



# KSA 4: WATER UTILISATION IN AGRICULTURE

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## KSA 4: WATER UTILISATION IN AGRICULTURE

### SCOPE

Utilisation and development of water resources in agriculture must be analysed in relation to the needs and requirements of people. People using water in agriculture comprise a diverse group of subsistence, emerging and commercial farmers within the following inter-related sub-sectors of agriculture:

- Irrigated agriculture
- Dry-land agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

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

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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

The research project portfolio for 2012/13 is organised within the following thrusts:

- Thrust 1: Water utilisation for food and fibre production
- Thrust 2: Water utilisation for fuel-wood and timber production
- Thrust 3: Water utilisation for poverty reduction and wealth creation in agriculture
- Thrust 4: Water resource protection and reclamation in agriculture

The scope of the strategic thrusts and programmes within KSA 4 is as follows:

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## THRUST 1: WATER UTILISATION FOR FOOD 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.

<i>Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain- fed and irrigated agriculture</i>	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.
<i>Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture</i>	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.

<i>Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations</i>	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.
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### 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.

<i>Programme 1: Sustainable water-based agricultural activities in rural communities</i>	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.
<i>Programme 2: Integrated water management for profitable farming systems</i>	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.

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## THRUST 4: WATER RESOURCE PROTECTION 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.:

<i>Programme 1: Sustainable water resource use on irrigation schemes and within river catchments</i>	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.
<i>Programme 2: Impact assessment and environmental management of agricultural production</i>	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.

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## BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed funding budget of R27 385 896. The consolidated research project budget for the research portfolio is presented below:

<i>Research portfolio</i>	Approved 2012/13 (R)
<i>Current projects</i>	24 385 896
<i>New projects</i>	3 000 000
<i>Total</i>	27 385 896

## CORE STRATEGY

### Strategic context

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.

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

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of the Medium Term Strategic Framework projects a society in which, inter alia:

- People are united in diversity while appreciating the common interest that binds 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

People-centred research and development for poverty reduction, productive use of natural resources and technology, with competitive growth in agriculture, have been key elements of the core strategy of the KSA, as presented in previous years and again elaborated below.

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.

In South Africa, at most 35% of the economically active population are directly or indirectly dependent on

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agriculture, although this percentage is declining each year. This consists primarily of small-, medium- and large-scale enterprises, which provide employment opportunities for formal and casual labour. Furthermore, 42.7% of the population are rural survivalists with traditional agrarian lifestyles. Estimates also show that 48.5% of the population are living below the poverty line of which 70% are in rural areas. According to the HSRC (2009) about 4.5 million Black people (or 9% of the population) in South Africa participate in agriculture in some form, mainly livestock production. Many of these are involved in low-input, low-output farming activity that provides supplementary food for households. Recent data from various surveys indicates that 52% of households experience hunger and, with a monthly income poverty line of R1 200, 59% of households are food insecure.

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, Water for Growth and Development in South Africa (2008) (Version 7). 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 material income and improve 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,

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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.

With this background it is important to emphasise that the strategic focus of water research in this KSA, which was also found to be relevant by the July 2006 External Institutional Review, continues to be on:

- Increasing the efficiency and productivity of water use for food, forage, fibre and fuel production (i.e. improving the knowledge of biological, technical and economic processes of production)
- Increasing the household food security and profitability of farming and thereby the livelihoods of people dependent on agriculture (i.e., improving the knowledge of management processes by people who are using water)
- Ensuring sustainable water resource use in rain-fed and irrigated areas (i.e., improving the knowledge of natural processes and people-induced impacts of resource use)

### Needs analysis

During 2000 the Presidential Imperative Programme on Integrated Sustainable Rural Development was announced. The goal of the programme is to promote development and improve the quality of life of marginalised groups and communities. The objectives

are to alleviate poverty through enhanced production, productivity, creation of employment opportunities and a more equitable distribution of resources. Outputs which are envisaged include agricultural production systems and sustainable utilisation and management of natural resources and the environment.

At the end of 2001 the Strategic Plan for South African Agriculture was released by the National Department of Agriculture, Agri SA and the National African Farmers Union (NAFU), and is currently being revised. The strategic goal is to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural sector, contributing to a better life for all. This strategic goal is expected to guide all relevant partners in their quest to deliver and implement a range of programmes in accordance with basic premises of, amongst others:

- Fair reward for effort, risk and innovation
- Security of tenure for present and future participants
- The sustainable use of natural and biological resources
- Sound research, science, knowledge and technology systems
- Market forces which direct business activity and resource allocation

The outcomes which are envisaged to flow from successful implementation of programmes include:

- Increased creation of wealth in agriculture and rural areas
- Increased sustainable employment

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- Increased income and foreign-exchange earnings
- Reduced poverty and inequalities in land and enterprise ownership
- Improved farming efficiency
- Improved national and household food security
- Increased investment in agricultural activities and rural areas

One of the three core strategies which are discussed in the strategic sector plan for agriculture is sustainable resource management which also impacts on water systems. Central to this strategy is, inter alia, the promotion of sustainable use of soil and water through increased crop and livestock productivity and intensified farming systems, while farmer participation is a key success factor. Degradation of soil and water resources is considered to be a serious threat and therefore programmes must be designed to overcome the causes of degradation. Such soil and water conservation programmes will focus on areas where there is a reasonable chance of success, as determined by, e.g., available technologies and access to markets, inputs and services.

On a regional level the Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD) (2003) places the focus on land and water management as one of four pillars for priority investment. It is stated that "water and its managed use has been an essential factor in raising the productivity of agriculture and ensuring predictability in outputs. Water is essential to bring forth the potential of the land and to enable varieties of both plants and animals to make full use of

other yield-enhancing production factors. By raising productivity, water management (especially when combined with adequate soil husbandry) helps to ensure better production both for direct consumption and for commercial disposal, thereby enhancing the generation of economic surpluses which are necessary for uplifting rural communities".

A call is made for increased investment in land and water and the point is made that "protecting and improving water and the soil makes good business sense". It is indicated "that by enabling a rapid increase in production, irrigation can make food more readily available but that its impact on reducing hunger depends on appropriate arrangements for the poor to have access to irrigated land". The further point is made that "while increased irrigation is not a panacea for all agricultural ills, it nevertheless makes possible other opportunities for agricultural growth such as better husbandry of soils and resources in general, and makes more worthwhile the use of fertilisers, improved plant varieties and upgraded infrastructure".

