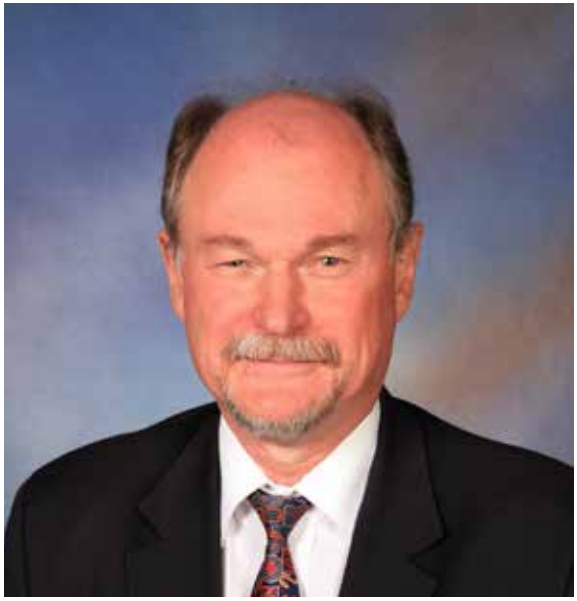
KSA 4:
WATER UTILISATION IN AGRICULTURE

SCOPE

The strategic focus in this KSA is on increasing the efficiency and productivity of water use for production of food, forage, fibre, and fuel crops; improving food security; reducing poverty and increasing the wealth of people dependent on water-based agriculture; and ensuring sustainable water resource use. The needs and requirements of present and future generations of subsistence, emergent and commercial farmers are addressed through creation and application of water-efficient production technologies, models and information systems within the following interrelated sub-sectors of agriculture:

- Irrigated agriculture
- Rain-fed agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

The challenge for applied research is contributing to finding sustainable solutions for water use in agriculture, with priority given to innovative new products which support economic development and inform decision-making for private business and public policies. In the process of undertaking these research projects, the composition of research teams endeavours to broaden representation by Black and female researchers, postgraduate students are trained to improve the expertise of human capital, with research empowering individuals and groups in rural communities.



Gerhard Backeberg: Executive Manager

Water users in all of the above-mentioned subsectors, as well as organisations such as WUAs, cooperatives, agri-businesses and government departments serving water users, are the clients or target groups of the research output. The point of departure of applied research is therefore the real-life opportunities and problems experienced primarily by water users and related organisations, for irrigated and rain-fed crop production, fuel-wood and timber production as well

as livestock and fish production. The problems which may be experienced in practice for any aspect of water use on the farm, irrigation scheme or river catchment vary from non-existence of knowledge, doubt regarding the applicability of existing knowledge, deviation of empirical observations from some relevant theoretical optimum, to an unclear outcome of possible alternative decisions and actions.

Research as a dynamic, creative and problem-solving process must provide information, technologies and models, which can be applied by present and future generations of water users. The overall objectives are to utilise scarce water resources efficiently, beneficially and sustainably to increase household food security and farming profitability, and thereby increase economic and social welfare, i.e., efficient growth and equitable distribution of wealth on a farming, local community and regional level. These objectives must be achieved through the creation of knowledge by means of research and dissemination of knowledge, technology transfer, training and extension. Traditionally contributions are made by scientists in applied disciplines or focus areas of soils, crops, engineering, climatology, economics and sociology. Increasingly, however, the complexity of the information needs of water users requires a multidisciplinary or interdisciplinary research effort. In all instances the priorities are enhancement of management abilities in order to improve the efficiency of water utilisation for agricultural and food production.

OBJECTIVES

The primary objective is to increase national and household food security and to improve the livelihoods of people on a farming, community and regional level through efficient and sustainable utilisation and development of water resources in agriculture.
The secondary objectives are to:

- Increase biological, technical and economic efficiency and productivity of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection, restoration and reclamation practices

THRUSTS AND PROGRAMMES

THRUST 1: WATER UTILISATION FOR FOOD, FORAGE AND FIBRE PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture	**Scope:** Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.
Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture	**Scope:** Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in assessment of the fitness-for-use of surface and underground water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations	**Scope:** In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Programme 1: Sustainable water-based agricultural activities in rural communities	**Scope:** Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research which improves knowledge, farming skills and leadership capabilities.

Programme 2: Integrated water management for profitable farming systems	**Scope:** Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

THRUST 4: WATER RESOURCE PROTECTION, RESTORATION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use.

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments	**Scope:** With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.

Programme 2:
Impact assessment and environmental management of agricultural production

Scope: Agricultural decisions to use land and to conserve rainfall, or to withdraw water from rivers, dams and boreholes, have wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

STRATEGIC CONTEXT

The National Water Resource Strategy 2 (2012) includes the following critical thrusts under 11 different core water strategies, with emphasis on those in which the Water Research Commission (WRC) has functions to perform:

- Fostering innovation and knowledge management, investing in people's capabilities, cultivating a more water educated and literate society, as well as increasing economic growth and social development
- Enhancing indigenous knowledge systems to meet the challenges of globalisation, focusing on the role of women and the youth
- Developing a knowledge-based water sector as a strategic move to raise the value added of all water use activities and optimising empowerment of people in society
- Strengthening human resource development to produce an efficient, effective and knowledgeable workforce
- Pursuing water security and environmentally sustainable development to re-enforce long-term growth
- Ensuring sound investment policies and infrastructure management as well as enhancing efforts to develop a knowledge-based water economy
- Improving user's knowledge, skills and expertise as well as upgrading innovation, science and technology

Key strategic actions which require inputs by the WRC and which are most relevant to the KSA: Water Utilisation in Agriculture are the following:

- Investment in the development of 'smart' solutions for water use efficiency, research of appropriate technologies, management solutions and appropriate institutional as well as organisational arrangements
- Development of a programme for investment in research and development of water efficient technologies and management systems

- Co-ordinate a skills development programme to build capacity in water management, including investment in education and youth development programmes, together with DWA and Universities

The National Planning Commission released the National Development Plan and Vision for 2030 on 11 November 2011. The most relevant sections which direct the Research and Development (R&D) Strategy of the Key Strategic Area (KSA) on Water Utilisation in Agriculture are first, 'Key drivers for change' of science and technology; second, 'Economy and employment' in relation to the National System of Innovation and Learning that permeates society and business; third, 'Economic infrastructure', in particular water resources and services; fourth, 'Inclusive rural economy', regarding trade-offs and risks for agricultural expansion; and fifth 'Improving education, innovation and training', with a focus on achieving the vision for 2030.

According to the New Growth Path (2011) measures must be taken to address income inequality in society, including skills enhancement and small enterprise development. Efforts to support employment creation will be given priority, with key sectors including, amongst others, the agricultural value chain. This includes measures to encourage growth in commercial farming for improved national food security. The agricultural value chain also offers employment opportunities through smallholder schemes and beneficiation with processing of agricultural products. Furthermore, improvement of rural livelihoods is possible by upgrading farmworkers' living conditions and by enabling rural households to increase food production. However, the growth path also requires a radical review of the training system to improve skills development and address shortfalls in technical skills. It is 'critical to ensure a space for smaller enterprise in the value chain' and promoting small business and entrepreneurship.

In the Programme of Action of The Presidency (2010), there are two outcomes which give further strategic direction to research in the KSA. Under Outcomes 7 and 10, the following outputs are specifically relevant:

Outcome 7: Vibrant, equitable and sustainable rural communities and food security for all:
- Output 1: Sustainable agrarian reform
- Output 2: Improved access to affordable and diverse food
- Output 4: Improved employment opportunities and promotion of economic livelihoods
- Output 5: Enabling institutional environment for sustainable and inclusive growth

Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced:
- Output 1: Enhanced quality and quantity of water resources
- Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmosphere quality
- Output 3: Sustainable environmental management

Furthermore, the Green Paper on National Strategic Planning (2009) seeks to answer, amongst others, how to reduce poverty and what capacity is needed to ensure availability of water, energy and food in the future. The intention is to articulate a vision and strategy for the next 15 years, to which all organisations of Government are aligned.

In this regard the South Africa Vision 2025 of the Medium Term Strategic Framework projects a society in which, inter alia:

- People are united in diversity while appreciating the common interests that bind them together
- Conditions have been created for full participation of women
- Effective programmes exist to reduce poverty and protect the most vulnerable in society
- Beneficial and sustainable use is made of human resources, natural resources and modern technology
- Common interests are promoted by investment and competitive returns for the private sector

In addition, the strategic context for research on water utilisation in agriculture was given renewed impetus by a 2008 report of the National Agricultural Marketing Council (NAMC), which serves the strategic positioning of South African agriculture. It was reported that food production had not kept pace with consumer demand, mainly driven by population growth and increasing per capita income, leading to food price increases. Several factors had contributed to the poor performance, including adverse climatic conditions, lack of availability and quality of water, and low profitability with lack of investment because of high input costs and insufficient progress to increase productivity. The report highlighted the importance of making available adequate water and fertiliser production inputs and of improving agricultural support through research in order to increase food production.

