to find a balance between these and national priorities. These developments should be encouraged. A formal priority setting process should also identify the points at which personal research agendas and national interests appear to be in conflict and avoid these. Although coordinated at the national level, priority setting should be bottom up process, and should occur at three different levels of research planning. These are:

- At the macro-economic level among research themes and programmes;
- At programme level among commodities and agro-ecological zones/production zones;
- At project level between different experiments and studies.

In the South African NARS, as is the case elsewhere, priority setting should occur at the following levels:

- At commodity level – between commodities;
- Within a commodity on research thrusts – breeding vs. management; and
- Within research thrusts on different technological options.

The criteria used at the macro-level will be different from those at the micro-level as Table 5 illustrates.

Table 5: Simplified view of decision-making levels for priority setting in national research organisations

Decision level	**Decision type**	**Common decision maker in supply-led approaches**
National	By program (commodity, factor) sometimes by region across programmes	National DoA supported by the NARF
Programme	By sub-program (disciplinary or technology type) and by region within programmes	Research programme co-ordinator or institute direction
Sub-programme	By project (technology types and characteristics)	Sub-programme leader or departmental head
Project	By technology characteristics	Lead scientist for project(s)

Adopted from Byerlee, 1999.

Government will lead the National Strategic priority setting exercise and implementation of plans arising from priority-setting process carried out through the NARF. Policy guidelines are pre-required to provide the level of specificity needed to develop clear and consistent national research programmes. Industry organisations should lead the priority setting and implementation plans at commodity level.

4.4.2 Intellectual property rights (IPR) management

In South Africa, the IPR policy resides within the Department of Trade and Industry (the DTI), but requires clear strategies for implementation from various sectors such as agriculture. The prime focus of the DTI is on patents and trade-related intellectual property issues. The initiative to amend the Patents Act will incorporate a number of matters relating to the declaration of prior knowledge in respect of indigenous knowledge systems. The biodiversity protection and conservation related property right issues are managed under the Biodiversity Act (2004) of the Department of Environmental Affairs and Tourism (DEAT).

The Department of Science and Technology (DST) takes responsibility for intellectual property arising from publicly funded research and has, in partnership with a range of stakeholders, developed a policy framework for indigenous knowledge systems (IKS). The DST has observer status, on behalf of government, in the Committee for Science and Technology Policy (CSTP)

of the Organisation for Economic Cooperation and Development (OECD). The Department of Agriculture is responsible for IP issues relating to plant breeders' rights.

All IPR relating to public good should reside with government and managed accordingly. As a matter of priority, enabling legislation needs to be put in place to address the management and ownership of IPR from jointly funded research. This legislation should cater for co-funding of research (public: private partnerships) which will encourage the formation of partnerships and the co-funding of research at or with public research institutions. The legislation should furthermore not impinge on any party's freedom of association in selecting its research partners and research service providers.

4.4.3 Monitoring, evaluation and impact assessment

Monitoring and evaluation need to be implemented with a view to assessing the potential impact of research in priority setting and planning; reviewing the performance and quality of research outputs and; assessing the relevance of research programmes and their ultimate outcomes and impacts on research and development objectives.

All national research programmes should contain clear elements of monitoring and evaluation (M&E) and impact assessment (IA) before approval. The challenge is to institutionalise M&E and IA as management tools for managing and assessing efficiency and cost-effectiveness of investments in research and development and technology transfer.

The success of the Agricultural R&D Strategy in providing continued funding and promote long-term research is dependent not only on individual programs, institutions and infrastructure, but also on interacting "portfolios" of programs. It is also important to evaluate how national funding of Agric R&D programmes interfaces with private sector behaviour, provincial research activities and regional and foreign investment on agriculture research and development. Therefore, appropriate monitoring processes and evaluation methods should be developed that take into account the complexities of multiple levels of decision making and interdependent science program portfolios. This should be done by developing a set of system indicators that are monitored periodically and used to revitalize the system.

5. FINANCIAL MECHANISMS

The implementation of the new governance system for science and technology in South Africa implies the replacement of the Science Vote (under the DST) by line department budget allocations to the respective Science Councils. Accordingly, the DoA is charged with the duty to develop R&D plans and to provide budget detail for the agricultural sector to National Treasury. The DoA must build sufficient capacity to execute this duty and to promote R&D across the sector through appropriate incentives and investments. The national R&D survey of 2003/04, puts the gross expenditure on R&D (GERD) at R10. 1 billion, which translates to ~ 0.81% of GDP. This places South Africa at the low-end of the OECD countries, but ahead of Argentina, Hungary and Poland. In order for South Africa's GERD to reach 1.0 % of GDP as stipulated in the National R&D Strategy (2002), GERD would have to reach some R16 billion. Across the sector, business performs the bulk of R&D (55.5%), followed by government (21.9 %) with the science councils and universities accounting for roughly equal shares (20.5 %).