The Development Report by the DBSA (2005) found that "the poverty problem remains a predominantly rural phenomenon". Furthermore farming still provides "a source of income for many rural communities in South Africa" and therefore contributes to poverty alleviation. This role can be strengthened by investment in the drivers of agricultural development, namely human capital, biophysical capital, rural institutions and agricultural research. The conclusion is "nonetheless, while agriculture plays a major role in poverty alleviation, promoting the growth of smallholder agriculture alone cannot solve the poverty problem in South Africa. More attention should also be given to the promotion of non-farm activities (e.g. agri-industries), particularly those that are linked to the smallholder agricultural sector.

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A strategy that strengthens farm/non-farm linkages is likely to yield better results with regard to employment and income generation”.

In the biannual *Overview of the World Food Situation* by the International Food Policy Research Institute (IFPRI) at the end of 2007 it is stated that renewed attention must be given to agriculture, nutrition and health in adjusting research agendas. Strategies must be directed at poor members of society. In this regard social security measures must be taken that focus on early childhood nutrition, particularly of poor households. With increasing risks caused by climate change, more investments must be made in agriculture to improve productivity. This includes investment in agricultural science and technology to facilitate a production response to rising food prices.

At a conference on Nutrition and Food for Special Dietary Uses, held in Cape Town at the beginning of November 2008, the Minister of Health stated that “food insecurity and high rates of malnutrition, coupled with high food prices, remain the biggest threat to nutrition in Africa”. More research is thus needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices.

Specific recommendations by DWA (2008) to promote water for growth and development of agriculture were: measurement of water; correct scheduling and implementation of appropriate technologies to enhance efficiency and to reduce the amount of water used for irrigation; re-establishment of high-value crops under irrigation in areas where production can be supported on a sustainable basis; revitalisation of irrigation schemes and exploring, developing and using groundwater for small-scale irrigation on household and community food plots; and investment in small projects

for rainwater harvesting and conservation in rural areas.

During 2009 the Minister of Water Affairs raised three key issues which are directly relevant to the KSA: first, the need for incentives, technologies, guidelines and training for rainwater harvesting; second, the need for awareness, knowledge, education, compliance and enforcement to prevent water pollution; and third, the need to disaggregate models and enable intervention at a local level to improve agricultural productivity with climate change under conditions of water stress.

In the 2009 Budget Vote, the Minister of Agriculture, Forestry and Fisheries emphasised the Comprehensive Rural Development Programme (CRDP). This will enable people in rural areas to meaningfully participate in the economy through the productive use of natural resources at their disposal and thereby effectively reduce poverty. Specific mention was made of the need and commitment to train extension officers. Regarding forestry, the Million Trees Programme and Livelihoods Programme encourage the planting of trees and harvesting of firewood, building material, medicinal plants and edible fruit to address the basic needs of the rural poor. It was also stated that the declining fish stocks must be managed by development and sustainable use of natural resources.

The consultation with stakeholders during 2009 highlighted the following priorities which are relevant to the KSA: water security; poverty alleviation; trade-offs between food and bio-fuel production; efficiency of water use and improved measuring tools; the water footprint of agriculture; water shortages and drought; and the impact of climate change.

The review of the strategic plan for **agriculture**, which was completed in 2008, identified a number of concerns: limited capacity within Government, slow

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pace of implementation and inadequate funding for critical programmes, such as food security. In the case of **forestry**, the multiple benefits of woodlands, forests and plantations and their contributions to the economy, society and environment are acknowledged. This requires flexibility to respond to community needs, incorporate water catchment management principles and utilise commercial and other opportunities for woodlands and plantation forestry. For **fisheries**, high demand for access to resources must be balanced with requirements of environmental sustainability, given the opportunities for economic and social development.

For the purpose of Integrated Growth and Development Planning (IGDP) (2010), a range of current realities and challenges are discussed. Amongst others, factors such as the lack of access to land, water, markets, finance, infrastructure, education, skills development and flow of information, will prevent marginalised members of society from making substantive progress in farming, forestry and fisheries across the entire value chain. It is argued that a driver of economic growth of these sectors and the related productivity has been the support provided through research and technology development for water resource management, risk management, natural resource management, seed and cultivar breeding programmes, due to public investment in research and development (R&D). However, existing organisations involved in R&D have major capacity constraints and experience difficulties in acquiring and retaining scientists. It is maintained that R&D projects are not co-ordinated, are not aligned to industry and Government priorities and that inadequate funds have been allocated to R&D.

The vision for the IGDP is 'an equitable, productive, competitive, profitable and sustainable agriculture,

forestry and fisheries sector'. The mission will be developing and sustaining a sector that contributes to:

- Economic growth and development
- Job creation
- Rural development
- Sustainable use of natural resources
- Maintenance of biodiversity and ecosystems
- Sustainable livelihoods
- Food security

One of four sector challenges is environmental/ecological sustainability and the related sector goal is formulated as 'improved, sustainable natural resources management', with specific focus on the protection of scarce and threatened resources, e.g., water, soil and fish stocks. The interventions include recognition of the importance of freshwater systems to the sector and integrating them as a key component of the IGDP. Funding should be sourced for research directed at natural resource issues and conducting cooperative research to address the research implementation gap. In this regard applicable activities are water conservation and water demand management for agriculture, forestry and fisheries, in particular water use efficiency systems for irrigation.

According to the National Planning Report (2011), "science and technology (S&T) are key to development, because technological and scientific revolutions underpin economic advances, improvements in health systems, education and infrastructure." Therefore, access to and application of, knowledge are critical. "S&T are the differentiators between countries that are able to

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tackle poverty effectively by growing and developing their economies, and those that are not. Innovation is the primary driver of technological growth and drives higher living standards. To promote technological advances, developing countries should, amongst others, ensure that knowledge is shared as widely as possible across society." "In societies that have large stocks and flows of knowledge, virtuous circles that encourage widespread creativity and technological innovation emerge naturally, and allow sustained growth over long periods. The investment climate is crucial, as are the right incentive structures, to guide the allocation of resources, and to encourage research and development (R&D). A substantial R&D sector, with support into commercialisation is essential. A well functioning research capacity is critical to sustaining growth and improving productivity. South Africa's competitiveness will rely on national systems of innovation, permeating the culture of business and society. Public policy could focus on R&D in existing areas of competitive advantage, where global markets are set to grow. These include high-volume agriculture and downstream processing." "The national system of innovation, the education system and private industries should create a common overarching framework to address pressing challenges. Special consideration should be given to dedicated programmes in water, amongst others, in which South Africa has both comparative and competitive advantage."

