



KSA 4: Water Utilisation in Agriculture

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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 namely:

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

As in previous years, the scope in terms of people and subsectors is comprehensive and inclusive and will therefore be retained.

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

OBJECTIVES

The **primary objective** is to increase 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 of water use

- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices

THRUSTS AND PROGRAMMES

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. 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. 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 the assessment of the fitness-for-use of 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. This thrust includes two programmes:

- Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture
- Fitness-for-use of water for crop production, livestock watering and aquaculture

THRUST 2: WATER UTILISATION FOR FUELWOOD 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. 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. This thrust includes one programme:

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

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. 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 be promoted further through participatory action research which improves knowledge, farming skills and leadership capabilities. 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. This thrust includes two programmes:

- Sustainable water-based agricultural activities in rural communities
- Integrated water management for profitable farming systems

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. 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. Agricultural decisions to use land and to conserve rainfall or to abstract water from rivers, dams and boreholes, has 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. This thrust includes two programmes:

- Sustainable water resource use on irrigation schemes and within river catchments
- Impact assessment and environmental management of agricultural production

RESEARCH PORTFOLIO FOR 2010/11

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. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction and wealth creation in rural areas and prevention of resource degradation. These efforts are aligned to the DWAF strategy Water for Growth and Development (Version 7), the National Agricultural Research and Development Strategy, the Green Paper on National Strategic Planning and to 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 themes of the research portfolio:

- Irrigation and water use efficiency
- Fitness-for-use of water in agriculture
- Water use efficiency in agro-forestry and woodlands
- Aquaculture and fisheries in rural livelihoods
- Rainwater harvesting and conservation
- Adaptive research of technologies in rain-fed and irrigated agriculture
- Technology transfer of water management models
- Impact of land-use management on point and diffuse pollution in agriculture

Over the past eight 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 and ongoing projects indicates the direction and priorities for future research. In the next 2 years, emphasis will be placed on quantification of water use and the nutrient content of economically important food crops in diets of the rural poor; determination of rain-fed and irrigated crop water use with satellite imagery; determination of tree water use for re-establishment of woodlands and agro-forestry systems; revision and refinement of guidelines on groundwater quality for domestic use and livestock watering; empowerment of women through water use security and skills development for improved livelihoods and reduced poverty in rural areas; assessment of the potential of small and large storage dams for inland freshwater fisheries to produce fish for food security in rural areas; promotion of the efficient conservation of water resources and water inputs within food-value chains for emerging farmers as part of land and water allocation reform projects; developing technical and financial standards for drainage of irrigated land; determination of the magnitude of pollution by agricultural chemicals and the potential risks for the environment; developing guidelines for rainwater harvesting and livestock production on natural grasslands for generation of biogas as renewable energy.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to committed funding of R24 279 587, including R2 600 000 for new projects.

CORE STRATEGY

Strategic context

The Green Paper on National Strategic Planning (2009) seeks to answer, amongst others, how to reduce poverty and what capacity is needed to ensure availability of water, energy and food in the future. The intention is to articulate a vision and strategy for the next 15 years, to which all organisations of government are aligned. In this regard the South Africa Vision 2025 of the Medium Term Strategic Framework projects a society in which, *inter alia*:

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

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.

Furthermore, 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, 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 to improve 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 grass-lands, woodlands and forests respectively. Rainwater runoff and deep percolation become available as surface- and ground-water 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 recognise the business and employment opportunities which are created.
- 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 agricul-

ture, 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 Blacks (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 above-mentioned current reality of agriculture in South Africa is also clearly stated by the Department of Water Affairs and Forestry (DWAf) in the strategy on *Water for Growth and Development in South Africa* (2008) (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

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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 relative high ratio of people to cultivated land and a dependence on agriculture in rural areas to increase the material income and improve the social wellbeing, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that the use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences. Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible 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*, will continue to be on:

- Increasing the efficiency of water use for food, fibre, wood and timber production (i.e. improving the knowledge of biological, technical and economic processes of production)
- Increasing the household food security and profit ability 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)

In drawing up plans to implement these strategies, cognizance has to be taken of the national needs, technological trends and stakeholder expectations.

Needs analysis

Previously identified needs, re-affirmed by recent reports, reviews and policies, continue to give direction to applied research. 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
- 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. 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 at the beginning of November 2008 in Cape Town, 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 DWAF (2008) to promote water for growth and development of agriculture are 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; 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 encourages the planting of trees and harvesting of firewood, building material, medical 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

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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.

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

Key stakeholders

This KSA clearly supports South African government strategies and initiatives where water conservation and in particular water 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.

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 45 000 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. It 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 largely have 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, 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. 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.

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 of water availability and access; productive water use; water quality, health and environment; and water governance.

The CGIAR Challenge Program 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.

Research providers

The main suppliers of research projects are universities and colleges (currently Universities of KwaZulu-Natal, Pretoria, Free State, Stellenbosch, Rhodes, Fort Hare, Cape Town and Tshwane University 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.