The water resource base is therefore of key importance in agriculture. Together with other renewable and interdependent natural resources, it forms the ultimate support of the productive economic activity of people. Water utilisation can best be quantified as rainfall-dependent, surface water- and groundwater-dependent use. Approximately 12% and 62% of rainwater in South Africa is used annually for dry-land cropping and by natural grasslands, woodlands and forests respectively. Rainwater runoff and deep percolation become available as surface water and groundwater of which approximately 62% is used for irrigation. It is abundantly clear that the biggest share of water is used for both extensive and intensive production in agriculture. The significance of agriculture and the impact of research in the development process encompass the following:

- Everybody in society consumes food. Technological progress in agriculture therefore has widely distributed benefits.
- Agriculture is the key to poverty reduction in rural areas. Water resource use and production should be analysed as a value-adding process (from farmer to consumer) and the business and employment opportunities which are created should be recognised.
- Research increases the productivity of natural and human resources. This improves the competitive advantage of agriculture in a global economy.

As is typical of an industrialised economy, the relative contribution of agriculture, forestry, hunting and fishing is low, at between 2 to 3% of gross domestic product (GDP). The forward linkages to processing industries and backward linkages to input suppliers in agriculture are, however, of considerable importance for economic activity in urban and rural areas, increasing the contribution to 20 to 30% of GDP. Until 2006 agriculture was also a net exporter of food,

contributing 10% of total exports of which 50% are processed products. During 2007, imports exceeded exports, mainly due to import of processed food products. Since 2008 the trade balance is again positive.

The abovementioned current reality of agriculture in South Africa was also clearly stated by the Department of Water Affairs and Forestry (DWAF) in the strategy on Water for Growth and Development in South Africa (2008). Effective change in water use behaviour to promote water savings for growth could be achieved through incentives to improve irrigation efficiency and conservation practices. These include water measuring and user charges as tools to manage demand, upgrading irrigation technology and trading of water use entitlements. Revitalisation of irrigation schemes in the former homelands is required for household and community level irrigation. Furthermore it is important to provide water for food production in home gardens in rural villages or towns and peri-urban areas. This can be done through development of small-scale infrastructure for different forms of rainwater harvesting and storage, which promotes rural development.

Critical issues in the forthcoming years and the next two decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing consumer income levels. Expansion of agricultural production on land suitable for cultivation will be increasingly constrained by the availability of water. Increasing hazards of rainfall variability, with western parts of South Africa getting drier and eastern parts wetter, over the long-term, are caused by climate change. This requires adaptive management practices to reduce the vulnerability of people in rural areas and prevent disasters of crop failures, income loss and widespread famine. At the same time, there is a relatively high ratio of people to cultivated land and a larger dependence on agriculture in rural areas to increase the material income and improve the social wellbeing, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that the use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences. Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible restoration and reclamation practices. Consequently, although the quantity and quality of water resources available for agricultural use are limited, it is important to note that this is not a constraint for economic development. The requirement is that water resources must be utilised productively and greater efforts with research and development must be made to increase productivity growth and thereby the competitiveness of agriculture.

BUDGET FOR 2013/14

The approved funding of the research portfolio for 2013/14 led to a committed funding budget of R30 507 464.

Research portfolio	Approved 2013/14 (R)
Current projects	27 507 464
New projects	3 000 000
Total	30 507 464

RESEARCH PORTFOLIO FOR 2013/14

In this KSA a holistic systems approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Research projects are managed within the innovation cycle to ensure that scientific research is applicable and socially beneficial. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction and wealth creation in rural areas and prevention of resource degradation. These efforts are aligned to the Vision for 2030 of the National Development Plan; the outputs for Outcomes 7 and 10 in the Programme of Action announced by the Presidency; core water strategies of the NWRS-2; measures in the framework for the New Growth Path; the Green Paper on National Strategic Planning; the DWA framework on Water for Growth and Development; the DAFF Integrated Growth and Development Plan; the National Agricultural Research and Development Strategy; and the Comprehensive Africa Agricultural Development Programme of NEPAD. Work continues to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following key activities of the research portfolio:

- Increasing the productivity of rainwater and irrigation water for crop and livestock production
- Uplifting rural economies through commercial food production and reducing income inequalities
- Quantifying the water footprint in food value chains
- Eradicating hunger and reducing poverty
- Improving food security, nutrition and health
- Generating alternative sources of renewable energy
- Preventing soil and water degradation and pollution
- Adapting farming systems to climate change

Over the past 11 years a strategic shift has been made to achieve a balance between research projects in irrigated

and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities through participatory action research; and to take research projects further toward practical application of results with technology transfer projects. The baseline of completed projects and stakeholder requirements indicates the direction and priorities for future research. In the next two years emphasis will be placed, through new projects, on quantification of the water use of indigenous field crops; determining the water footprint of selected food crops; measurement and modelling of fruit orchard water use; technology transfer for water quality management in aquaculture; rehabilitation of grasslands after eradication of invasive trees; evaluation of the water use and nutritional productivity of food crops in the diet of rural poor people; contribution of inland freshwater fisheries to rural livelihoods; action oriented knowledge transfer for training of productive water use in homestead food gardening and cropland rainwater harvesting; wide-scale modelling of water use and water availability with earth observation/satellite imagery; investigating entrepreneurial development paths of smallholder farmers; optimisation of electricity cost for sustainable irrigation water use; impact assessment of sedimentation on water flow and salinisation of irrigated land; revision of the 1996 water quality guidelines for agricultural water uses; and vulnerability analysis for drought impact assessment and resilience related to climate change. The output of these projects will mainly contribute to the flagship initiatives of the water, energy and nutrition/food nexus as well as the green village and model catchment.

COMPLETED PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water use of drought-tolerant food crops
University of KwaZulu-Natal (Crop Science); University of KwaZulu-Natal (Howard College); South African Sugar Association Experiment Station
No. 1771

The initial task of the project was to identify and characterise indigenous and conventional food crops with application potential in South Africa. This was done taking into consideration, inter alia, (i) what can grow where under water-scarce conditions, (ii) water requirements and crop responses to water stress, and (iii) production and yield under water-stress conditions. A series of trials, including controlled, field and rainshelter experiments, were conducted in three provinces of South Africa – KwaZulu-Natal, Free State and Gauteng. The overall objective of the experiments was to understand the agronomy of selected crops and to determine whether or not they were drought tolerant. This included understanding their water use and water productivity. Modelling of the selected crops to

determine performance under dryland conditions was a secondary objective. A novel approach of the project was to select at least four crops that could be used to develop a crop model for indigenous crops. Over a period of five years, this study achieved the overall objective of providing agronomic information about the response of selected indigenous crops, indigenised taro and traditional maize, to management under field and controlled environmental conditions when water is limited.

Cost: R4 350 000 (incl. leverage)
Term: 2007 - 2013

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Interaction between aquaculture and water quality in on-farm irrigation dams: Extended monitoring and mitigating procedures to manage environmental impact
University of Stellenbosch (Division of Aquaculture)
No. 1802

Irrigation dams in the Western Cape Province have a history of enrichment through external factors such as agriculture (fertilizers and pesticides), runoff and stormwater from the surrounding areas and effluent from infrastructure extension (housing and informal settlements). The incorporation of aquaculture into such dams adds additional nutrients to the water column and sediment, although the nutrients are not very concentrated. Irrigation dams can play a role in providing water bodies for floating net cage farming systems. However, water quality analyses over the research period indicated that farm dams in the Western Cape, overall, had good water quality, indicating that commercial crop farmers are exercising better management practices. The water quality was generally within the South African Water Quality Guidelines for agriculture, aquaculture and recreational use. The introduction of aquaculture under the prevailing farm-dam water quality guidelines generally did not pollute the water to such an extent that crop farming was compromised. Thus, there is a case to be made for promoting integrated aquaculture-agriculture farming. Sustainability for both uses can be maintained through robust site selection and diligent hands-on management of both fish- and crop-farming operations. This approach will ensure that commercial crop farmers' irrigation regimes and yield quality is not negatively affected. Recommendations include prevention or minimisation of pollution through aquaculture in irrigation farm dams by means of effective technology transfer and knowledge dissemination.

Cost: R1 680 000
Term: 2008 - 2013

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services
ASSET Research; University of Stellenbosch; independent consultants
No. 1803

The specific objectives of this study were to conduct ecological, hydrological, and socio-economic assessments to determine the impact of restoration at several existing, and ecologically and socio-economically different, restoration sites by comparing them with degraded or un-restored areas in close proximity. The outputs from these studies were used to develop an integrated system dynamics model on the likely impact of restoration on the ecology, hydrology and economy of, notably, agriculture. The research team identified eight existing restoration sites that were well established and that had significant/sufficient supporting data. An ecological, hydrological and economic assessment of the impact of restoration on ecosystem function was done. A summary of the classification of projects suggests that those with the highest potential payoffs (the pearl projects) are the water projects, in other words those projects where downstream water consumers benefit from the restoration project. The Agulhas, Beaufort West, Kromme and Sand study sites are all examples of this. This study provided unique perspectives in that it was reflective, and multi-disciplinary. The study demonstrated that standard economic evaluation methods have limited ability to take system dynamics into account and could, therefore, easily misdirect or reject investment in restoration, potentially leading to disastrous social and ecological consequences. Using the proposed decision-making framework with respect to the development of markets/payment systems for ecosystem goods and services following restoration, decisions can now be taken against the backdrop of the risk involved in achieving such rewards or benefits. Neither systems dynamic approaches nor risk quantification in themselves are new, but applications to existing and on-going restoration projects are novel. This study has contributed to the science and practice of restoration through such an evidence-based approach to integrating economic evaluation and ecosystems dynamics. The report makes various technical and policy recommendations.