These relevant needs and priorities as expressed by Government, public organisations and stakeholder representatives, at national, regional and international levels, are all receiving attention in the Research and Development Strategy of the KSA. As in previous years, they will guide the selection of topics for expansion of projects in the research portfolio and can be summarised under the following key activities:

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

### Overview of technological trends

In the book *The Necessary Revolution* (2008) it is argued that "previously taken-for-granted aspects of daily life – food, water, energy, predictable weather – seem less and less reliable". The reasoning continues that "if we see each problem – be it water shortages, climate change or poverty – as separate, the solutions will be short-term, doing nothing to address deeper imbalances. The first imbalance concerns nature's capacities to regenerating resources and providing the 'eco-services' upon which human life depends – clean water, breathable air, fertile soil, pollination and a stable climate". It is stated that the "diminishing resources and growing waste underlie a host of economic stresses and reflect environmental and social imbalances that all but ensure that, without significant change, these problems will worsen". Consequently a shift in thinking is required to start a revolution that can transform society. This pre-supposes

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that core capabilities must be acquired of observing and analysing systems in practice, collaborating across disciplinary boundaries and creating a new reality instead of finding opportunistic, 'quick-fix' solutions.

In the KSA explicit efforts will consequently continue to stay at the forefront of new technological developments and promote application of existing technologies. This is achieved by purposefully leading the **innovation cycle**, which involves scientific research, practical application of inventions and exploitation of the commercial potential of the research output to achieve socially and economically beneficial outcomes. A balance must therefore continuously be found between research projects and technology transfer projects and also between research on appropriate technologies for irrigated and rain-fed agriculture.

With a growing demand for water in the domestic and industrial water-use sectors, the competition for water currently used for agricultural production will increase in future. Technologies, models and methods are available to improve the efficiency of irrigation water use in different stages of, e.g., water measurement, canal and on-farm water distribution, field application and irrigation scheduling. With the demand for food also increasing in a globalised trade environment, agricultural production will have to be competitive in both local and overseas markets. While irrigated agriculture contributes 25 to 30% of gross production, technological and managerial innovations are required in all subsectors of agriculture to reduce costs and to increase income.

In particular, attention will continue to be given to rain-fed agriculture and the existing technologies which have been developed for water harvesting in Sub-Saharan Africa. The challenge for research is therefore to adapt or develop and apply technologies which will enable water conservation in rain-fed agricultural production on dry-lands, grasslands and woodlands. In the case

of irrigation, locally available technologies must be integrated and the financial benefit of efficient water use must be demonstrated over all stages of water distribution and application. Emphasis must be placed on making all technologies and models user-friendly. This requires attention to the specific needs of traditional subsistence farmers and modern commercial farmers.

The twofold effort to develop technologies for increased water-use efficiency in both rain-fed and irrigated agriculture is also in support of global trends: As part of the water focus of the World Summit on Sustainable Development (WSSD), the recommended target is to increase water productivity in rain-fed and irrigated agriculture to enable achievement of food security for all people without increasing water use above levels for 2000. Furthermore, one of the four programmes identified within the New Partnership for Africa's Development (NEPAD) initiative is to expand the extent and operation of integrated land and water management, with the main emphasis on the eradication of poverty in Africa. These trends have been reinforced by the Comprehensive Africa Agriculture Development Programme of NEPAD, published in July 2003.

According to the National Agricultural Research and Development Strategy by the Department of Agriculture (2008), a key area for technology development is sustainable natural resource management. The statement is made that: "Farmers maximise income and risk in a dynamic context and often under harsh conditions and serious constraints. Research must respond to these challenges through inclusion of technologies to address sustainable natural resource management. This would include technologies to address soil erosion degradation, nutrient depletion, loss of bio-diversity, prevention of invasion by alien species, maintenance of water quality and veld productivity,

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optimisation of water use efficiency under both irrigated and rain-fed conditions, capturing and storing rainwater (rainwater harvesting) and restoration or creation of new balances in biotic communities. Geographic Information System-based technologies, natural resource inventories and adequate characterisation and monitoring are considered essential.”

Together with a growing population and high degree of food insecurity, there is increasing competition for water and uncertainty about future water availability. Major questions arise, such as: what is the role of land use and water use changes on water availability and how does managed land use affect consumptive water use? There is a need to separate non-beneficial soil evaporation and beneficial plant transpiration. This also leads to questions on water productivity; in particular, how much food is produced in rain-fed and irrigated agriculture and what are the ranges of water productivity for food, forage, fibre and fuel crops? Water accounting from satellites is an innovative step towards standardised description of water resources. The water accounting framework links water users with the process and benefits of land use. Satellite images ensure data flow on changes in water use. This will enable quantification of beneficial and non-beneficial use for different land use classes.

Under the heading ‘Anticipating and addressing strategic issues and trends’, published in the Green Paper (2009), the following national planning issues are mentioned which could be subject to ad hoc investigations:

- Long-term availability of water
- Energy consumption and production
- Conservation, biodiversity, climate change mitigation and adaptation
- Food security and sustainable rural development

- Innovation, technology and equitable economic growth
- Poverty, inequality and the challenge of social cohesion
- National health profile and developmental health care strategies

The Green Paper envisaged that a national plan would be developed by 2010 with expert panels advising on issues such as food security, water security, energy choices, economic development, poverty and inequality, climate change, human resource development, social cohesion, health profiles and scientific progress. This task has been accomplished with publication of the National Development Plan (2011). Under the section dealing with ‘Water resources and services’, it is stated that for 2030 the vision is that “the country’s economic and social development will reflect an understanding of and an alignment with available water resources. As a result, all main urban and industrial centres will have a reliable supply of water to meet their needs, while increasingly efficient agricultural water use will support productive and inclusive rural communities. The natural water environment will be protected to prevent excessive abstraction and pollution.” For the purpose of water conservation and demand management “reducing demand, rather than just increasing supply, is important.” “Agriculture uses the largest volume of water (albeit at far lower levels of reliability than urban and industrial uses). As a result, the farming sector will have to increase the efficiency of its water use to expand production and allow transfers to other users in water-scarce areas, as well as for expansion in irrigated agriculture. The commission proposes a dedicated national programme to provide support to local and sectoral efforts to reduce water demand and improve water-use efficiency. Water-saving and demand-management projects should be

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considered as part of the overall range of water supply investment programmes. These can be compared with supply expansion projects, and should be prioritised accordingly, based on their merits.” This support for increased water use productivity and potential water saving can indeed be provided with integrated implementation of the management systems, models and tools from river catchment to irrigation scheme level, to farm and field level, developed through WRC research projects and already applied in practice.