STRATEGIC INITIATIVES

National initiatives

- AgriSA organised a Water Conference with the theme: Water Utilisation and Food Security - Policy and Practice, 11 August 2010, Kempton Park, at which the KSA Director was invited to give a presentation on the 'Strategic direction for research on water utilisation in agriculture'.
- The KSA manages the Network on Irrigation Research and Extension for Smallholder Agriculture (NIRESA), established to facilitate interaction between researchers at universities and science councils on the one side and extension officers in provincial departments on the other. Particular attention is given to available knowledge and practical requirements on smallholder irrigation farming and schemes which must receive priority attention. NIRESA held their annual workshop from 26 to 28 October 2010 in the Western Cape, which included a field visit to irrigation schemes on the 27 October 2010.

Leadership positions

- Treasurer and members of the Executive Committee of the South African National Committee on Irrigation and Drainage (SANCID). The KSA Director was invited to give a presentation at the biennial SANCID Symposium, Upington, 16-18 November 2010, on 'Innovations for effective agricultural water management and efficient food production'.

Strategic positioning

- Discussions were held with the following officials in the Department of Agriculture, Forestry and Fisheries (DAFF) for leverage of research funding:
 - The existing Collaboration Agreement with funding from the Directorate: Water Use and Irrigation Development expired in March 2011. Research projects of mutual interest to DAFF and WRC were agreed to and a list of projects with requested funding was completed and will be submitted with a request to extend the Collaboration Agreement with 5 years and a total annual budget for leverage funding of R3 million.
 - A new Service Level Agreement is being negotiated

- with the Directorate: Agricultural Engineering Services.
- A new Service Level Agreement is also being negotiated with the Directorate: Animal and Aqua Production Systems.
- The Deputy Director-General of the Department of Agriculture, Forestry and Fisheries (DAFF), requested the KSA 4 Director to give a presentation to the CEO Steering Committee on the findings of WRC project (K5/1773/4) on a 'Quantitative investigation into the link between irrigation water quality and food safety' during a meeting held on 26 July 2010.
- On request of the Acting DG of DWA and the CEO of the WRC, a presentation was given by the KSA 4 Director to DWA Top Management on 'The value of water for economic development', on 6 September 2010, followed by an interactive discussion on the issues raised during the presentation.
- Following the meeting between staff of DWA and WRC held on 2 September 2010, regarding oversight of the R&D strategy and business plan for 2010/11 to 2012/13, a discussion was organised with the Acting DDG to explain how the WRC-funded Water Administration System (WAS) can support DWA to implement water loss control and achieve significant water savings in irrigated agriculture.
- Progress is being made with the research impact study on WRC-funded irrigation scheduling tools and models being undertaken by the University of Pretoria, Department of Agricultural Economics, Extension and Rural Development. The purpose is to determine whether research-based knowledge for irrigation scheduling was used for decisions and actions.
- Frost and Sullivan International have been commissioned to develop a database of all water-related research projects in agriculture which have been undertaken in South Africa during 2010. A questionnaire has been sent to all research organisations (universities, science councils, grower associations and provincial government departments) to gather information on the project title, project aims and objectives, and total project funding. It will also be determined in what area (rain-fed and irrigated cropping, agro-forestry, livestock watering and aquaculture/inland fisheries) research is being undertaken in comparison with the thrusts and programmes of the KSA: Water Utilisation in Agriculture of the WRC.

African leadership

- Member of Advisory Board, International Centre for Water Economics and Governance in Africa (IWEGA).
- Chairman, Southern African Regional Irrigation Association (SARIA).
- From 14 to 16 September 2010 IWEGA presented a course on 'Water Economics and Governance in South

Africa: Basic Issues and Operational Tools' to staff of DWA at the Roodeplaat Training Centre. The KSA 4 Director presented a case study on 'Development and financing of irrigation schemes' and the available WRC guidelines on the revitalisation of smallholder irrigation schemes were explained.

- A research manager attended a regional stakeholder consultation forum in Zambia organised by IWMI, 10 to 11 August 2010, with participants from different countries in the SADC region, and chaired one of the discussion groups. The purpose of the meeting was to discuss the research programme of IWMI, which is currently conducting a restructuring process.
- The Partnership for Agricultural Water in Africa (AgWA) is a voluntary partnership comprising various African public and private organisations and international bodies that have a common interest and desire to support agricultural water management (AWM) and development in Africa. During the second-half of 2010, extensive consultations took place in East/Southern and West/Central regions of Sub-Saharan Africa to develop propositions on the governance and implementation architecture of AgWA. A research manager participated in the discussions at the final meeting of this series of consultative meetings, held in Johannesburg from 17-18 January 2011, in his capacity as Chairman of SARIA.
- A research manager organised and chaired the annual workshop and steering committee meeting of the Southern African Regional Irrigation Association (SARIA), held from 15-17 February 2011 at Maguga Lodge, Swaziland. The KSA 4 Director presented a paper at the workshop entitled 'Towards productive water use and household food security in South Africa', based on various completed WRC research projects including the comprehensive resource material on 'Agricultural Water Use in Homestead Gardening Systems'.

by the KSA 4 Director in his capacity as Chairman of the ICID Task Force on Financing Water for Agriculture. The topic of the Workshop was 'Country policies and strategies on financing and implementation of current water use charging systems in irrigation'. A paper was presented at a workshop on 13 October on 'Water saving practices in agriculture' of the Working Group on Water and Crops. A paper was also presented on 'Towards productive water use and household food security in South Africa' during the *6th Asian Regional Conference*.