Cost:	R3 450 000 (incl. leverage)
Term:	2008 - 2013

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa
ARC (Institute for Soil, Climate and Water); ARC (Livestock Business Division); Department of Agriculture Forestry & Fisheries
No. 1775

Extensive research in South Africa has gone into developing a water harvesting system for growing crops in homestead gardens, although focus is shifting to implementing water harvesting in croplands at a much larger scale. Various techniques were identified, of which only few were deemed appropriate for use in this project. It was decided to concentrate on-farm micro-catchment techniques including contour ridging, tied ridging, tied furrows, strip catchment tillage, mechanized basins and stone terracing. The in-field rainwater harvesting technique was originally proposed in South Africa in 2000 as an alternative to conventional crop production. The technique was designed to maximize productive losses of rainwater. By combining the advantages of water harvesting, no-till, basin tillage and mulching on high drought-risk duplex and clay soils, the integrated rainwater harvesting technique reduced runoff to zero and considerably reduced evaporation. The general aim of this research was to assess rainwater harvesting and conservation (RWH &C) techniques/practices and related institutional arrangements for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research.

Cost: R4 728 500 (incl. leverage)
Term: 2007 - 2013

Improving plotholder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province
Tshwane University of Technology; ARC; Wageningen University; PANNAR
No. 1804

The main thrust of the work was the testing of a number of farming system innovations, but attention was also given to social resource constraints. The research was conducted in the Limpopo Province, which is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of schemes to be constructed. A survey of all registered smallholder irrigation schemes in the Vhembe District was conducted. The findings confirm the continued relevance of canal irrigation and show that gravity-fed canal schemes are more likely to be operational and to last longer than pumped schemes. The case study of Dzindi provides detailed evidence

of a rapidly decaying water distribution system, which is at least partially due to neglect on the part of plotholders, who have allowed the collective organisation that was responsible for routine maintenance of the system to collapse. For this reason, establishment of an effective routine maintenance system was identified as a critical condition for the sustainability of canal schemes. The empirical work identified the lack of a comprehensive legal framework that enables plotholder communities to assert their land rights as an important weakness of the current tenure system on smallholder irrigation schemes in Vhembe. The report covers issues of production, particularly dealing with irrigation scheduling of Chinese cabbage and green maize. The findings of the project have important implications for the improvement of smallholder irrigation schemes in South Africa, as a rural development option. The report contains recommendations derived from the project, with specific reference to policy. These recommendations have a significant bearing on policies such as the National Development Plan 2030 and the Limpopo Department of Agriculture's RESIS recharge programme, among others. Three guidelines were developed for use by development practitioners.

Cost: R1 890 000
Term: 2008 - 2013

CURRENT PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water use of fruit tree/orchard crops
CSIR (Natural Resources and the Environment)
No. 1770

In summer and winter rainfall areas, water stress in river catchments is increasing. Limited water resources can constrain development if productivity is not improved. This is particularly important for the fruit tree industry where at least 90% of production is dependent on irrigation. However, there is a lack of comprehensive information of the water use of fruit trees or available information on water use is incomplete and contradictory. Correct knowledge is absolutely essential for drawing up on-farm water management plans for fruit production. The recently-published research reports on water use of citrus and deciduous fruit trees did not provide conclusive results. More specifically it is clear that soil-based measurements present a challenge to obtain accurate and reliable information on water use. Existing models in South Africa can also not confidently simulate water use of fruit trees for different climate,

soil, water and management conditions. Therefore, the definite need exists to do intensive research on the tree-based measurements and to design tree-specific models. The purpose of this project is to develop comprehensive knowledge of water-use characteristics and the water use of selected fruit tree/orchard crops for application in fruit tree/orchard management in South Africa. This will require a review of available knowledge on water use of tropical, sub-tropical and deciduous fruit trees/orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic importance, current hectarage, geographic distribution and gaps in knowledge on water use. The main outputs will be reports on the empirical measurement of water use at the selected sites and the development, verification and validation of models for the selected fruit trees/orchard crops. More precise modelling approaches and knowledge of water use will improve management advice to farmers on the productive water use of fruit trees within and between seasons over the productive life of the orchard.

Estimated cost: R5 567 500 (incl. leverage)
Expected term: 2007 - 2014

Water use of cropping systems adapted to bio-climatic regions in South Africa and suitable for biofuel production
University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)
No. 1874

In South Africa, the establishment of an economically viable biofuels industry is increasingly becoming a possibility due to technological advances; global commitment to limit greenhouse gases and to reduce global warming; the need to diversify energy supply; and the need to accelerate rural economic growth by the agricultural sector. With diminishing fossil fuel resources and increasing oil prices, attention is being focused on producing alternatives to fossil fuel, with emphasis on the production of biofuels. The Biofuels Industrial Strategy of South Africa specifies the use of certain crops as feedstocks for bio-diesel and bio-ethanol production. The consideration of a range of crops and cropping systems as feedstocks is necessary, especially those which may produce food and fodder as well as fuel. Furthermore, the evolution of 'second generation' biofuel technologies which allow for the conversion of cellulose (biomass) for biofuel production must also be investigated in terms of water use and potential impacts on the country's food production. Studies on the water use impacts of the biofuels industry on South Africa's limited water resources are urgently required for both local and national water resource planning. A scoping study on the water use of crops/trees for biofuel production (WRC Project No. 1772) provides preliminary results on the water use and growing conditions of limited biofuel crops based on broad climatic parameters and crop bio-physical requirements. The report of this follow-on project will document the water use and optimal growing conditions for a comprehensive range of potential crops/trees. It will include detailed mapping of suitable production areas and the projected impact of biofuel production on water resources and food supply.

Estimated cost: R7 400 000 (incl. leverage)
Expected term: 2009 - 2015

Water use efficiency of irrigated agricultural crops determined with satellite imagery
UKZN (Bioresources Engineering and Environmental Hydrology)
No. 2079

Advances in recent years in the use of remote sensing (RS) information now make it possible to assess crop water use, biomass and yield production (and WUE) spatially for each pixel (< 30 to 250 m) of a satellite image. For agricultural (field-scale) applications a number of models have been developed, including the Surface Energy Balance Algorithm for Land (SEBAL) model. Assessing the spatial WUE data over time can help farmers to detect, e.g., an uneven application of irrigation water (in a field or across a farm or irrigation scheme), a mismatch between irrigation water supply and that actually required (indicating over- or under-irrigation), potential seepage losses or drainage problems and other resources (e.g. fertiliser and energy) wastage. This project will build on research projects conducted in South Africa in recent years where the use of spatially-explicit data (from the SEBAL model) in irrigated agricultural water management has been evaluated. In South Africa, there is a need for information to be available operationally, so that WUE at field, farm and irrigation scheme level can be evaluated regularly, problems detected and addressed swiftly, crop WUE and other resource use (fertiliser, electricity, etc.) optimised, and water wastage minimised. This project will aim at conclusively confirming the degree of accuracy of the SEBAL model (when compared to traditional methods) for estimating ET and WUE of selected agricultural crops. This project should therefore pave the way for the operational near real-time application of RS data in agricultural water management. There will be collaboration with potential users of the data (researchers, farmers, irrigation advisors, water managers on irrigation schemes) and the project will continue to build capacity (students, extension officers, researchers) in generating and using this data.

Estimated cost: R4 000 000 (incl. leverage)
Expected term: 2011 - 2014

Investigating the possibility to improve water use efficiency and reduce canopy management inputs of wine grapes through deficit irrigation
ARC Infruitec-Nietvoorbij
No. 2080

At present, wine grape farmers are advised by viticulturists to follow certain canopy management practices, such as suckering, tucking in and topping of shoots. This is done to ensure that the grapes fall within a prescribed quality class. Under current economic circumstances, as well as with the rising cost of labour and fuel prices, these practices are becoming increasingly expensive to maintain, as farmers are not necessarily compensated for the additional expenses. Knowledge of how different canopy management practices at different deficit irrigation strategies will influence the combination of vegetative growth, production and wine quality is limited. A completed Winetech project investigated the effect of different deficit irrigation strategies on the water usage, production, growth, plant water potentials and overall wine quality, and crop factors were determined for a range of irrigations at different soil water depletion levels. The same canopy management was applied to the grapevines of all the treatments (two-spur winter pruning,

suckering twice during spring and the tucking in of shoots into trellis wires). The cost of these different management practice inputs has not been investigated. In previous irrigation trials conducted on wine grapes, a blanket standard canopy management was done on all the treatments as the object of these trials was to investigate the effect of the different irrigation strategies on the grapevines' yield and wine quality. In previous canopy management research, the same irrigation volumes were applied to the various treatments while their canopies were manipulated. The effect of different canopy management inputs in combination with different irrigation strategies, and the water requirements of these different canopies, has thus not previously been investigated. Depending on the outcome of the trial, the results could be used as subroutines in future economic models to calculate the profitability of wine grape vineyards.