Under the heading ‘Trade-offs and risks for agricultural expansion’ it is recommended that, amongst others:

- “Investing in water resource and irrigation infrastructure where the natural resource base allows, and improving the efficiency of existing irrigation to make more water available.
- Providing innovative market linkages for small-scale farmers in the communal and land reform areas, with provisions to link these farmers to markets in South Africa. This will require infrastructure to improve the time and place utility of farm products through road, rail and communications infrastructure that gets the products from the farm gate through the different stages of the value chain.
- Creating tenure security for communal farmers. Tenure security is vital to secure incomes for all existing farmers and for new entrants. Investigating the possibility of flexible systems of land use for different kinds of farming on communal lands. However, as long as these farmers (especially women farmers) do not have secure tenure, they will not invest, and agricultural production will not grow at the rate and pattern required for growth in employment.
- Supporting innovative public-private partnerships. South Africa’s commercial farming sector is full of examples of major investments that have resulted in new growth, and new job opportunities.
- Recognising the consequences of industrialised agriculture and the country’s unique ecosystems, which also demand that serious attention is paid to advances in ecological approaches to sustainable agriculture. This includes greater attention to alternative energy, soil quality, minimum tillage, and other forms of conservation farming.
- Improving and extending skills development and training in the agricultural sector, including entrepreneurship training. This should include the training of a new cadre of extension officers that will respond effectively to the needs of small-holder farmers and contribute to their successful integration into the food value chain.
- Increasing and refocusing investment in research and development for the agricultural sector. Growth in agricultural production in South Africa has always been fuelled by technology, and the returns on investment in agricultural research and development have always been high.”

In the research portfolio of the KSA: Water Utilisation in Agriculture of the WRC, different aspects of all these strategic issues are being researched. These are, in particular, water use in food value chains; land and water use security for empowerment of women; models for public-private-partnership, such as for rural freshwater aquaculture; investigating water use for bio-fuels and bio-gas as sources for alternative, renewable energy; up-scaling rainwater harvesting and conservation to

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croplands; developing training material for improving the capabilities of extension officers regarding irrigation water management on smallholder schemes; and determining entrepreneurial development paths for productive water use by smallholder farmers. The available and future research output of the KSA is therefore positioned and geared to make a constructive contribution by responding to the recommendations and achieving the vision for 2030 of the National Planning Report.

### Key stakeholders

This KSA clearly supports South African Government strategies and initiatives where water conservation, in particular, water development and utilisation for agriculture, is of concern. Government departments, especially the Department of Water Affairs (DWA) and the Department of Agriculture, Forestry and Fisheries (DAFF) are important stakeholders. These links have also been formalised by the support of selected projects of mutual interest through leveraged funding. In addition, district municipalities, provincial departments of agriculture, water user associations (WUAs), catchment management agencies (CMAs), cooperatives and agribusinesses, are all stakeholders with whom the WRC is engaging. In all cases co-operation is achieved by invitations to review research proposals and to serve on the reference group of relevant research projects as well as research project related cooperation.

Key stakeholders and beneficiaries of this KSA remain as previously described. These are farmers who are represented by Agri SA and NAFU. It is estimated that there are 35 000 commercial farmers, 250 000 emergent farmers and 4.5 million subsistence farmers.

Communication channels exist with officials in the representative organisations on a national level. A more effective range of communication strategies has been

designed by formalising stakeholder relationships. This is gradually being implemented to reach farmers and their representatives on a provincial and local level. The purpose is to obtain an accurate indication of practical problems which they are facing and what their assessment is of the priorities for research, technology transfer and extension.

### *Other 'players'*

Other organisations providing services to water users in agriculture have largely remained the same as in previous years, and are the provincial departments of agriculture (PDAs), the DAFF mainly through its Directorate: Water Use and Irrigation Development and DWA through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC are firstly, and, inter alia, an initiative by the DAFF to give policy direction to development through integrated water management for agricultural use and implementation of the irrigation strategy, and, secondly, the water conservation and demand management strategy in agriculture, the water allocation reform strategy and the broad-based black economic empowerment guidelines for water use that DWA is implementing.

Locally the Human Sciences Research Council (HSRC) has reorganised its research activities and regrouped its projects into interdisciplinary new priority areas (NPAs). The Integrated Development NPA is to undertake research which is designed to promote sustainable development in rural and urban areas. In addition various institutes of the Agricultural Research Council (ARC) obtain funding and undertake research on water-related subjects. Of particular relevance is water research in relation to soils and climate, engineering, field, horticultural and forage crops. At eight universities across South Africa there are faculties or departments of agriculture, many of whom have in the past mainly relied on WRC funding to undertake water research.

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Globally the International Water Management Institute (IWMI), as a member of the Consultative Group on International Agricultural Research (CGIAR), has a sub-regional office for Southern Africa in Pretoria. Since the establishment of the IWMI Africa Office, which is now based in Ghana, the WRC is serving on the IWMI-South Africa Consultative Committee with the main function to determine priorities for IWMI's work in this sub-region. Research is done under four themes: water availability and access; productive water use; water quality, health and environment; and water governance.

The CGIAR Challenge Programme on Water and Food (CPWF) is an international, multi-organisational research initiative. The partnerships seek meaningful impacts for people who use innovations developed by scientific research. Its goal is to increase the productivity of water used for agriculture, leaving more water for other users and the environment. In the Limpopo basin, the development challenge is to improve rural livelihoods through better management of rainwater, including management of small dams.

### *Providers of research*

The main sources of research projects are universities and colleges (currently Universities of KwaZulu-Natal, Pretoria, Free State, Stellenbosch, Rhodes, Fort Hare, Cape Town, and North-West, and the Tshwane and Cape Peninsula Universities of Technology); science councils (various institutes of the ARC and CSIR Natural Resources and the Environment); as well as established and emerging private consulting groups.

### RESEARCH PORTFOLIO FOR 2012/13

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 Vision for 2030 of the National Development Plan; the outputs for Outcomes 7 and 10 in the Programme of Action announced by the Presidency; the Green Paper on National Strategic Planning; the DWA framework, Water for Growth and Development (Version 7); the DAFF Integrated Growth and Development Plan; the National Agricultural Research and Development Strategy; and the Comprehensive Africa Agricultural Development Programme of NEPAD. Work will continue 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
- Quantifying the water footprint in food value chains
- Eradicating hunger and reducing poverty
- Improving nutrition and health
- Generating alternative sources of renewable energy
- Preventing soil and water degradation and pollution
- Adapting farming systems to climate change

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Over the past 10 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. An overview of completed projects and stakeholder requirements indicates the direction and priorities for future research.