- Representatives from international and national research organisations and various SADC countries (i.e. Malawi, Zambia, Tanzania, Zimbabwe, Botswana), and the Department of Science and Technology attended the International Institute for Applied Systems Analysis (IIASA) regional workshop for Southern Africa in Cape Town on 27 and 28 January, 2011. A research manager presented a paper on the Water Research Commission's research and development strategy on 'Water utilisation in agriculture' during the workshop, and was also one of the panel members in a session on 'Climate adaptation: Food and water in changing urban and rural landscapes'.

International player

- Chairman, ICID Task Force on Financing Water for Agriculture (TF: FIN).
- Vice-Chairman, ICID African Regional Working Group (Af: RWG).
- A paper was prepared and a presentation was made on 'Crop production and water use for bio-fuels in South Africa' at the *3rd International Seminar on Crop Science for Food Security, Bio-energy and Sustainability*, 1 to 3 June 2010, Szeged, Hungary, held by the Cereal Research Non-Profit Ltd., Hungary and International Foundation for Sustainable Development in Africa and Asia (IFSDDA), Göttingen, Germany.
- KSA members participated in the Pre-Council meetings of Workbodies and the *6th Asian Regional Conference of the International Commission on Irrigation and Drainage (ICID)*, held in Yogyakarta, Indonesia, 11 to 15 October 2010. A Workshop on 12 October was organised

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

During 2010/11 135 students received training as part of KSA 4 projects, of which 78 (58%) were from previously disadvantaged (PD) backgrounds.

TABLE 1

Capacity building through student involvement in KSA 4 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Agricultural Research Council	3	5
Aquagreen Consulting	1	4
Asset Research	0	5
CPH Water	0	1
CSIR	9	14
Institute of Natural Resources	2	2
Rhodes University	4	6
Sigma Beta	4	8
Tshwane University of Technology	8	8
University of Cape Town	0	6
University of Fort Hare	5	5
University of the Free State	5	9
University of KwaZulu-Natal	15	24
University of Pretoria	12	19
University of Stellenbosch	10	19
TOTAL	78	135

Capacity building interventions

Meetings were held with various faculties of agriculture in South Africa in 2010/11 with the intention of improving communication, strengthening the working relationship between universities and the WRC and discussing the way forward in the context of the WRC research and development strategy. Particular attention was given to identifying priority areas for research and co-operation for post-graduate training and building careers for scientists in water related research.

Meetings were held with:

- Dean of the Faculty of Agriculture of the University of Fort Hare, 28 July 2010
- Deputy Vice Chancellor for the College of Agriculture, Engineering and Science of the University of KwaZulu-Natal, 3 August 2010
- Dean of the Faculty of Natural and Agricultural Sciences

- of the University of Pretoria, 31 March 2011
- Director for Research of the School of Agricultural and Environmental Sciences at the University of Limpopo, 11 April 2011
- Dean of the Faculty of Agricultural Sciences at the University of Stellenbosch, 13 April 2011

Knowledge dissemination

- On 8 September the Aquaculture Association of South Africa (AASA) organised an Aquaculture Workshop at the Willows Country Lodge in Pretoria, at which the KSA 4 Director was invited to give a presentation on 'Research initiatives of the Water Research Commission on Aquaculture and Freshwater Inland Fisheries'. This opportunity was used to invite the representatives at the workshop to use the AASA as a channel to communicate research priorities to the WRC.
- During the 3rd African Association of Agricultural Economists and the 48th Agricultural Economics Association

KSA 4: Water Utilisation in Agriculture

of South Africa Conference, held in Cape Town from 19 to 23 September 2010, the KSA 4 Director organised a mini-symposium on 23 September with the topic 'Opportunities for more productive water use and household food security in South Africa'.

- The South African Institute of Agricultural Engineers invited the KSA 4 Director to give a presentation on 'Institutional reform and modernisation of irrigation systems in South Africa' during a Continuous Professional Development (CPD) Event held from 28 to 30 September 2010 at the Pumulani Lodge near Pretoria.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- Presentation on 'Innovations for effective agricultural water management and efficient food production' during the *SANCID 2010 Symposium*, Upington, 16 November 2010.
- Paper and presentation on 'Towards productive water use and household food security in South Africa' during the *6th Asian Regional Conference of ICID* held in Yogyakarta, Indonesia, on 14 October 2010.
- A paper was presented at the *2nd International Seminar of the International Foundation for Sustainable Development in Africa and Asia*, July 2009, held in Göttingen, Germany. All peer-reviewed papers have now been published in a book. The reference is as follows: Backeberg GR (2010). Improving Rural Livelihoods with Rain-water Harvesting and Conservation on Communal Croplands in South Africa: Opportunities and Obstacles. In: Behl RK, Merbach W, Meliczek H and Kaetsch C (Editors) *Crop Science and Land Use for Food and Bioenergy*. Agribios International, Jodhpur, India.
- Following a workshop held in January 2009 as part of

the WRC-initiated solicited research project (No. 1771) on 'Water use of drought tolerant food crops', an issue with selected peer-reviewed papers was published by the *South African Journal of Plant and Soil*. The Foreword to this issue was written by the KSA 4 Director, entitled: 'Underutilised indigenous and traditional crops: why is research on water use important for South Africa?' (*S. Afr. J. Plant & Soil*, 27(4), 291-292).