Estimated cost: R2 072 000
Expected term: 2011 - 2015

Nutritional water productivity of indigenous food crops
ARC (Vegetable and Ornamental Plant Institute)
No. 2171

Many indigenous vegetables (underutilized crops in particular) have high nutritional levels of micro-nutrients and could significantly contribute to nutritional security if eaten as part of the daily diet. A WRC project on nutritional value and water use of eight indigenous vegetables showed that 100 g leafy indigenous food crops (morogo) contain sufficient beta-carotene to supply more than 80% of the recommended daily allowance (RDA) of 4-8 year olds, and more than 40% of the RDA for 19-50 year olds. The eight indigenous food crops studied for their nutritional value were amaranth, cowpea, chinese cabbage, nightshade, spider flower, jew's mallow, watermelon and pumpkin leaves. Despite the importance of these vegetables in combating malnutrition and poverty, they are still poorly understood by the South African scientific community. In the abovementioned project, one of the research gaps identified was whether crop nutritional value is closely interlinked to water and nutrients, especially nitrogen (N), potassium (K) and phosphorus (P). This new project will explore the nutritional water productivity of four indigenous food crops, which have the potential to broaden the food basket. The crops are jute mallow, orange-fleshed sweet potatoes, nightshade (or *Amaranthus*) and *Cleome*. These crops are selected based on their popularity, nutritional quality and potential for small-scale and commercial production. The above questions will be investigated through field experiments linked to the ongoing Department of Science and Technology (DST) funded projects at the ARC-Roodeplaat VOPI, particularly the commercial production and breeding programmes of these indigenous food crops. Considering the importance of indigenous vegetables to combat malnutrition and broaden the food base in rural South Africa, the DST has funded ARC with over five million rand per year for the next three years. Rural based universities are targeted for this trial work as a major access point to the rural communities to introduce the technology solution developed at the ARC.

Estimated cost: R1 950 000
Expected term: 2012 - 2016

Current rain-fed and irrigated production of food crops and its potential to meet year-round nutritional requirements of rural poor people in North West, Limpopo, KwaZulu-Natal and Eastern Cape Provinces
University of Pretoria (Institute for Food, Nutrition and Well-Being)
No. 2172

Renewed attention must be given to agriculture, nutrition and health in adjusting research agendas, and strategies must be directed at early childhood nutrition, particularly of poor households. More research is needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices. The on-going WRC scoping study (WRC Project No. K5/1954//4) entitled 'A baseline and scoping study on water use and nutrient content of crop and animal food products for improved household food security' identified insufficient data on food intake of poor households in rural areas of South Africa. The study also found that very little information is available on the sources of foods consumed by rural households. This means that, overall, insufficient data are available to make generalisations about the 'basket' of foods and the source of foods of the rural poor in this country, and consequently it is difficult to develop appropriate programmes that will improve the nutritional health of rural communities. Although dietary studies indicate that rural poor people meet very little if any of their nutritional requirements through own food production, this is contradicted by case study evidence from an agricultural perspective. It is therefore necessary to undertake empirical research on food production and intake by poor households. Opportunities exist that some of the foods in a balanced diet can be produced in gardens or field plots, which are currently underutilised. The provinces of North West, Limpopo, KwaZulu-Natal and Eastern Cape have been prioritised because this is where the majority of rural poor people live and produce crops under rain-fed and irrigated conditions, and potential exists to enhance production. It is important to identify the food crops for detailed follow-on research of water use and nutritional productivity for the purpose of reducing under-nourishment and increasing household food security.

Estimated cost: R3 650 000 (incl. leverage)
Expected term: 2012 - 2016

Water use and crop parameters of pastures for livestock grazing management
University of Pretoria (Department of Plant Production and Soil Science)
No. 2173

The focus of this project will be to integrate irrigation and nitrogen management in order to improve the efficiency of both inputs. In South Africa, returns generated from animal production enterprises make pastures one of the highest value crops produced under irrigation. It is estimated that the total area utilized for irrigated pasture production is approximately 16% of the total area under irrigation. The most common irrigated pastures are ryegrass, kikuyu and lucerne. Irrigated ryegrass and dryland kikuyu with supplemental irrigation are the primary sources of feed in the pasture-based dairy industry and these are mostly grown in the relatively higher rainfall areas. Therefore, in this project, the promising practice of temperate legume with tropical grass or temperate grass mixture and the most commonly

practised grazing mixture of kikuyu/ryegrass will be researched. Lucerne is regarded as the most important pasture legume produced in the drier parts of South Africa for its high quality roughage (hay). This roughage is extensively used in many animal production systems, including feedlots, dairy systems, the animal feed industry and the wildlife industry. The studies to be conducted under controlled environments and at representative research stations and commercial farms will aim to: (i) determine water use and irrigation requirements of most common farmers' practices including kikuyu/ryegrass, legume/ryegrass mixtures and lucerne; (ii) evaluate irrigation systems (flood, sprinkler and sub-surface drip) for lucerne production; (iii) conduct detailed physiological studies of lucerne as affected by different water stress treatments, and (iv) parameterise, test and validate selected crop growth/pasture model(s). As end products, databases of irrigation requirements of kikuyu/ryegrass, clover/ryegrass mixtures and pure lucerne under different pasture management practices will be developed. Finally, the validity and practicality of irrigation tools developed will be assessed in conjunction with pasture-producing industries.

Estimated cost: R2 750 000
Expected term: 2012 - 2016

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

An investigation into the link between water quality and microbiological safety of fruit and vegetables from the farming to the processing stages of production and marketing
University of Pretoria (Department of Microbiology and Plant Pathology)
No. 1875

With decreasing water resource availability for agricultural purposes and increasing water pollution, contamination of food products may increase health risks. Poor health due to water and food contamination has negative impacts on the productivity of human resources in all sectors of the economy. This emphasises the importance of minimising food safety risks. Due to under-nutrition, consumption of fresh and raw fruit and vegetables is encouraged as a source of essential micro-nutrients. If the water and produce are not safe, or if there is a lack of effective food safety management, this benefit may be eliminated and the health of all people, but in particular the vulnerable poor people, will weaken. In addition, earning of foreign exchange is a key contribution of agriculture to the economy. Microbial contamination of food products for local and export markets will have negative impacts on trade relationships. Losing market access due to perceived high risks of contaminated produce could have severe constraining implications for future economic development. For food safety management, European and American models are currently applied. These are not necessarily appropriate for South Africa and consequently the risk may not be correctly assessed. In addition, CODEX standards are presently adopted and officials are not able to benchmark these with locally verified data. Therefore, this research project on microbial contamination of fruit and vegetables will enable the drafting of relevant national microbial standards which comply with international requirements. The knowledge obtained through the project will also contribute to effective management of water resources and food products to improve food safety. Better understanding of the nature and extent of the problem of microbial contamination of food,

in the context of South Africa as a developing country, will support accurate health risk assessment and subsequent community health management.

Estimated cost: R6 219 200 (incl. leverage)
Expected term: 2009 - 2015

Scoping study on different on-farm treatment options to reduce the high microbial contaminant loads of irrigation water to reduce the related food safety risk
University of Stellenbosch (Department of Food Science)
No. 2174

There is an urgent need for research into possible on-farm treatment options to help reduce the high levels of microbial contamination in irrigation waters and thereby reduce the associated food safety risk to consumers. Of primary concern during such treatment is the reduction of pathogens in the irrigation water, and that the treatment process be financially feasible and technically appropriate and robust. Over the past few years it has been established that many of the South African rivers that are drawn from for agricultural irrigation purposes are carrying extraordinarily high pathogenic loads; some of the products irrigated by this water are minimally processed foodstuffs or products that are consumed raw. The WRC projects A quantitative investigation into the link between irrigation water quality and food safety (K5/1773//4)' and 'An investigation into the link between water quality and microbiological safety of fruit and vegetables from the farming to the processing stages of production and marketing (K5/1875//4)' have clearly demonstrated the extent of the problem in terms of geographic distribution and the high microbial loads in rivers used as irrigation water sources. Several risks have been identified when polluted water is used for crop irrigation. Risks can be short-term and range in seriousness, depending on the potential contact with humans, animals and the environment. No irrigation water contaminated by untreated or poorly-treated faecal waste is risk-free. The purpose of this scoping study is to explore alternative on-farm treatment options that can reduce this risk. Emphasis will be placed on technical and financial feasibility and determining the priorities and scope for further research.

Estimated cost: R2 250 000 (incl. leverage)
Expected term: 2012 - 2016

Evaluation of the risks associated with the use of rain-water, harvested from roof tops, for domestic use and homestead food gardens; and groundwater for domestic use and livestock watering
University of Pretoria (Department Microbiology and Plant Pathology)
No. 2175

Harvesting rainwater from rooftops is an ecologically-friendly alternative approach to addressing the country's critical water shortages. Water collected in this manner can address domestic water shortage and provide irrigation

water for home gardens. Prior to promoting rooftop water harvesting, it is essential to determine the potential level of microbiological and chemical risks associated with such water collection systems. Water collected in this manner is also commonly stored in large plastic containers using well-known brands such as Jo Jo. The ability of microorganisms to proliferate in such water storage systems has been well documented. The quality of such harvested and stored water is however, not well known. In general, dust, bird droppings, chemical leachates from the roof material, adhesives and coatings, etc., may be washed down from the roofs after heavy rain storms with the result that this water will be collected in the storage water unit posing a potential risk for the consumer. Water quality may thus be compromised by the water collection approach. In addition, biofilms may develop in the storage unit and may further compromise the water quality. This is of particular importance since it is known that waterborne pathogens may survive, proliferate and shed into the waterways thereby contributing to the contamination risk. While the quality of groundwater varies significantly from one area to another, available research results (WRC Report 1175/1/06) to assess the risk of groundwater for use in domestic consumption as well as livestock watering has to be refined and updated. By understanding the risks associated with roof-top harvested rainwater and groundwater, improved usage of these valuable resources can be made. Through improved intervention strategies, guidelines and regulations, basic public health issues can be managed and exposure to contamination prevented.