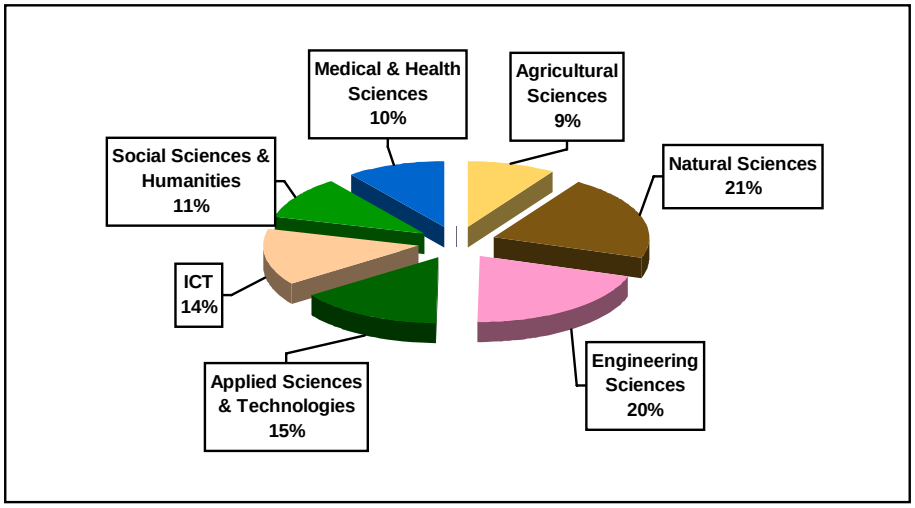

Figure 2. Allocation of the Science Vote to different sectors of the economy for the period 1999/2001

Establishing sound financial management and administrative practices is an important first step towards successful resource mobilisation. Moreover, research managers must consider funding strategies to cover research needs as well as recurrent costs. The funding mechanisms must satisfy the need for regular and continuous resource flow, as well as the needs of policy makers for higher-quality research and accountability. The most commonly used mechanisms for the mobilisation of financial resources include grants, levies, endowments, trusts and cost-sharing. The intention, given the different sources of such funds, is to create an enabling and supportive environment that allows individual decision making regarding the funding of research, choosing and utilisation of preferred service providers.

5.1 Funding structure of the Research Development strategy

The proposed model for the funding of the implementation of the Research and Development strategy is presented in figure (3).

5.1.1 Parliamentary grant

The Parliamentary grant shall be sufficiently motivated to address two main components of the Agricultural Research Council, namely the core mandate, and infrastructure maintenance and associated costs with respect to the provision of national services.

5.1.1.1 Block grant for ARC's Research Mandate

A significant portion of the parliamentary grant shall be allocated to cover the core mandate of a statutory body within the ASI, notably the ARC. This will also cover all agricultural development institutes with regards to their core staff salaries.

5.1.1.2 Infrastructure renewal, capital investment and national services

Part of the parliamentary grant to the ARC should be ring-fenced for capital investment and infrastructure renewal. National assets should be expanded to include all agricultural research facilities that are of a public good nature, inclusive of facilities at universities, agricultural development institutes and PDA's and should be audited to determine the minimum level of funding required. The capacity of the research system to maintain high level national services such as veterinary, diagnostics and regulatory services should be priority in fund allocation.

5.1.2 National Agricultural Research and Technology Fund

Given the level of demand for scientific intervention in agricultural production, the appropriate levels of investment in agriculture should be determined to guide planning and resource allocations. The agricultural research and technology fund should be sufficiently motivated to cover a Matching Grant Fund for research and technology transfer, Centres and Networks of Excellence Fund, Agricultural Technology and Human Resources for Agriculture Programme (ATHRAP) Fund and Agricultural Extension Services, Technology Transfer and adaptive Research Fund. The management of the National Agricultural Research and Technology Fund should be delegated to a competent authority. In figure 3, the blocks refer to possible modes in which the government fund can be allocated. In the first two, this is intended to provide adequate core funding for the activities of the ARC (in the areas of core research, national assets, infrastructure and services). There are a number of premises on which funding allocations in the other modes will be determined, and these will include principles, drivers, process and clear criteria.

5.1.1.3 Principles

The following principles should be adhered to in the allocation of funds to the different areas of support:

- Partnerships will be encouraged;
- Sharing of capacity among NARS;
- Development of capacity and human resources;
- Funding will follow actions/programs;
- Innovation will be encouraged;
- Technology transfer to all agricultural producers.