- The summary and conclusion of the paper presented at the *ICID 6th Asian Regional Conference* in Yogyakarta, Indonesia, entitled 'Towards productive water use and household food security in South Africa' was published as a popular article in two technical magazines: *SABI Magazine* (Volume 3, Issue 2, December 2010/January 2011, 33-34) and *The Water Wheel* (Volume 10 No 1, January/February 2011, 32-33).

IMPLEMENTATION PLAN

Research portfolio for 2010/11

As in previous years, the **primary objective** is to increase household food security, improve livelihoods of people and to increase efficient growth and equitable distribution of wealth 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 of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices

TABLE 2

Overview and description of thrusts and programmes

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.

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

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

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

KSA 4: Water Utilisation in Agriculture

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

<p>Programme 1: Sustainable water resource use on irrigation schemes and within river catchments</p>	<p>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.</p>
<p>Programme 2: Impact assessment and environmental management of agricultural production</p>	<p>Scope: Agricultural decisions to use land and to conserve rainfall or to withdraw water from rivers, dams and boreholes, has 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.</p>

RESEARCH PROJECTS FOR 2010/11 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

Standards and guidelines for improved efficiency of irrigation water use from dam-wall release to root zone application

ARC (Institute for Agricultural Engineering)

No. 1482

The activities undertaken during the course of the project have contributed to local knowledge on issues regarding irrigation water use efficiency. The outcomes have created new knowledge in that:

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator
- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices

The resulting approach that has been documented in the final report therefore still complies with the original proposed improvement process of 'measure; assess; improve; evaluate'. It promotes an investigative approach

to improving efficiency, rather than relying only on water accounting. The main output of the project was the compilation of guidelines for improved irrigation water management from dam wall release to root zone application. The guidelines are aimed at assisting both water users and authorities to achieve a better understanding of how irrigation water management can be improved, thereby building human capacity, allowing targeted investments to be made with fewer social and environmental costs. Using lessons learnt during the WRC project, best practices and technologies were introduced and illustrated.

Cost: R5 742 128 (incl. leverage)

Term: 2004 - 2010

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

Guidelines for sustainable use of grey-water in small-scale agriculture and gardens in South Africa

University of KwaZulu-Natal (School of Biological and Conservation Sciences)

No. 1639

This project was undertaken to provide guidance regarding the conditions under which grey-water use should be allowed or propagated and to provide guidance to users about its sustainable use in small-scale agriculture and gardens. Two main products were produced: a user-friendly Guidance Document and a supporting Technical Background Document which captures the technical information on which the Guidance Document is based and describes the extensive process that was followed to devel-

op the Guidance Document. The Guidance Document is aimed at municipalities, NGOs and informed members of the public who wish to implement grey-water irrigation. The focus of the Guidance Document is to minimise the risks of:

- Illness in handlers of grey-water and grey-water irrigated produce, or consumers of grey-water irrigated produce
- Reduction in growth or yield of plants/crops irrigated with grey-water
- Environmental degradation, especially reduction in the ability of soil irrigated with grey-water to support plant growth

Cost: R1 670 000
Term: 2005 - 2010

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

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

Best management practices for smallholder farming on 2 irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research

University of Fort Hare; University of Pretoria; Zakhe Agricultural Training Institute

No. 1477

The project was conducted in the form of two case studies based in Zanyokwe Irrigation Scheme (ZIS) which uses sprinkler irrigation and Tugela Ferry Irrigation Scheme (TFIS) which uses a short-furrow irrigation system. The main objective was to carry out research in Zanyokwe and Tugela Ferry irrigation schemes with a view to developing and implementing technologies and knowledge useful for farmers in order to improve their livelihoods and those of surrounding communities. Participatory research methodologies were employed where the smallholder farmers and other stakeholders were involved in project activities. Important agronomic and socio-economic (including organisational and institutional arrangements) constraints to crop production on the two schemes were identified and action was taken together with the farmers to address the problem. The need for training of extension staff in irrigation management in order to better support farmers was highlighted. The project had a positive impact on the irrigating and non-irrigating communities of Zanyokwe and Tugela Ferry. The participatory implementation of interventions to address identified constraints, socio-economic factors and water and crop management factors, was to a large extent successful. The findings of the action research agronomic studies clearly indicated that it is possible to significantly improve yields to near-potential levels by

simply improving the crop husbandry practices. It is, therefore, recommended that smallholder irrigation scheme revitalisation programmes should place capacity building in basic crop and irrigation management practices, and strengthening institutional/organizational arrangements, prominently in their revitalisation agendas in any efforts to improve on the performance of these schemes in South Africa.