### 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*

**Baseline and scoping study on water use and nutrient content of crop and animal food products for improved household food security**

University of Pretoria; Human Sciences Research Council; Medical Research Council  
No. 1954

The general objective of the project was to determine nutritionally important foods for the diet of rural households in South Africa, with specific reference to the poor; and to describe the nutrient content and water use of related unprocessed crop and animal products using existing knowledge. This exploratory project was a desktop study that systematically examined the literature available. The report shows that whilst certain general trends have become apparent, there seems to be insufficient available evidence to compile one basket of

contemporary food intake of poor households in rural areas of South Africa. Purchasing of staple foods seems to be the most important source, but regarding the foods of which intakes appear to be low (foods of animal origin, fruit and vegetables), and which could potentially be home-produced, there is limited evidence of its source, including seasonality. The report also shows that information on the reasons for the foods consumed by rural South Africans is sparse and fragmented. Based on dietary as well as biochemical indicators, key micronutrients lacking in the diet are Vitamin A, iron and zinc, which relates to low consumption of foods of animal origin, fruit and vegetables. The report includes an in-depth discussion of the nutrient composition of two crops, orange sweet potato and dark green leafy vegetables, as a sub-group. Initial benchmark estimates of nutritional water productivity (NWP) for key nutrients of selected crops (cereals, legumes, fruit, dark green leafy vegetables, and yellow/orange vegetables) and animal food products were made. Gaps in existing knowledge and research were highlighted and the foundation for follow-up research was laid.

Cost: R1 000 000  
Term: 2010 - 2012

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

##### **A quantitative investigation into the link between irrigation water quality and food safety**

University of Stellenbosch (Department of Food Science); University of Pretoria (Virology); University of Venda; University of KwaZulu-Natal (Pietermaritzburg)

No. 1773

There is a growing concern about the 'safety status' of South African agricultural produce, especially

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that which is consumed raw. If these products are contaminated they will impact not only the health of the final consumer but also that of people living next to rivers and the producers. This will immediately impact both national and international trading status and cause a suspension of exports. Furthermore, there were, and still are, regular articles in the local press reporting on the shocking environmental status of local rivers. The source of contamination of the agricultural products was identified as irrigation water that had been contaminated before irrigation took place. The health risks associated with the use of contaminated irrigation water on agricultural products thus became an increasing concern. The main objective of this solicited research project was to do a quantitative investigation into the link between irrigation water quality and food safety. Results indicated that the microbial pollution levels of rivers and fresh produce monitored at selected sites in different provinces of South Africa over a period of 3 to 4 years were of an unacceptable standard and did not meet either the international or national guidelines for safe irrigation or human consumption. Other potential waterborne bacterial, virus and protozoan pathogens were frequently recovered from both the water and the produce. It was concluded that there is a high risk of exposure to pathogens when water from these rivers is used to irrigate produce that is consumed raw or without any further processing steps. In the research it was shown using phenotypic and genotypic identifications that direct water to produce linkages could be made. It was concluded that species from the surface of produce were present as a result of transfer from the contaminated irrigation water. There can now be no doubt that specific carry-over does take place. The potential of pathogenic organisms to be transferred from irrigation water to the surface of fresh produce plus their ability to survive in these unfavourable conditions presents a scenario where

consumers unknowingly face a high risk of being infected with harmful organisms when consuming fresh produce. Various recommendations for further research are made ranging from distribution profiles of pathogenic bacteria, seasonal variations and monitoring in irrigation water, development of effective quality assurance measures for detection of enteric viruses to investigation of effective on-farm treatment options for contaminated irrigation water.

Cost: R5 232 500

Term: 2007 - 2012

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

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

**Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province**

University of Fort Hare; ARC (Institute for Animal Production); ARC (Institute for Soil, Climate and Water)  
**No. 1478**

The aim of this project was to select and implement water harvesting and conservation techniques that would assist two rural communities (Guquka and Khayaletu) in the Eastern Cape to improve their livelihoods by increasing their food production and developing their rangeland/livestock production systems. On-station and on-farm field experiments were conducted in order to test rainwater harvesting and conservation (RWH&C) techniques. The results showed that subsistence farmers in the semi-arid areas

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could improve maize yields considerably by replacing their conventional practices with in-field rainwater harvesting (a specific form of micro-catchment water harvesting) without cover crops and, if possible, applying mulch on the basin and runoff areas. This would improve their level of food security. The project found that if the intention of small-scale farmers is only to produce well-balanced fodder in bulk for their animals or fodder for their animals as well as food for the household, then the IRWH treatments with cover crops might be a good option. It is evident from the research findings that using micro-catchment water harvesting in combination with either mulch or brush improved moisture retention enhancing productivity both in croplands and rangelands. Land tenure and ownership are major challenges in both croplands and rangeland, and thus affect the management of these resources. The IRWH technique was used by village members of two villages in the Eastern Cape, Guquka and Khayaletu, to greatly improve their household food security.

Cost: 5 200 000  
Term: 2004 - 2012

### **Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities**

University of the Free State (Department of Agricultural Economics); ARC (Institute for Soil, Climate and Water); University of Fort Hare  
No. 1648

The point of departure for this research was 'an assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities'. The main objective was however stated more humbly as

'to evaluate the social, economic and institutional determinants of sustainable rainwater harvesting and conservation (RWH&C) techniques and practices'. With the Sustainable Livelihoods Framework (SLF) as theoretical basis, the main objective was achieved through 16 specific objectives with a focus on evaluating the five capitals, natural, physical, financial, human and social, of the SLF utilising Participative Active Research (PAR) as the main research methodology. It can generally be concluded that all the five capitals proved very important for the sustainable adoption of selected RWH&C practices and techniques. Each must be known and evaluated on its own and then in conjunction with all others taking characteristics, adequacies, limitations, etc., into consideration. The natural capital (soil, climate, etc.) must, for instance, as a point of departure, be suitable for implementing specific RWH&C practices and techniques. If this is not the case it is not worthwhile attempting to implement action. In three villages, Potsane, Rietfontein and Cata, the natural capital is fairly good while in Kwezana-West the lower annual rainfall is, for instance, a constraining factor in the application of some of the RWH&C techniques, like IRWH. Thereafter the physical capital must be evaluated and followed by describing, analysing and evaluating the financial, human and social capital. Although each capital on its own is very important, the interactions amongst all capitals are equally important and must be known to identify competitive, supportive and synergistic relationships. In this regard the human and social capitals play an overarching role but these are relatively much more complex than the other capitals and very difficult to understand, assess and evaluate. The lessons learnt and recommendations reported provide guidelines on factors and issues that must be considered/evaluated with regard to the different capitals before venturing into the promotion of RWH&C techniques and practices in other areas. Extrapolating

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the findings and recommendations to other areas must however be done with caution given the uniqueness of each area and the complexity of understanding and assessing the different capitals on their own and in conjunction with other capitals.