5.1.1.4 Drivers

It is recognised that the NARS in South Africa will be driven largely by the following drivers, which need to be balanced at various levels, for the different funds:

- Governance;
- Institutional arrangements;
- Priorities at national, provincial. Regional and industry specific;
- Availability of funding;
- Innovation.

5.1.1.5 Process

The realisation of full and effective implementation of the national agricultural research and development strategy will depend on establishing the following:

- Priority setting at various levels to inform national agenda;
- Building budgets at various levels;
- Communication (bottom up and top down.

5.1.1.6 Pillars for the National Agricultural Research and Technology Fund

The following provide broad guidelines for the development of specific criteria for allocation of funds in the different categories:

5.1.1.6.1 Competitive and matching fund for agricultural research and technology generation

A component of the Agricultural Research and Technology Fund should be for allocation on both a matching and competitive basis in order to broaden participation in research, avoid duplication, promote collaborative research, ensure that research is directed at client needs and incentivise industries and other private sector parties to fund research. Competition is one of effective approaches to deliver national priority needs by competent service providers. The aim is to improve the scientific and technical quality of research

proposals, and ensure a greater level of networking and collaboration among the national research institutions.

All research institutions (public and private) should have equal access to these funds. Research institutions should qualify for access to the Matching Grant funds proportional to the research and technology transfer funds they are able to attract from other sources, including industries and the private sector. This provides a mechanism of ensuring that the research institutions meet the needs of the clients and it provides an incentive to industries and private enterprises to fund research. The involvement of the private sector is to ensure that research projects and contracts entered into by the competitive funding program will support relevant research addressing their needs. The rationale being that relevance will in turn promote financial investment, and therefore ease the burden on public funding for agricultural research. Allocations of funds should ensure that:

- Projects have a lead agency, with fully integrated sub-components from other institution(s) within the NARS;
- Research topics address any of the priority areas defined by a national planning/ priority setting process
- As an incentive in the Fund, there should be the availability of 'start up' grants for project preparation and an 'initial grant' covering the planning stage for project proposals.
- The matching funds should be allocated on a sliding scale to be determined, normally on a 1:2 ratio between government and industry.

Given South Africa's experience with the peer-review system of the NRF and the Innovation Fund, the competitive fund for agricultural research should be managed under the existing institutional arrangements. The implementation of a competitive funding mechanism should not undermine the long-term ability of national research institutes (NARIs) to develop and maintain a viable capacity and infrastructural renewal. The regulatory environment for intellectual property and plant breeders' rights, as an inducement to encourage private sector investment will need to be strengthened.

5.1.1.6.2 Innovation and Centres of Excellence in Agriculture

A sectoral analysis of the kinds of innovative approaches and requirements for new or improved institutions and or centres of repute and excellence in key strategic areas need to be conducted. A call for expression of interest should be made to encourage existing institutions to realign their mandates and focus towards national priorities. Specific criteria for designation of centres of excellence and promotion of innovation should compliment the efforts of the Department of Science and Technology. Funding to be allocated on a competitive basis, but ensure:

- Sustainability of an intuition, with a long term vision.
- Clearly articulated and identified strategic niche for the intuition within the agricultural research domain;
- Comparative advantage from a human and infrastructural capacities.

5.1.1.6.3 Agricultural Technology and Human Resources Programme (ATHRP)

The current THRIP model sponsored by DTI and managed by the NRF has successfully demonstrated the partnership principle between government, industry, HEI's and SETI's. It is evident however that the THRIP model does not fit the exact requirements of Agriculture. It is therefore necessary to introduce an Agricultural Technology and Human Resources for Agriculture Programme (ATHRAP) to be administered by DoA as part of the National Agricultural Research and Technology Fund. The aim of the ATHRAP will be:

- To provide the South African Agricultural industry (large and small) with solutions to technology and technology transfer needs.
- To produce a flow of highly skilled researchers and technology managers who understand research, technology development and technology transfer.
- To foster collaboration between the agricultural industry, HEI's, SETI's and other players in the research arena.

The key objective of ATHRP should therefore be to increase the overall competitiveness of the South African agricultural sector by supporting research and development activities and enhance the quantity and quality of appropriately skilled people in agriculture. Funding from government will be competitive, and should attract matching funds from industry and private partners for activities and programs addressing the national R&D agenda and priorities. Competitive bursaries, scholarships and fellowships will be made available to outstanding nationals on merit. All projects funded by ATHRP must include a human resource development (Honours, MSc, PhD and Post Doctoral levels).

5.1.1.6.4 Agricultural Extension Services, Technology Transfer and Adaptive Research (AESTTAR)

The long term impact of this strategy will be measured, among others, by the extent and level at which farmers and farming communities realise efficiencies and improvement in their production systems. Agricultural extension services and technology transfer will include the packaging and further development of existing technologies, commercialisation of products. The Government will fund in partnerships with other role players, these and related activities to improve production and increasing income generation in the sector. Financial support will be made available to service providers on a competitive basis, to institutions to strengthen their capacities to facilitate technology transfer, undertake adaptive research and provision of advisory services.