Cost: R4 500 000
Term: 2004 - 2010

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Definition of process zones and connectivity in catchment-scale NPS processes

University of KwaZulu-Natal; ARC; University of Pretoria; Sigma Beta

No. 1808

This project made use of sediment fingerprinting, geophysical and soil pedological surveys and stable isotopes to study the processes through which water, sediment and nutrients are delivered in a research catchment, with the aim of improving our understanding and ability to predict and model agricultural non-point source pollution. The processes studied include land-based connectivity and stream reach barriers and controls. It was found that the earlier construction of a drainage ditch through the upstream-most wetland has significantly altered the geomorphic and hydrologic connectivity of the catchment. Sediment source was furthermore found to vary as a function of runoff magnitude. The dominant mechanism for nutrient transport in the landscape appears to be in the subsurface, through lateral discharge in the intermediate layer between the sandy soil and bedrock. This relatively short-term study has thus significantly improved our understanding of the processes and controls affecting the transport of nutrients and sediments.

Cost: R722 540
Term: 2008 - 2011

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

Guidelines for irrigation management in pasture production

CSIR (Natural Resources and the Environment)

No. 1650

It is estimated that the total area utilised for irrigated pasture production is approximately 16% of the total area under irrigation. The returns generated from these enterprises make pastures one of the higher value crops produced under irrigation in this country. However, the management of the water requirements of pastures is not easy. They are often established on heavy and shallow soils that would not normally be considered for irrigation. Limited rooting depths and the need to integrate irrigation and grazing management further aggravate the position. Judicious management of irrigation is essential not only to utilise labour and water resources effectively and maintain production and profitability, but also to prevent serious degradation of land. Although management of dairy farming has now attained unprecedented levels of technology due largely to the availability of practical equipment and methods for planning, managing and monitoring most facets of dairy farming, this does not apply to the irrigation of pastures. That still tends to rely on experience and tradition despite the increasing role of pastures in milk production. It appears likely that it will be possible to develop a model or models that can be used to integrate the factors that must be taken into account when planning irrigation strategies and methods. It should also be possible to develop practical on-farm equipment and methods for recording and monitoring performance. There is, however, a dearth of reliable information and data pertaining to pasture water requirements to facilitate these developments. Alternate methods to address this problem therefore need to be investigated and applied in practice in order to increase water use efficiency at farm level. This will be done initially by assessing the application of the main irrigation methods in conjunction with accepted grazing and irrigation management strategies and identifying opportunities for improvement. The 2nd phase would target the development of databases on the fodder crops and their characteristics, climate, soils, irrigation and on the development of methodologies for measurement and monitoring. The validity and practicality of the material and equipment developed would finally be assessed in conjunction with the industry.

Estimated cost: R2 117 600

Expected term: 2006 - 2011

Water use of fruit tree/orchard crops

CSIR (Natural Resources and the Environment)

No. 1770

In summer and winter rainfall areas, water stress in river catchments is increasing. Limited water resources can

constrain development if productivity is not improved. This is particularly important for the fruit tree industry where at least 90% of production is dependent on irrigation. However, there is a lack of comprehensive information of the water use of fruit trees or available information on water use is incomplete and contradictory. Correct knowledge is absolutely essential for drawing up on-farm water management plans for fruit production. The recently-published research reports on water use of citrus and deciduous fruit trees did not provide conclusive results. More specifically it is clear that soil-based measurements present a challenge to obtain accurate and reliable information on water use. Existing models in South Africa can also not confidently simulate water use of fruit trees for different climate, soil, water and management conditions. Therefore, the definite need exists to do intensive research on the tree-based measurements and to design tree-specific models. The purpose of this project is to develop comprehensive knowledge of water-use characteristics and the water use of selected fruit tree/orchard crops for application in fruit tree/orchard management in South Africa. This will require a review of available knowledge on water use of tropical, sub-tropical and deciduous fruit trees/orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic importance, current hectarage, geographic distribution and gaps in knowledge on water use. The main outputs will be reports on the empirical measurement of water use at the selected sites and the development, verification and validation of models for the selected fruit trees/orchard crops. More precise modelling approaches and knowledge of water use will improve management advice to farmers on the productive water use of fruit trees within and between seasons over the productive life of the orchard.

Estimated cost: R4 350 000 (incl. leverage)

Expected term: 2007 - 2013

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 bio-climatic regions in South Africa and suitable for biofuel production

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)

No. 1874

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

requirements. The report of this follow-on project will document the water use and optimal growing conditions for a comprehensive range of potential crops/trees. It will include detailed mapping of suitable production areas and the projected impact of biofuel production on water resources and food supply.