Cost: R3 100 000  
Term: 2006 - 2012

### ***Programme 2: Integrated water management for profitable farming systems***

#### **Development of training material for extension in irrigation water management**

University of Pretoria (Department of Agricultural Economics, Extension and Rural Development);  
Lowveld College of Agriculture; PICWAT  
**No. 1649**

It is generally recognised that extensionists provide the link between research output and solving the perceived problems which farmers experience. All types of farmers, but especially smallholder farmers, are dependent on extension services as a source of information and knowledge. Discussion forums organised by the WRC in all provinces between 2000 and 2003, in which a wide range of farmers participated, have highlighted that the extension link has deteriorated in recent years and become less effective. In 2005 a consultancy project was undertaken for the WRC to establish a database of extensionists who are active on smallholder irrigation schemes in South Africa. In that process it was also determined that the current level of training presented by tertiary organisations to extension workers for the tasks they have to perform on irrigation schemes is inappropriate in the majority of cases. The outcomes of this consultancy project formed the basis for the solicited research project. The aim for this project is to develop and interactively test learning material for the

capacitating of extensionists in the promotion of efficient use of irrigation water by smallholder farmers. The main output of this research project was the development of the learning material for the eight learning areas that were identified to form the 'knowledge profile' of the irrigation extensionist. The aim of the learning material is to support tertiary training organisations like agricultural colleges and universities of technology offering agricultural programmes on NQF Level 5, as well as to support training providers offering short courses in irrigation management. The learning package consisting of nine parts is aimed to help build the necessary skills and competencies required of irrigation extensionists to assist irrigation farmers in the learning process they need to undergo regarding irrigation water management. It is recommended that the outcomes of this project should be marketed and disseminated to all relevant tertiary and private training organisations in the country for future practical training on various aspects of irrigation water management. This will ensure that the lack of competencies amongst extensionists is addressed, and will restore their credibility and self-esteem towards the rendering of a professional service to irrigation farmers.

Cost: R2 370 000  
Term: 2006 - 2012

#### **Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement**

WSM Leshika Consulting (Pty) Ltd; WRP Consulting Engineers (Pty) Ltd; MBB South Consulting Engineers (Pty) Ltd; NB Systems; Clear Pure Water  
**No. 1778**

The results of this technology transfer project can be summarized in four key messages for potential users of measuring devices for irrigation water:

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- Assign the responsibility for implementation to a skilled person: A knowledgeable and skilled person employed by the Water User Association (WUA) or Irrigation Board is required if water measurement is to be implemented successfully. Such a person should preferably have a technical background and be involved with the process of implementation right from the start, to ensure that they share all the experiences in the process of finding a sustainable measurement solution for the area under consideration. This person must be able to develop a measurement system for the specific situation and also be able to see to the day-to-day operation and maintenance of the measuring devices (with assistance if necessary).
- Preparation is key: In order to find the best solution, it is recommended that any possible technology that is being considered for wide-scale implementation must first be evaluated on a trial basis to obtain first-hand experience with its installation, operation and maintenance requirements. It is better to try out as many technologies as possible on a small scale before making a final selection, as this can prevent inappropriate, costly systems from being purchased that may become redundant after a short while of operation. The cost of single units of a few different technologies is money well-spent in view of selecting the best solution.
- Commit to an implementation plan: Any project should be planned and implemented as simply and practically as possible – unnecessary complication is a threat to successful project implementation. This can only be achieved if knowledgeable implementing agents manage the project through careful planning and in-depth assessment of the situation presenting itself, as every project will be different in its own right and therefore require site-specific solutions, an outcome that will hopefully be achieved through the careful application of the proposed implementation guidelines and plan.
- Install the most appropriate technology that can be afforded: Research work undertaken over the past 10 years has shown that suitable technologies and devices are available for the measurement of irrigation water, even in challenging situations with regards to aspects such as water quality and installation conditions. Failure of measuring devices or systems can usually be blamed on incorrect selection, application, installation or maintenance rather than on the technology itself. Under demanding conditions, it is imperative that the best technology or device available and affordable is obtained, to ensure a sustainable system that will serve the purpose that the owners of the system intended it for. The benefits of a suitable system will ensure that it pays for itself within a short period of time but an unreliable system will only cause frustration and lead to unnecessary expenses and an additional work load on the water managers of a scheme.

Cost: R1 800 000

Term: 2007 - 2012

### **Assessment of the contribution of water use to value chains in agriculture**

University of the Free State (Department of Agricultural Economics)

No. 1779

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Actual achievements where emerging farmers are successfully operating in commercial agri-food chains are scarce. The small number of success stories means that the objective to allow farmers to improve their livelihoods through irrigated agriculture is not met. It is noted that access to agricultural water plays a necessary role in increasing productivity, but access to water alone is not a sufficient condition to enhance productivity and alleviate poverty. Given the scope of the analysis that was required to meet the objectives of this study, the conceptual framework that was used consists of a problem tree analysis and an integrated New Institutional Economics (NIE) and Structure-Conduct-Performance (SCP) analysis of the three levels (micro, macro and meso) that comprise the value chain within which the emerging farmers are participating. The nature of the conceptual framework requires both qualitative and quantitative analyses. Within the application of the SCP framework, qualitative analyses were used to investigate the physical environment (structure) within which the farmers operate, the way they behave in the physical environment (conduct), and the level of performance in terms of production volumes and income generated. The analysis of the resource allocation level within the NIE framework consists of quantitative analyses of the levels of efficiency with which production inputs are used to generate income. The integrated NIE and SCP framework was applied to three case studies: the case of raisin producers from Eksteenskuil in the Northern Cape Province, the case of vegetable producers from Zanyokwe Irrigation Scheme, and the case of maize and vegetable producers from Thabina Irrigation Scheme. The results from the analyses of the distribution of water use along the value chains show that the bulk of all of the water that is used along the value chain is used at farm level to produce the food products. Efforts to increase the efficiency with which water is used along the value chain thus should focus