Estimated cost: R2 750 000 (incl. leverage)
Expected term: 2012 - 2016

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Water use and economic value of the biomass of indigenous trees under natural and plantation conditions
CSIR Natural Resources and the Environment
No. 1876

Specific findings, recommendations and gaps in knowledge regarding the water use efficiency (WUE) and economic potential of indigenous tree systems were identified in a previous WRC project (K5/1462) which was finalised in March 2008. These included the need for improved understanding of the WUE of a wider selection of indigenous tree species growing under a range of bio-climatic conditions in South Africa. This information is needed to explore the possibility of expanding and growing the local forestry industry using indigenous tree species. Potential benefits of this expansion include the expected lower water use rates of indigenous species, and the high economic value of biomass products. Furthermore, it is important to place the water use of exotic commercial plantations in perspective, through

comparisons with indigenous tree-production systems. There is also a need to establish a baseline water use by indigenous trees under natural conditions to facilitate the evaluation of likely water resource changes associated with a change in land use. Improved knowledge in these aspects will contribute to improving or enhancing rural livelihoods through the use of indigenous tree-production systems. In addition, possibilities exist to provide alternative wood-production systems to replace alien invasive plants, as the process of alien plant eradication continues. Ultimately, the research output should enable formulation of recommendations regarding the use of indigenous natural and plantation tree systems, with emphasis on WUE, site-species matching and economic viability to support sustainable rural development.

Estimated cost: R6 799 100 (incl. leverage)
Expected term: 2009 - 2015

Rehabilitation of alien-invaded riparian zones and catchments using indigenous trees: An assessment of indigenous tree water use
University of Pretoria (Plant Production and Soil Science)
No. 2081

Much of the tree water use research is based on forest hydrology and has focused on exotic tree species and their impacts on streamflow. In order to support the Government's rural tree programmes, there is a need to expand current research to include the water use of indigenous trees used in forest expansion, the rehabilitation of degraded lands and the restoration of riparian zones. One of the biggest problems with current rehabilitation programmes is that exotic species (e.g. vetiver grass) are used to restore the ecosystem services (e.g. water production and reduced soil erosion). However this ignores the importance of ecosystem structure and functioning (e.g. biodiversity). Research and policy support in South Africa is required to promote and scale-up indigenous tree planting and growing initiatives in degraded areas and riparian zones. The impact of expanding the use of indigenous trees to catchment hydrology is of critical importance in a water-scarce country. It is therefore important to understand the plant water use (transpirational changes) brought about by introducing indigenous trees into degraded landscapes and alien-cleared riparian zones. There is a widespread belief in South Africa that indigenous tree species, in contrast to the exotic trees, are water-efficient and should be planted more widely in land restoration programmes. This is based on observations that indigenous trees are generally slow growing, and that growth and water-use are broadly linked. However, tree water use is technically difficult and expensive to measure, and so there is scant evidence of low water-use by indigenous trees. This is even more so for pioneer tree species more suited to the rehabilitation of degraded lands and those found re-colonising riparian zones previously invaded with exotic trees (e.g. wattle). This study will therefore focus on determining the water use of potential indigenous, pioneer tree species suitable for rehabilitation programmes.

Estimated cost: R4 900 000
Expected term: 2011 - 2016

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Baseline and scoping study on the development and sustainable use of storage dams for inland fisheries and their contribution to rural livelihoods
Rhodes University (Department of Ichthyology and Fisheries Science)
No. 1957

In South Africa the potential of inland fisheries, which exists in the form of hundreds of water impoundments or storage dams throughout the country, is largely underdeveloped and underutilised. With exception of traditional practices in e.g. specific regions of KwaZulu-Natal and Limpopo Province, there is no culture of fish consumption in rural areas, despite the fact that fish is one of the best sources of protein. Due to the decline of production of marine fish stocks (which has been caused by overfishing) and a higher demand for fish, the price of fish is increasing. With increase in demand, the development and use of water resources in storage dams for inland fisheries have the potential to contribute to uplifting rural economic activity. There is a need for government interventions to formulate policies and strategies that support inland fisheries. These inland fisheries encompass community-managed subsistence fishery, commercial fishery and recreational fishery. The links between hatcheries, aquaculture and inland fisheries, such as culture-based fisheries, and the stocking of small farm dams and large storage dams, also needs to be explored. Inland fisheries can thereby create a fairly large support base for job creation, skills development and poverty reduction at a local level. Sustainable use of water resources with inland fisheries requires appropriate institutional arrangements, organisational structures and governance systems, for the application of technologies, management of water resources and service delivery to be successful. In this baseline and scoping study the current situation regarding water use for inland fisheries will be documented. Contributions will be made to formulate strategies for future development. The gaps in knowledge and priorities for further research will be identified.

Estimated cost: R4 000 000 (incl. leverage)
Expected term: 2010 - 2014

Empowerment of women through water use security, land use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas of, amongst others, Limpopo Province
University of KwaZulu-Natal (Agriculture Sciences and Agribusiness)
No. 2082

Although the South African Constitution enshrines gender equality, women in rural areas experience a lack of water use security and lack of knowledge to achieve food security. Lack of water and land use security refers to physical,

legal and tenure insecurity while lack of food security implies insufficient access by all people at all times to enough food for an active and healthy life. Empowerment of women through secure access to water and land, as well as by obtaining knowledge and developing skills must receive priority attention. This will provide the necessary incentives to take ownership of the process of productive use of water to achieve food security and improve rural livelihoods. Research is therefore required to bridge the divide between the abovementioned current reality and Government policy intentions. This research must improve the understanding of social dynamics at the household level that impact on the empowerment of women and attainment of sustainable food production. It includes better understanding of institutional and organisational impediments affecting the decision making powers of women. Better understanding of what impact land reform and rural development policies have on women is of specific importance. This will lead to better understanding of the contradiction between actual poverty, under-nourishment, food insecurity, etc., on the one hand, and the observed under-utilised land and water resources at local level in rural areas on the other. Finally more empirical information must be documented on the existing and required knowledge, as well as skills, for empowerment of women to take decisions which are affecting their immediate environment.

Estimated cost:	R3 000 000
Expected term:	2011 - 2015

Empowerment of women through water use security, land use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas of, amongst others, the Eastern Cape Province
Umhlaba Consulting Group (Pty) Ltd
No. 2083

Although the South African Constitution enshrines gender equality, women in rural areas experience a lack of water use security and lack of knowledge to achieve food security. Lack of water and land use security refers to physical, legal and tenure insecurity while lack of food security implies insufficient access by all people at all times to enough food for an active and healthy life. Empowerment of women through secure access to water and land, as well as by obtaining knowledge and developing skills must receive priority attention. This will provide the necessary incentives to take ownership of the process of productive use of water to achieve food security and improve rural livelihoods. Research is therefore required to bridge the divide between the above-mentioned current reality and Government policy intentions. This research must improve the understanding of social dynamics at the household level that impact on the empowerment of women and attainment of sustainable food production. It includes better understanding of institutional and organisational impediments affecting the decision making powers of women. Better understanding of what impact land reform and rural development policies have on women is of specific importance. This will lead to better understanding of the contradiction between actual poverty, under-nourishment, food insecurity, etc. on the one side and the observed under-utilised land and water resources at local level in rural areas on the other. Finally, more empirical information must be documented on the existing and required knowledge as well as skills for empowerment of women to take decisions which are affecting their immediate environment.

Estimated cost: R3 000 000
Expected term: 2011 - 2015

Empowerment of woman in rural areas through water use security and agricultural skills training for gender equity and poverty reduction in KwaZulu-Natal and North West Province
North West University (Department of Agricultural Economics and Extension)
No. 2176

In rural areas land is available, and the high unemployment rates, generally ranging from 30 to 40%, suggest the availability of labour to practise agriculture. Whilst financial and infrastructure support for resource-poor farmers in rain-fed and irrigated agriculture is clearly required, investment in social and human capital, i.e., trust among people, clear property rights, the rule of law, education and skills development are equally important. Secure water use entitlements and land tenure are essential to provide incentives for enabling the poor to increase productivity of natural resources. A report to guide policy in Eastern and Southern Africa published by IMAWESA, recognized that meeting the agricultural water management challenge requires five key actions. These include providing secure rights to land and water and developing human capacity. A key feature for sustainable rural productivity will clearly be to develop capacity of the principal users of the land who are women. It has been reported that women constitute 70% of the agricultural labour force and are the main food producers for rural households in South Africa. However, there is sufficient evidence to suggest that poor rural women are considerably more disadvantaged than poor rural men because of an explicit gender bias in land allocation, access to credit, access to rural organisations, marketing channels and agricultural services in general. Women living in traditional rural areas form part of the most economically and socially disempowered groups in South Africa. This project focuses on the skills and training needed by rural women in order to sufficiently equip them to address the challenges of food insecurity and poverty. Although reports on agricultural training and skills development are widely available and have been well documented, very few, if any, are specifically tailored to meet the skills and training requirements of women in rural areas within cultural and traditional realities. The project will identify skills required by women in agriculture (farming and non-farming activities within the food value chain) but will not develop training guidelines.