Estimated cost: R5 000 000
Expected term: 2009 - 2015

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)
No. 1773

A large percentage of the South African population is not in good health due to HIV and TB infections, and the health status is further worsened due to under-nourishment. As such the affected members of society are especially vulnerable to diseases; in particular those caused by water and food-borne pathogens. The source of contamination of river water is failing sanitation in, e.g., informal settlements, and failing water treatment in, e.g., non-operating sewage works. This water is often used for irrigation and there is a direct relationship between irrigation water quality and food production, food spoilage and food safety. Food such as fruits and vegetables which are eaten raw, without peeling or washing, or with minimal washing, ready-to-eat and lightly cooked, are the vehicle for transmission of pathogens in the polluted irrigation water. Furthermore, there is increasing concern over the safety of pickers, handlers, packers and farmers, while there is also an increase in the susceptible individuals. A decrease in the food safety of the final agricultural product will negatively affect the trading status of agricultural products, both locally and internationally. The problem of contamination of irrigation water and food products should therefore be seen in the context of stricter local and export requirements and may threaten the continued access to export markets. Biomonitoring of irrigation water quality is currently fragmented and not regularly published. Little is therefore known on a national level regarding the contribution of irrigation water and the associated potentially-contaminated raw produce to the burden of disease. Consequently little action is taken to remedy the situation. A clearer understanding of the problem is urgently required to make inputs for policy formulation and regulation to reduce contamination of irrigation water. This project will investigate the links between irrigation water quality (microbial and nutrient chemistry) and food safety in commercial as well as subsistence agriculture and give guidance towards treatment options of irrigation water to ensure food safety. This research project will therefore evaluate the extent of the problem

regarding contamination of both irrigation water and raw food products, endeavour to establish links between the two and provide recommendations on the way forward in terms of treatment of irrigation water. To achieve this, the main tasks include a baseline study on the extent (types and quantities) of contamination found in irrigation water as well as contamination found on the irrigated raw produce (fruit and vegetables) before and after harvest at the selected sites. The final report will document the extent of contamination found in irrigation water and on the irrigated raw produce; the links between contamination on raw produce and irrigation water applied; and make recommendations for further research in respect of validation of results and treatment options.

Estimated cost: R5 232 500 (incl. leverage)
Expected term: 2007 - 2012

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 - 2012

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, consump-

tion 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: R4 419 200
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

Agro-forestry systems for improved food production through the efficient use of water CSIR (Natural Resources and the Environment) **No. 1480**

Less than 15% of land area in South Africa is arable. This implies that there is very limited scope for conventional food production, both on irrigated and dry-land. In addition to limited arable land, South Africa is a water-scarce country. Its rainfall is below the world average, and its distribution is somewhat unreliable. The relatively low rainfall and limited arable land make it imperative to effectively and efficiently use these natural resources for food and fibre production. This is even more important for emerging and subsistence farmers who often lack access to information and use of production technologies. Smallholder agriculture, particularly in Africa, has been faced with land

degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a 'shift' from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands. In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor. This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally. Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale), incorporating local knowledge through participative assessment

Estimated cost: R3 250 000

Expected term: 2004 - 2009

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services

ASSET Research; University of Stellenbosch; CSIR

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 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 000 000

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: R4 999 100
Expected term: 2009 - 2015

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

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

The effect of the introduction of agroforestry species on the soil moisture regime of traditional cropping systems in rural areas. Phase II: On-farm trials of alternative agro-forestry systems

CSIR (Natural Resources and the Environment)

No. 1351

One of the major constraints in rural farming systems of the Upper Thukela is the shortage of adequate and good quality grazing during the dry winter season. Unfortunately, supplementation of feed using commercial supplements is difficult because the supplements are expensive and not easily available in remote areas. Provision of alternative sources of fodder such as tree leaves and pods can increase production. The introduction of tree species for fodder should decrease the grazing pressure on the existing grassland. This will result in improved basal cover, decreased soil erosion and promote greater water infiltration. The project aims are:

- To determine the effect of different agro-forestry systems on increasing fodder production in rural farming systems
- To determine the effect of agro-forestry practices on soil water availability to traditional crops (e.g. maize)

- To determine whether the inclusion of trees in traditional cropping systems can enhance the infiltration of rainfall and prevent soil loss
- To compare the water use of an indigenous fodder tree (Acacia karoo) and an exotic fodder tree (Morus albus), in order to test the hypothesis that indigenous fodder trees are more conservative water users than exotic tree species.

Estimated cost: R2 400 000 (incl. leverage)
Expected term: 2002 - 2011

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the KwaZulu-Natal Province

Zakhe Agricultural College

No. 1465

Approximately 74% of South Africa's rainwater is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exerts even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention should be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods should be analysed.

Estimated cost: R3 000 000
Expected term: 2003 - 2009

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

No. 1478

Approximately 74% of South Africa's rain-water is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exert even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 200 000

Expected term: 2004 - 2010

Nutritional value and water use of indigenous crops for improved rural livelihoods

University of Pretoria (Centre for Nutrition)

No. 1579

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (WRC Report No. 944/1/04). It is also important to determine the nutritional value and water requirements of these crops. The best combination, between indigenous crops and a range of home-grown vegetables and other foodstuffs, to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conserva-

tion for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (WRC Report No. 1267/1/04). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosa, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of a combination of food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households. An interim report on the outcomes of this project has been published: WRC Report No. TT 362/P/08, Nutritional Status of South Africans: Links to Agriculture and Water).