the attention on water use at farm level. A number of key success factors were also identified from the results of the study that prove to have great potential to contribute towards the successful participation of emerging farmers in commercial agri-food chains. The key success factors include, amongst others, effective support to emerging farmers; effective collective action among emerging farmers; actions to minimise the potential negative impact of cultural activities on the performance of the farm businesses; secure tenure; tailor-made financing schemes; and coordinated efforts to overcome stumbling blocks. The results from this study show that emerging farmers have great prospects to increase their production levels by using their production inputs more efficiently and thereby substantially improve their cash flow positions. It is important to note that the farmers can increase their production at current input levels and within their existing technology set. Based on the findings from the three case studies, recommendations are made for emerging farmers to enhance their ability to successfully participate in commercial agri-food chains, for policy makers to formulate new policies and to adjust some of the existing policies to enhance the successful participation of emerging farmers in commercial agri-food chains, and for future research that needs to be conducted to contribute to the topic of the optimisation of economically beneficial water use by the integration of emerging farmers into the mainstream of the economy.

Cost: R2 430 000  
Term: 2007 - 2012

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### **The development and testing of an integrated set of models to evaluate the financial/economic impact of irrigation water curtailment decisions on participant farm case studies in the Crocodile Catchment**

CPH Water; University of the Free State; Danish Hydraulic Institute; Land, Water and Health; South African Sugarcane Research Institute  
**No. 1805**

A major modelling achievement of this project is the linkage of hydrologic simulation with economic optimisation to quantify possible impacts of changes in catchment water management scenarios on irrigation farming profitability and livelihoods. Through the development of the integrated hydro-economic decision-making framework the research showed that it is possible to replicate the decision-making framework used by DWA to manage water in the Crocodile East catchment. The developed framework proved to be flexible and the researchers were able to incorporate operating rules that were practised in the catchment. Accommodating these operating rules increased the credibility of the results which enhanced participation and discussions about alternative water management scenarios. Strong participation of stakeholders definitely resulted in an improved modelling framework and better understanding of the issues surrounding catchment water management and the implications thereof for water users. The integrated modelling framework hinges strongly on the outputs from the irrigation module to optimise agricultural water use. This was achieved through the development of an FAO 56 based irrigation module that is integrated with MIKE BASIN on a daily basis. The irrigation module was used to provide the inputs for the optimisation model to optimise water use. Further development of the whole-farm SKELETON model was done through the development of state contingent response functions

that are able to more accurately model the impact of different levels of assurance of supply. It is important to note that the state contingent approach increased the dimensionality of the programming model to such an extent that it was collapsed into a single annual time period. Thus, the modelling framework does not allow for dynamic changes in irrigators' response to changes in catchment management over the long-run. Overall, the objectives of the research were achieved to a better than satisfactory extent. The knowledge that was gained through the development of the integrated decision support system provides the basis for more sophisticated developments to model the impact of changes in water management on irrigation farming profitability over the long-run.

Cost: R1 790 000  
Term: 2008 - 2012

### **THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE**

#### ***Programme 2: Impact assessment and environmental management of agricultural production***

#### **Applications of rainfall forecasts for agricultural-related decision making in selected catchments**

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology); University of Cape Town; University of the Free State; ARC (Institute for Soil, Climate and Water); CSIR  
**No. 1646**

The overall objective of this project was to develop and test techniques and models for translating weather and climate forecasts in South Africa into applications for decision support at a range of spatial scales in both

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rainfed and irrigated agricultural production and water management, in order to reduce risks associated with the vagaries of day-to-day seasonal climate variability. The report contains an audit illustrating that there is no lack of climate forecasts available for South Africa. Seven case study applications of weather and climate forecasts are presented. One of the specific objectives of this project was to work towards developing a framework for agrohydrological forecasting for South Africa. This was achieved in two phases, the first being in the early stages of the project with emphasis on a research-based framework for an agrohydrological forecasting system for South Africa with the second, building upon the first, moving towards an operational agrohydrological forecast framework. Having utilised climate forecasts for the agricultural sector and developed an agrohydrological climate-driven forecast system, a series of benefit analyses of such forecasts is also presented. The report includes an economic benefit analysis of maize management decisions using seasonal rainfall scenarios, in which a verification study of maize yield estimates from the APSIM model is followed first by an analysis of simulated maize yields and then, more importantly, by a comparative economic benefit analysis of different management decisions. One of the recommendations from this project is that sustained and adequate funding (possibly from multiple sources) be made available for one institution in South Africa to be made responsible for the collation (from different sources) and uniform quality control of climate data, and that these data then be made freely available to all bona fide researchers.

Cost: R5 700 000 (incl. leverage)  
Term: 2006 - 2012

### 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/

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orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic importance, current hectareage, 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 drought-tolerant food crops**

University of KwaZulu-Natal (Crop Science)  
**No. 1771**

A significant proportion of the South African population experiences food insecurity and malnutrition (micronutrient deficiency) despite living in a country that is a net exporter of food. One of the main food security challenges facing the country is the need to increase the ability of vulnerable groups to meet their minimum daily requirements for adequate nutrition. About 14.3 million people are vulnerable to food insecurity, particularly women, children and the elderly. There is therefore a need to increase the content of the South African food basket particularly for the poorest households living in rural areas. However, drought is one of the major hurdles facing agriculture in Sub-Saharan Africa. South Africa, like many countries in the region, is prone to severe water shortages which seriously impacts on the availability of food. One way to combat inadequate availability of water is to develop or select crops that are more tolerant to water stress. Indigenous edible plants

that are resilient have sustained rural populations in developing countries for centuries. These traditional crops are native to specific localities and are therefore better adapted to the local environmental conditions and cultivated without the need for much external inputs such as agrochemicals or a high water requirement. However, information on the utilization of indigenous crops in South Africa is not well documented. Moreover, no comprehensive overview of the spectrum of food crops available for food production in South Africa in relation to drought tolerance, crop adaptability, economic importance and water use characteristics has been conducted. This project seeks to understand the water use characteristics of drought-tolerant crops through the use of empirical measurement and crop growth models. The parameters needed for modelling will guide the empirical research.