Estimated cost: R3 000 000
Expected term: 2012 - 2016

Up-scaling of rainwater harvesting and conservation on communal crop- and rangeland through integrated crop and livestock production for increased water use productivity
Institute of Natural Resources (Department of Sustainable Agriculture and Food Security)
No. 2177

Sustainable crop-livestock systems can support the majority of poor members of rural communities. Rainwater harvesting techniques and practices in these systems have the potential to improve the livelihoods of these

communities. Many rainwater harvesting techniques have been tested and are proven to be effective, but their successful application in rural areas for crop-livestock systems is limited. Clearly, correctly designed institutions and organisations are required to support the application of rainwater harvesting techniques by individuals and groups in communities. Conflict that often exists between livestock owners and crop farmers usually leads to low or no production. By clarifying the production potential and rules that determine access to resources, solutions can be found to resolve conflicts. Production systems should be geared towards optimising both crop and livestock production and exploiting the synergies between the two. By up-scaling from the homestead food garden to the croplands and rangelands, opportunities are created to increase production and move from subsistence to profitable levels of farming. In an uncertain environment, interventions such as rainwater harvesting for crop-livestock water use productivity can bring resilience to the system. However, the integrated functioning of the crop- and rangeland system is not well understood. There is also a lack of knowledge of livestock water use productivity in rural areas since livestock have mainly been kept for cultural reasons, whilst demand for livestock products has increased. The challenge for research is therefore to adapt or develop technologies and practices which will improve land productivity whilst enabling water conservation in rain-fed agricultural production on dry-lands and rangelands. Participatory action research should be undertaken to demonstrate that higher crop and livestock water use productivity at lower risks is achievable.

Estimated cost:	R2 864 465
Expected term:	2012 - 2016

Programme 2: Integrated water management for profitable farming systems

Analysis of food-value chains in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy
University of KwaZulu-Natal (Institute of Natural Resources)
No. 1879

The inclusion of subsistence and emerging farmers in the mainstream of the economy is a nationally identified priority. Structural and cyclical obstacles must be overcome to accomplish this. These are mainly the dualistic nature of the agricultural economy and the recent occurrence of food shortages with high input costs. Although expectations are high for subsistence farmers to enter the market, experience shows that technical and business skills are required to obtain access to assets in agriculture by entering food-value chains. With high poverty levels and increasing unemployment, there is also a need to ensure growth with equity and therefore impacting on a wider group of people to promote rural economic development. Achieving this is a real possibility, since on the demand side there are different value chains, with consumers demanding food in different marketing outlets. On the supply side there are a large number of rural inhabitants, which includes groups who can be broadly categorised as subsistence, emerging and commercial farmers, who can potentially respond and enter any one or a combination of these value chains.

The productive use of water in the value chain for both rain-fed and irrigated food production is of particular importance. The project will investigate factors such as needs and aspirations, technical capabilities, risks of crop production, food price expectations, water use security and incentives to increase water productivity which influence the decision of what value chain to enter and the degree of success obtained. The report will highlight innovative ways to promote integration of subsistence, emerging and commercial farming in food-value chains for crop and animal products with use of rain- and irrigation water.

Estimated cost: R2 999 989
Expected term: 2009 - 2014

Investigation of water conservation in food value chains by beneficiaries of water allocation reform and land reform programmes in South Africa
CSIR (Water Resources Governance System)
No. 1958

The Water Allocation Reform Strategy of the Department of Water Affairs and Forestry (2008) states that by 2014, 30% of allocable water should be to the benefit of Black people. By 2024 the target is 60%, of which half should be under control of black women. Indications are, however, that so far very few water use entitlements have been awarded and/or taken up by individuals or groups of black emerging farmers. Evidence is also increasing that most water allocation reform and land reform projects are not leading to sustainable development. For establishment of commercially-oriented black farmers, the support services need to be substantially improved. These include access to finance and markets, better local organisation, improved management training and provision of extension services. Food value chain analysis is an appropriate basis for determining the requirements for integrating subsistence, emerging and commercial farming enterprises. There are different approaches for this analysis and in practice value chains vary in complexity. Food value chains essentially are the different stages for the production, marketing and distribution of goods and services. Important participants are value chain players (e.g. farmers, processers, retailers); influencers (e.g. regulators of food safety and trade); and supporters (e.g. providers of information and training). Within the embeddedness of a particular set of societal norms, the structure, conduct and performance of value chains can be analysed in combination with institutional arrangements, governance systems and resource allocation. In the South African context of water allocation reform, this approach should be applied and tested. The research input will show how black emerging and white commercial farmers can be integrated and productivity of water use can be increased through value adding in the food chain. Recommendations will be made to give support and direction to successful implementation of the Water Allocation Reform Strategy and enable meeting of the set targets.

Estimated cost: R3 000 000
Expected term: 2010 - 2014

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Eastern Cape Province
University of Fort Hare (Department of Agricultural Economics and Extension)
No. 2178

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued (Sunter, 2011) that, for a balanced economy, both an outward and inward focus is required. The last mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The millennium development goals also require reduction in poverty levels and empowerment of women. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows for negotiating higher prices and improving operating margins. For this purpose ways must be found to enable more productive farming practices, and more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost:	R1 950 000
Expected term:	2012 - 2016

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Limpopo Province
Umhlaba Consulting
No. 2179

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued (Sunter, 2011) that, for a balanced economy, both an outward and inward focus is required. The last mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should

therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The millennium development goals also require reduction in poverty levels and empowerment of women. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows for negotiating higher prices and improving operating margins. For this purpose ways must be found to enable more productive farming practices, and more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost: R1 950 000
Expected term: 2012 - 2016

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Methodology to monitor the status of water logging and salt-affected soils on selected irrigation schemes in South Africa
ARC (Institute for Soil, Climate and Water)
No. 1880

Major capital investments have been made in irrigated areas of South Africa. Declining productivity due to salinisation will have an impact on individual farms and the sustainability of food production is potentially threatened. Therefore, it is important to monitor degradation and plan rehabilitation at scheme level. Since the late 1980s no national effort has been made to quantify the extent of water logging and salt accumulation across irrigation schemes. Indications are that water quality is declining and these problems are actually escalating. In order to identify soils for drainage and reclamation, the extent of water logging and salt accumulation has to be determined. National monitoring of water logging and salt accumulation is a high priority but currently no verified methodology is available to undertake this task. Data of soil conditions for different irrigation schemes is located at different organisations and the ARC-ISCW needs to be supported to act as custodian of baseline soils data. The GIS database and mapping is a new tool that is available for national application with the Agricultural Information System (AGIS). The general aim of this project is to

develop and test a methodological approach for identification, classification and monitoring the extent and degree of water logging and salt accumulation at scheme, farm and field level. Guidelines will be produced for application at national scale which will ensure sustainable utilisation of soil and water for irrigation.

Estimated cost: R3 693 800
Expected term: 2009 - 2015

Development of technical and financial norms and standards for drainage of irrigated lands
ARC (Institute of Agricultural Engineering)
No. 2026

The extent and severity of drainage problems on irrigation schemes in South Africa is clear from the fact that an estimated 242 000 ha is affected by rising water tables and salinisation. These problems appear to be expanding and indications are also that costs of drainage have increased quite significantly. Apart from isolated projects which were undertaken for specific reasons, no comprehensive research on drainage has been done in South Africa over the past 25 years. Existing norms and standards have been adjusted over the years by means of ad hoc studies. There is evidently a need to revise and publish up-to-date norms and standards. New ways of managing drainage should be introduced instead of having only a narrow focus on the presently-known solutions. Irrigation, surface run-off and sub-surface drainage are all related and need to be managed as a whole. It is essential to distinguish between requirements and standards for design, installation, operation and maintenance of drainage. The internationally available research results and modelling approaches will be assessed and evaluated for applicability in South Africa. The demand for design and installation of drainage in the field by far exceeds the available capacity. Timing is critical because only a very small group of experts is still active in the field and there is an urgent need to train new practitioners. This report will form the basis for training at tertiary level and for providing guidance to practitioners. The research output will form the basis of informing public policy formulation and strategies for implementing drainage systems on irrigation schemes.

Estimated cost: R4 000 000
Expected term: 2010 - 2015

Programme 2: Impact assessment and environmental management of agricultural production

Impact of wastewater irrigation by wineries on soils, crop growth and product quality
ARC (Infruitec, Nietvoorbij)
No. 1881

The Department of Water Affairs is considering the issuing of a general authorisation (GA) for the irrigation of

agricultural crops, e.g. vineyards, with treated and augmented winery wastewater. This GA entails that the wastewater be treated to a specified quality standard, before storage in irrigation dams and mixing with raw irrigation water. In order to attain the specified wastewater quality standards, it is envisaged that wineries will adopt cleaner production approaches and replace chemicals that are detrimental to soils and crops with chemicals that will produce a wastewater rich in essential plant nutrients. Irrigation with the wastewater would thus be comparable to fertigation. While the effects of most of the winery constituents on soils and crops are fairly well known and their effect on soils and crops can thus be predicted with a fair degree of confidence, the same cannot be said for the organic content of wastewater, as measured by its chemical oxygen demand (COD). This project will consequently investigate the sustainable use of winery wastewater for irrigation of vineyards with respect to the effect it will have on soils, vineyard performance and wine quality. While the study will focus specifically on the effect of COD, it will also consider the effect of salinity, pH, sodium adsorption ratio (SAR), nitrogen, phosphorus and potassium contained in the wastewater. The research output will promote the beneficial reuse of winery wastewater, and the reclamation and protection of soil and water resources. This will inform legislation on wastewater management regarding regulations that promote the beneficial use of wastewater for productive purposes and lead to improved industry guidelines and practices for managing winery wastewater.