Expected cost: R5 700 000 (incl. leverage)

Estimated term: 2005 - 2010

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)

No. 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on biophysical aspects of in particular infield RWH&C has been done (see WRC Report No. 1176/1/03). A start has also been made to evaluate the social acceptability and economic viability of this technique (see WRC Report No. 1267/1/04). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the United Nations Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low-potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use

local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R3 100 000 (incl. leverage)
Expected term: 2006 - 2011

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 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

Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)

Umhlaba Consulting Group

No. 1776

Water harvesting and conservation practices have been tested and demonstrated to be sustainable and contribute to food security. Many of these techniques and practices have been documented in the form of research reports and information material for public interest, but not packaged as training material for the end user. In addition, advisors and farmer support personnel such as extension services are often ill-informed and inadequately trained in agricultural water management including water harvesting and conservation. High illiteracy, particularly among the rural population, limits the ability of farmers to access information and utilise new technologies. There is, therefore, a need for accredited yet appropriate training material for certified trainers and learners (farmers). Training, education and skills development will need to follow a broad-based approach that is aligned to government initiatives such as the Joint Initiative on Priority Skills Acquisition (JIPSA) and grounded on Outcomes Based Education (OBE) and Adult Basic Education and Training (ABET) principles. This project will develop a comprehensive learning package for the application of WH&C for household food production and poverty alleviation in rural areas. It will identify the existing unit standards for training in WH&C and fill the gaps in learning material by adopting and adapting available material and developing a comprehensive package (NQF level 4/5 facilitators guide for trainers, ABET levels 1 and 2 learning material for learners and assessment guide). The learning package will be tested in the field with trainers, facilitators and learners.

Estimated cost: R1 950 000
Expected term: 2007 - 2012

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.

Estimated cost: R1 890 000
 Expected term: 2008 - 2012

Empowerment of women in rural areas through water use security and agricultural skills training for gender equity and poverty reduction

University of KwaZulu-Natal (School of Environment Sciences)

No. 1878

The joint document published in 2008 by the Department of Agriculture and Land Affairs, the Land and Agrarian Report Project (LARP), among other things, prioritises the revival of agricultural production by 10 to 15% in former homelands where valuable fertile land lies fallow. This plan is complemented by the objectives of the Department of Water Affairs, which seeks to, among others, ensure reliable and equitable supply of water for sustainable economic and social development including the eradication of poverty. 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 because of gender bias in land allocation, access to credit, 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 report will identify skills required by women in agriculture (farming and non-farming activities within the food-value chain). The report will furthermore highlight the incentives of secure water and land entitlements which enable women to increase food security and reduce poverty at the household level.

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

Programme 2: Integrated water management for profitable farming systems

Water resource management for profitable small-scale farming along the banks of the Orange River

University of the Free State (Department of Agricultural Economics)

No. 1354

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of

technology, access to markets and financing methods and procedures will be clearly defined. According to the Provincial Department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment. The main aim of this project is to develop an appropriate methodology to successfully establish small-scale irrigation farmers in South Africa. Sub-aims are to:

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme
- Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land.

Estimated cost: R970 000
Expected term: 2002 - 2010

Revitalisation of provincial fish hatcheries and training facilities to promote profitable aquaculture

Rhodes University (Department of Ichthyology and Fisheries Science)

No. 1580

A baseline study on the Contribution of Aquaculture to Rural Livelihoods in South Africa has been done by Rhodes University (WRC Report No. TT 235/04). This study showed that the present factors constraining aquaculture in rural areas were mainly a consequence of a lack of policy and institutional capacity and that the development of rural aquaculture will depend principally on a public sector led intervention, inclusive of technical support and fingerling supply. The study revealed that there are many state-owned hatcheries and training facilities falling under various government departments that are unproductive, privatised, or defunct. Though not assessed these assets are worth millions of rand. Based on the survey results it was further agreed that the involvement of the private sector in rural aquaculture would be essential for sustainable growth. As policy issues were being addressed by the National Department of Agriculture, it was suggested that the WRC should support the undertaking of workshops in preparation for participatory action research (PAR) with the various public and private sector stakeholders to appraise the potential role of these hatcheries in the

light of emerging policy, and where applicable to develop a framework for a community private public partnership (CPPP) to revitalise government hatcheries that are currently under-utilised. The workshops have been completed and the PAR can now proceed. The PAR is a process which includes research and implementing goals and objectives. Stakeholders in the Limpopo, Mpumalanga and Eastern Cape Provinces will be engaged and an end-point will be identified (for example, through CPPP revitalising a specific government hatchery). Once the end-point has been identified, the role of the PAR implementers would be to actively facilitate and record the process, so that it is successful and repeatable elsewhere.