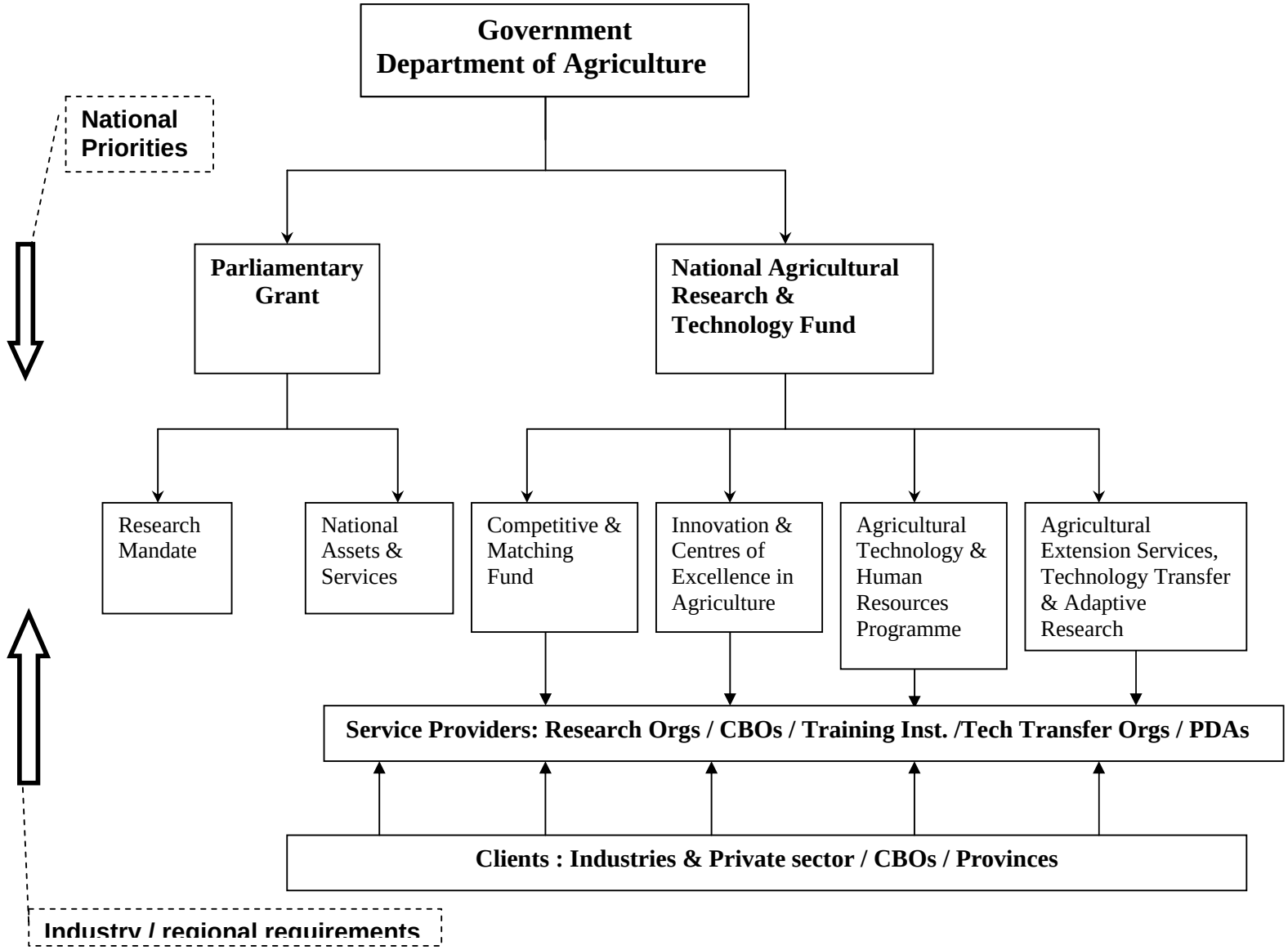

Figure 3: Financial flows within the NARS.

6. LEGAL FRAMEWORK FOR IMPLEMENTATION

The policy and institutional context in which agricultural research and innovation occurs have changed dramatically in South Africa. The current Agricultural Research Act (86, 1990) shall be reviewed to provide a basis for the implementation of this strategy, provide for the establishment of a board of governance for agricultural research in the NARS. The revised Act should also recognise the existence and role of the National Agricultural Research Forum as a body to enhance coordination and efficient research management, priority setting and development of a national agricultural research agenda.