Estimated cost: R3 500 000
Expected term: 2009 - 2014

Adaptive interventions in agriculture to reduce vulnerability of different farming systems to climate change in South Africa
University of Cape Town (Climate Systems Analysis Group)
No. 1882

South Africa has a high risk agro-hydrological environment which is likely to be exacerbated under conditions of climate change. It is widely recognised that ongoing changes in climatic conditions will generally have an adverse effect on, amongst others, agricultural production, biodiversity and water resources. Agriculture is a key sector in the economy with regard to rural livelihoods and food security and it is therefore vital to proactively access potential impacts of climate change on this sector. The National Disaster Management Framework of South Africa, a legal instrument specified by the Disaster Management Act, No 57 of 2002 recognises a diversity of risks and disasters that occur in Southern Africa, and gives priority to developmental measures that reduce vulnerability of disaster-prone areas, communities and households. In addition, the National Climate Change Response Strategy for South Africa, compiled in 2004, aims to address issues identified as priorities for dealing with climate change in each sector in the country. These documents informed the recently completed Climate Change Sector Plan for Agriculture compiled by the Department of Agriculture. The plan seeks to address institutional arrangements, vulnerability assessments, adaptation and mitigation as well as response and recovery of the agricultural sector as a result of climate change. Research related to vulnerability and adaptation is identified in the plan as a priority. There is a lack of integrated knowledge regarding the vulnerability of agriculture in terms of climate change and water availability. The project aims to investigate the impact of projected climate change on agriculture; assess the vulnerability of crops, rangelands and

farming households and enterprises; identify and suggest appropriate adaptive techniques and practices in selected catchments and farming areas. The report will provide an assessment of the vulnerability of different farming systems to climate change. It will evaluate alternative adaptation practices and techniques (indigenous and science-based knowledge) and if necessary develop and test innovative, appropriate and sustainable interventions, including internal management measures and external policy measures.

Estimated cost: R4 300 000 (incl. leverage)
Expected term: 2009 - 2016

Improving the livestock carrying capacity with rainwater harvesting and conservation on grasslands for extensive and/or intensive livestock production and biogas generation from manure in rural areas of South Africa
University of KwaZulu-Natal (Department of Grassland Science)
No. 1955

The majority of households in communal areas are dependent on resources from the local woodlands, grasslands and livestock production. Livestock are a potential asset to rural households because of the opportunities presented for participation in the rural economy. It has been shown that households are eager to keep livestock for the multiple benefits they provide, rather than for exclusively social status. One potential benefit is livestock as a source of manure for biogas production. Biogas technology, in its simplest form, involves the use of digesters that are vessels in which animal waste and other biodegradables are broken down (digested) by bacteria in the absence of oxygen. In particular livestock manure must be collected, transported and stored for the biogas digester. Therefore it is important to consider how livestock will be managed with reference to rotational grazing on the commons, keeping livestock in a kraal overnight near the village and utilising manure from the kraal for biogas digesters at household or village scale. These household or village scale biogas digesters require access to water; therefore rainwater harvesting tanks will need to be constructed. Biogas generation as an energy source for cooking, heating, cooling and lighting can play an important role in improving the quality of life for rural households. It is a single intervention that directly addresses energy insecurity, and indirectly through liquid fertiliser also food security, at the household garden level and thereby reduces vulnerability of the poor. By linking biogas generation to manure management and rainwater harvesting, this research report will make an innovative contribution and fill a major knowledge gap.

Estimated cost: R5 000 000
Expected term: 2010 - 2015

Investigation of the contamination of water resources by agricultural chemicals and the impact on environmental health
CSIR (Natural Resources and the Environment)
No. 1956

Agricultural activity is potentially a source of a number of hazardous chemicals in water resources. Concerns have been expressed that some of the pesticides used in agricultural practice for crop spraying and animal disease control may enter and pollute the rivers and dams and cause endocrine disrupter effects in animals and humans that use the water for drinking and recreational purposes. A scoping study (WRC Report No. 1774/1/08) indicated that there is no clarity on the extent and level of contamination of water resources by agricultural products with ED (endocrine disrupting) properties. However, a number of WRC studies have been done identifying different chemicals in different areas that are hazardous as well as having ED properties. Some studies identified EDCs in water resources and indicated ED effects in sentinel species in and around contaminated water resources. Most of these studies in South Africa are not specifically focused on the link between the chemicals used in agricultural practices and the impact on human health with water as a pathway. This research report will document the impact which agricultural chemicals have on human and animal health. Guidelines will be compiled for South African authorities to direct the safe use of agricultural chemicals in water resource management.

Estimated cost: R4 109 825 (Incl. leverage)
Expected term: 2010 - 2015

Insights into indigenous coping strategies to drought for drought adaptation in agriculture: The Southern Cape scenario
Cape Peninsula University of Technology (Centre for Water and Sanitation Research)
No. 2084

Drought is a normal, recurrent feature of South African climate. In the past, droughts have resulted in significant economic, social and environmental impacts on the country. South Africa will continue to experience droughts and the likelihood of serious drought is greater with climate change. In the Western Cape Province, for example, climate change projections indicate that the province can expect less rainfall, particularly to the eastern parts of the province. Thus the future climate change projections mentioned indicate that droughts will become a more regular phenomenon. The Southern Cape is the area most vulnerable to such extreme events and therefore the area of investigation. To develop drought preparedness strategies it is critical to capture local experiences. There have been limited studies capturing indigenous local knowledge of the impacts and experiences of past and current droughts in South Africa. Completed studies recommend three groups of drought mitigation measures –supply-orientated, demand-orientated and minimisation of impacts and losses. However, these coping strategies and mitigation measures are not concerned with local practices, and certainly do not incorporate indigenous knowledge and practice. In any case, these concern drought experiences of two to three decades ago. It is therefore critical that the experience of the current drought in the Southern Cape be captured to adequately prepare and mitigate against future anticipated droughts in the region. The research is intended to capture and assess local coping strategies and experiences of a current drought within the agricultural sector to inform preparedness planning for future droughts. In this respect the research would contribute to an indigenous knowledge base for informing mitigation and preparedness planning in both disaster risk management and climate change adaptation for the agricultural sector.

Estimated cost: R812 000 (incl. leverage)
Expected term: 2011 - 2014

NEW PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water footprint of selected vegetable and fruit crops produced in South Africa
University of Pretoria (Plant Production and Soil Science)
No. 2273

The vegetable and fruit industries are highly dependent on the availability of irrigation water and are clearly responsible for significant freshwater consumption. Numerous studies have evaluated irrigation practices and water use by horticultural crops in the country. Information is lacking on the long-term production and water consumption patterns at regional and industry scales over the entire agri-food production chain from field to fork. Standard methodology to calculate water footprints was recently published by Hoekstra et al. (2011). According to this methodology, water footprint assessments consider both the direct and indirect water consumption and pollution of a consumer or of a product. Blue-, green- and grey-water footprints make up the total water footprint, and temporal and geographic components are included. Blue water refers to surface and groundwater available to multiple users, green water is water originating from rainfall that is stored in the soil and available for vegetation growth only, and grey water refers to the volume of water required to dilute emitted pollutants to ambient levels. Generally, blue water is scarcer and has higher opportunity costs, meaning that irrigated crops with lower ratios of blue to green water consumption are viewed more favourably. Detailed water footprint assessments using standardized, state-of-the-art methodology for important vegetable and fruit crops is essential to: (i) enable regional-scale integrated water resource management and drive policy formulation, (ii) better understand the water-related risks to the production of vegetables and fruit in the country, and (iii) facilitate the identification of opportunities for reducing water use within the production chain to ensure the sustainability of these industries.

Estimated cost: R2 750 000
Expected term: 2013 - 2017

Determining water use of indigenous grain and legume food crops
University of KwaZulu-Natal (Crop Science)
No. 2274

Completed and ongoing WRC-funded research work (Projects K5/1579//4 and K5/1771//4) to determine water use has mainly focused on African indigenous vegetable crops. There is, however, recent evidence of knowledge gaps on water use, agronomic practices, etc., of indigenous legume and grain crops. The indigenous grain and legume crops include grain sorghum, maize landraces, cowpeas and Bambara groundnuts. Furthermore, limited research results on water use are available and little crop water use modelling has been done on these crops. There is clearly a need for research-based knowledge on water use which will contribute to higher production, water use productivity and food security. More research is required on these neglected crops to better inform farmers and extension officers of appropriate management practices. Quantifying water use should therefore be done for combinations of indigenous crops (such as grain sorghum, maize landraces, cowpeas and Bambara groundnuts) by means of intercropping or crop rotations in comparison with intercropping or crop rotations of conventional crops (such as hybrid maize, dry beans, green peas and groundnuts). This will make it possible to broaden the crops and products in the food basket for consumption in a more balanced diet of starch and protein for rural household members. In addition, this knowledge of water use will provide opportunities to prepare for the challenge of climate change by adapting agronomic practices and cropping systems, thereby preventing detrimental livelihood impacts. Higher production and supply of indigenous grain and legume food crops will enable storage and inter-seasonal transfers, to specifically bridge the gap in nutrition during late winter and early spring. From a perspective of rural development there is also the potential of processing and value-adding in the food value chain of these crops. As a whole it is therefore imperative to better understand the water use of indigenous grain and legume crops in the context of intercropping, to improve the fertility of the soil, and of producing food crops which combine staple grains with legumes as protein sources.