Estimated cost: R4 350 000 (incl. leverage)  
Expected term: 2007 - 2013

### **Water use of cropping systems adapted to bioclimatic 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

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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

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### **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

### ***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

This project will investigate the feasibility and practical implications of using on-farm irrigation water storage dams for aquacultural fish production. A recently-completed WRC project (No. 1461) found that although this dual use of water is mostly beneficial, it can also impact on water quality. This is a follow-on project that will continue with monitoring the effects of aquaculture at a number of sites, follow-up on the environmental concerns (especially enrichment or eutrophication of dam water) and investigate management and other measures aimed at reducing the enriching effects associated with intensive cage aquaculture.

Estimated cost: R1 680 000

Expected term: 2008 - 2013



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### **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

### **THRUST 2: WATER UTILISATION FOR FUELWOOD 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  
No. 1803

Large parts of the South African landscape, especially the former homelands, are heavily degraded and denuded due to, amongst other factors, historical over-population, mismanagement and exploitation of natural resources. While the country does have a limited history of restoring natural capital, i.e. rangelands and grassland catchments, woodlands and natural landscapes, few comprehensive analyses have been done to assess the ecological, hydrological and socio-economic impacts of rehabilitation across a range of contrasted sites and contexts. Very few investigations have been conducted to determine the tangible contributions restoration

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has made and can make to rural landscapes and local economic development. This study will assess the ecological, hydrological and socio-economic impact of improving degraded landscapes across the country at a number of contrasted sites in an integrative and dynamic systems approach. This will be done using a carefully selected assemblage of parameters to study how restoration specifically improves water flow, water quality, land productivity and in some instances carbon sequestration as well as generally improving the agricultural potential of the land. In addition, the socio-economic benefits of restoring natural capital will be assessed by investigating the contribution to employment creation and income generation. The economic quantification of restoration is likely to provide critical data needed for the implementation of payment for environmental services. A model will be developed based on information gathered by this study to assist in predicting the impact of future restoration projects on complex and dynamic socio-economic and ecological rural landscapes. This model will be used to consider the most effective and best ways to embark on future restoration projects. This decision support tool will be very valuable to national programmes and projects such as Working for Water, Working for Wetlands, Working for Woodlands and the land-care project.

Estimated cost: R3 450 000 (incl. leverage)  
Expected term: 2008 - 2013

### **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

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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*

#### **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)

No. 1775

Almost half of South Africa's population can be classified as living in poverty while 25% of the population can be categorized as ultra-poor. Although the country is self-sufficient in food production, about 14 million people are reported to be vulnerable to food insecurity and 43% of households suffer from food poverty. The majority (65%) of the poor are found in rural areas and 78% of those likely to be chronically poor are also in rural areas. Much of South Africa is covered by large areas of rangeland (veld) that is not privately owned but used communally by farmers for grazing domestic livestock and harvesting natural products such as fuelwood. Most of the communal areas are located in the former homeland areas in provinces such as Limpopo, Eastern Cape and KwaZulu-Natal. These rural landscapes are often also characterized by abandoned croplands that are infested by weeds and grasses. In communal areas, where individuals share land and water resources, understanding the complex norms, values and behaviours is very important. The success of community-based management of resources is

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dependent upon the functioning of the institutional arrangements. Water harvesting and conservation practices have not only been demonstrated to increase dry-land agricultural production but also to be environmentally sustainable. This project seeks to assess water harvesting and conservation techniques/practices for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research. It will investigate the institutional arrangements in these communities and assess the extent to which production was suppressed as a result of inappropriate working rules and how these can be approved. A guideline on best management practices for RWH&C for rangeland and crop lands in communal areas will be produced.

Estimated cost: R4 728 500 (incl. leverage)  
Expected term: 2007 - 2013

### **Improving plot-holder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province**

Tshwane University of Technology; ARC  
(Institute for Agricultural Engineering)

**No. 1804**

Livelihoods of plot-holder homesteads on small-scale canal irrigation schemes in South Africa are diverse and dynamic and the importance of irrigated farming in the livelihood portfolio of these homesteads also varies. Typically, the objectives of plot-holders on small-scale irrigation schemes range from production of food solely for own consumption to fully market-oriented production. While market-oriented farmers seek to expand the scale of their enterprise, subsistence farmers (food producers for own consumption) tend to have excess land. Most of the smallholder farmers on irrigation schemes require technical improvements

to the prevailing production systems to enhance the financial viability of plot enterprises and increase the efficiency of water and land use. Effective management of shared resources such as water is essential to all farmers on the irrigation schemes and is dependent on collective action. Despite the multi-faceted challenges facing smallholder irrigation schemes, very little research has been successfully conducted on integrated production systems on these schemes. At this stage these schemes are also not included in RESIS of Limpopo Province, except if farmers are prepared to switch to sprinkler irrigation. Changing to sprinkler irrigation will not necessarily increase water-use efficiency, particularly if it is done without participation by farmers. This project seeks to enhance plot-holder scheme productivity and to strengthen collective action by improving the availability of irrigation water to farmers. It will seek to enhance the establishment of robust community-based institutional systems that reduce uncertainty and risk in land-exchange contracts. It will also endeavour to integrate crop and animal production in order to contribute substantially to local resource use, value-adding and market access on smallholder irrigation schemes. In order to achieve these objectives, the project will adopt a participatory learning and action approach to collectively analyse the existing behavioural and communication patterns. It will employ both plot and field experiments in an effort to encourage the efficient use of water and improve plot-holder productivity. The final output of this project will be a comprehensive report that documents the holistic approach followed in addressing the challenges facing smallholder irrigation farmers and lessons learnt as well as practical crop and animal production manuals for smallholder farmers and their advisers. These outputs will contribute to national programmes of high priority that address issues of poverty alleviation and food security.

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Estimated cost: R1 890 000  
Expected term: 2008 - 2013

### **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

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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, among 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

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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

### *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

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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, processors, 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

## **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

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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 runoff 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

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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 assess 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

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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

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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: R712 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*

#### **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

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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: 1) determine water use and irrigation requirements of most common farmers' practices including kikuyu/ryegrass, legume/ryegrass mixtures and lucerne; 2) evaluate irrigation systems (flood, sprinkler and sub-surface drip) for lucerne production; 3) conduct detailed physiological studies of lucerne as affected by different water stress treatments, and 4) 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.

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

### THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

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

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,

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

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

#### **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

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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 750 000  
Expected term: 2012 - 2016

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

#### ***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 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

## KSA 4: WATER UTILISATION IN AGRICULTURE

### **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

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

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