Estimated cost:	R2 750 000
Expected term:	2013 - 2017

Quantifying citrus water use and water stress at tree and orchard scale
Citrus Research International
No. 2275

Citrus is the largest exporter in terms of volume and one of the largest in terms of the earning of foreign exchange, with more than 100 million 15 kg cartons exported annually. The 58 000 hectare citrus industry provides more than 100 000 jobs that support more than 600 000 people, but the whole industry is dependent on irrigation. Citrus is a perennial crop which requires a constant supply of water in order not to limit yields and returns on investment. Due to climate change, established production areas are likely to become drier, which will place increasing pressure on water resources and irrigation management to maintain productivity. An ongoing WRC research project (K5/1770//4) is using a sap-flow technique to quantify water use of mature citrus, deciduous fruit and nut tree cultivars under

best management practices. Initial findings indicate results that are contrary to expectations, specifically for citrus. In addition an external international review recommended more in-depth research to first validate measuring techniques; and secondly to quantify water use for different growth stages for different cultivars. The more detailed research must investigate water use over seasonal growth stages, from planting to mature canopy size, and water stress in relation to fruit yield and quality. In order to provide effective advice to both established and emerging commercial farmers on irrigation methods and scheduling, accurate knowledge is required on water use.
The emerging commercial farmers, who comprise approximately 300 of the 2 700 citrus growers and who are supported by the industry through bursaries, mentoring and extension, are especially in need of this information.
All citrus fruit producers are faced with a major challenge in maintaining high yields per hectare and fruit quality whilst simultaneously achieving viable returns and ensuring sustainability. Given the increase in competition for water between irrigation agriculture, secondary industry and domestic water use, more knowledge is required on citrus water use for growers to remain competitive and justify future production.

Estimated cost:	R2 750 000
Expected term:	2013 - 2017

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Knowledge transfer on water quality management for improved integrated aquaculture and agriculture systems
University of Stellenbosch (Aquaculture)
No. 2276

South Africa has a large number of irrigation dams and networks that can potentially be used for integrated aquaculture–agriculture practices. Many of these water resources have not realised their potential. The challenge remains how Government can provide support to develop the aquaculture sector, particularly in rural and peri-urban areas. The perception is that farmers are not effectively engaged or strategically supported. Research-based knowledge is available on water quality management in farm irrigation dams and extension manuals have been developed. However, it is not fully understood how much of the knowledge is sufficiently interpreted and successfully applied. Access to technology is one of the major constraints for small businesses development in South Africa. It is further elaborated that much of the available knowledge does not reach household and producer level. In order to determine the development agenda, technology transfer from the source to the receiver needs attention. Technology transfer was most successful when conducted at a time when people had a specific need for it in their projects. During this process, engagement with the farmers is a crucial element for success. To achieve successful technology transfer, the following elements must be understood:

- What information is available to aquaculture and agriculture and how it is disseminated
- What media/modes are used by the farmers to access information

- In what ways is accessed information utilised
- What are the constraints to information routes at farmer/producer level
- What thinking/rational processes drive information prioritising
- How much of successful farming practice is based on existing and new knowledge
- What are the cost implications of information dissemination

Estimated cost: R1 950 000
Expected term: 2013 - 2017

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Action-oriented development of a strategy for knowledge dissemination and training for skills development of water use in homestead gardening and rainwater harvesting for cropland food production
Umhlaba Consulting (Pty) Ltd
No. 2277

Household food security in South Africa remains a national challenge with an estimated 59% of 13.7 million households being food insecure, with hunger and chronic malnutrition being widespread within this group. Yet, present utilisation of available land and water resources for smallholders (0.5-10 ha), both in home-gardens and fields remain low. As it is women who are responsible in the majority of cases for farming decisions, they are a key group to target in initiatives aiming for increased crop-production and food-security. There is a substantial body of training information in the public domain which responds to the multi-faceted crop-production challenges faced by small growers. Two recent WRC research products are prioritised; one targeting homestead food production and the second water-harvesting and conservation techniques. In addition, there are other potentially useful publications for use in knowledge mediation processes. These include, for example, WRC grey-water re-use guidelines and in-field rainwater harvesting manuals. The challenge of achieving impact from research outputs is a global one; and is related to what is now recognised as inadequate Research-Develop-Disseminate-Adopt (RDDA) assumptions of how knowledge is/ought to be mediated in society. Contemporary theories of learning and change indicate that for knowledge or information to become meaningful, there is a need for the information to be related to the situation and experience of the user; and also to provide new knowledge or information that can expand existing knowledge and/or practice. The choice of strategic approach to achieve effective knowledge dissemination and uptake to transform available knowledge into productive practices will be determined by those opportunities that unfold during

the project, including consultations with both learning organisations and mass-media organisations (TV, radio etc.), and feedback with homestead gardeners and smallholder farmers.

Estimated cost:	R1 950 000
Expected term:	2013 - 2017

Programme 2: Integrated water management for profitable farming systems

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in KwaZulu-Natal and North West Provinces
University of KwaZulu-Natal (Agriculture Sciences and Agribusiness); African Centre for Food Security
No. 2278

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued that, for a balanced economy, both an outward and inward focus is required. The last-mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows negotiating higher prices and improve operating margins. For this purpose ways must be found to enable more productive farming practices, more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes, where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost:	R1 950 000
Expected term:	2013 - 2017

The optimisation of electricity and water use for sustainable management of irrigation farming systems
University of the Free State (Department of Agricultural Economics)
No. 2279

Electricity tariff structures have changed over the years, while electricity rates have recently escalated considerably and are expected to continue increasing in future. This requires a change in design norms and standards as well as a shift in emphasis to life-cycle cost evaluation. This subject was last formally researched more than 10 years ago, with publication of a report in 2002 (WRC Report No 894/1-4/02), followed by technology transfer activities (WRC Report No 274/05). This research output clearly needs to be revised and guidelines must be updated. Over the intervening years, new technologies have become available, such as variable speed drive (VSD) and energy-efficient motors (with a new classification system). Better engineering practices for pumps, including auto-restart and remote control, have led to increased accuracy and energy efficiency. It is therefore essential to evaluate and compare different technologies on the basis of efficient energy/power use and operating cost over the life cycle of the irrigation system. In addition, better automatic weather stations are accessible and convenient irrigation scheduling techniques, such as continuous logging probes with telemetry, can be applied. This enables more efficient use of water, reduced electricity consumption and higher food production. At the same time there are pressures to reduce the carbon and water footprint, especially for export food markets. In so doing, costs must be lowered, profitability and competitiveness increased and water use productivity improved. However, farmers need advice and extension based on user-friendly guidelines, in order to respond to these pressures and incentives by changing irrigation practices. These practices that influence electricity power use include determining water use of crops, soil water monitoring, application rates of water, pumping water from the river or storage dam to the field, installing energy-efficient motors, selecting correct pipe sizes, and regular maintenance of equipment, etc. Measurement and verification therefore requires determining the baseline and implementing an information system for management of reduced energy/electricity consumption and optimisation of water use on irrigation farms.

Estimated cost: R1 950 000
Expected term: 2013 - 2017

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Vulnerability, adaptation to and coping with drought: The case of the commercial and subsistence extensive livestock sector in the Eastern Cape
University of the Free State (DiMTEC)
No. 2280

Dry periods and droughts remain the major meteorological factor with devastating impacts on the livelihoods of most rural people in South Africa. The agricultural sector specifically incurs millions of Rands in losses every year.

For example, the direct mean annual loss (MAL) to the extensive livestock sector in the Northern Cape alone is in the excess of R350 million. Little evidence is available of the required adaptations to reduce vulnerability and increase resilience of farming enterprises to natural hazards such as drought. Given the expected increase in these extreme events due to climate change, more research is essential on how vulnerability can be reduced in order to prevent future disasters. The proactive approach towards drought risk management emphasizes the need for coordination and collaboration among all role players. This includes coordination between monitoring agencies in terms of reliable early warning systems, communicated in a comprehensible way to decision-makers, farmers, agricultural businesses and all that have an interest in agriculture. Collaboration at national and provincial level between the Department of Agriculture, Forestry and Fisheries (DAFF) at national level, provincial Departments of Agriculture, National and Provincial Disaster Management Centres (NDMC and PDMC), Department of Water Affairs (DWA), South African Weather Service (SAWS) and others is essential in this regard.

Estimated cost: R2 950 000 (incl. leverage)
Expected term: 2013 - 2017

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