Expected cost: R4 500 000 (incl. leverage)
Estimated term: 2005 - 2010

Development of training material for extension in irrigation water management

University of Pretoria (Department of Agricultural Economics, Extension and Rural Development)

No. 1649

The revitalisation of irrigation schemes and irrigation management transfer is accepted policy in South Africa (Department of Agriculture, 2003). Implementation of this policy can, however, not succeed without extension support. In the process of integrated development planning (IDP), extension services are also the essential link between government and rural communities who are dependent on agriculture. In both cases extensionists therefore perform an important function to promote agricultural development, which in turn leads to community development. 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 specifically emerging farmers, are dependent on extension services as a source of information and knowledge. This has been confirmed by a survey amongst emerging irrigation farmers (WRC, 2003). 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 has become less effective. Presently information is available on various biophysical and socio-economic aspects of irrigation management. Irrigation-related courses are also presented by universities and colleges. However, this information is not presented in the required format and the courses are not specifically targeted to be useful for extensionists in their work environment. Extensionists therefore do not have the appropriate knowledge base and skills to do their work. In many cases this results in a lack of confidence amongst extensionists, decline in their credibility and withdrawal from the community which they must serve. There is an urgent need to restore the self-esteem of individuals and improve the service delivery of

the extension profession. Extensionists require in-service training on all aspects of irrigation management, to meet the demands of subsistence, emerging and commercial smallholder farmers. Training material must be developed or adapted for this purpose. This will enable extensionists to become more effective, with the benefits not being limited to farmers only, but having a positive impact on the community in which extensionists and farmers live.

Estimated cost: R2 370 000 (incl. leverage)
Expected term: 2006 - 2011

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

WSM Leshika (Pty.) Ltd.

No. 1778

According to the National Water Resource Strategy of 2004, national water conservation and demand management (WC & DM) strategies are being developed. The strategy for irrigated agriculture provides a framework of regulatory support and incentives to improve efficiency, with a plan of action towards delivering amongst others the following outputs:

- Implement measures that reduce wastage
- Convince users to progressively modernise their water conveyance infrastructure and irrigation equipment.

The recently-published Water Conservation and Water Demand Management Conditions for Water Use Sector Authorisation (DWAF, 2006) imposes a duty to measure, record aspects of water use and requires that 'the licensee shall measure the amount of water supplied to each farm or user on a monthly basis using an appropriate flow measurement device'. The WRC has published reports and guidelines for the direct and indirect measurement of water on irrigation schemes in response to the practical need to measure and manage water effectively and efficiently. However, in most cases the water management system currently in operation does not incentivise water measurement, and consequently measurement of water use and volumetric charging is not widely practised. This project will facilitate a process towards effective implementation of water measurement at river, irrigation scheme and farm level in South Africa. In order to achieve this, end users of water measurement technology will be made aware and convinced to adopt the technology. Specific attention will be given to technical constraints and financial justification for implementation of the technologies for water measurement. This will require purposeful capacity building and training of end-users such as farmers while using the model of 'train-the-trainer', which has been found to be most successful. In this process a common understanding of the practical requirements of water measurement by

water users, water managers and regulators will have to be reached. Therefore it is necessary to obtain support of the DoA and DWA on training for adoption of water measurement. Since water user associations (WUAs) will increasingly provide an advisory role, the managers of WUAs and leader farmers whom they serve, will be targeted in order to achieve sustainable implementation of water measurement. The intention is to interact with these stakeholders as part of the preparatory phase; determine the incentives for water measurement as part of the analysis phase; and practically demonstrate how to undertake effective water management in the implementation phase. The final output of this technology transfer project will be an overarching report that documents the implementation process, the lessons learned and guidelines towards general implementation of water measurement.

Estimated cost: R1 400 000
Expected term: 2007 - 2011

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

University of the Free State (Department of Agricultural Economics)

No. 1779

The contributions of agriculture to the economy are mainly food production, creation of employment and earning of foreign exchange. The strategic goal of the Agriculture Sector Plan in South Africa (2001) is more specifically to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural industry. According to the Presidential Imperative Programme on Integrated Sustainable Rural Development, the goal is furthermore to promote development and improve the quality of life of marginalised groups and communities, amongst others by alleviating poverty through employment creation. In order to generate employment and income to reduce poverty, it is also recognised that a wide-ranging programme is required to develop agriculture. This includes improved food security through livestock husbandry and rain-fed or irrigated crop cultivation, as well as improvement of skills to earn non-farming income in agro-industries. However, in the current dual agricultural economy, the question arises: how can emerging producers be included in the mainstream of the economy? Only by obtaining access to available resources or assets in agriculture, can an impact be made to improve rural livelihoods, in particular for vulnerable groups such as the rural poor. In this regard the concept of the value chain can be used to better understand the links between farming and non-farming activities in agriculture. This project will apply value chain analysis for optimising economically-beneficial water use in agriculture in order to integrate commercial and emerging farmers in the mainstream of the economy. It will investigate whether emerging farmers, who are

producing a combination of rain-fed or irrigated field and vegetable crops, can obtain better market access. On the basis of water resources which are common to all, and water as a production input in farming and non-farming agriculture, it will be determined how emerging and commercial producers can be integrated through value chains and thereby promote economic development. The main outputs will be: firstly, a conceptual framework based on the literature review of the value chain analysis with specific reference to water utilisation and competitiveness in agriculture; secondly, demonstration of the application of the conceptual framework for commercial and emerging agriculture in the horticultural and field crop industries; thirdly, empirical analysis and modelling of selected value chains in commercial and emerging agriculture with specific attention to mapping of water use at critical points in the value chain, optimisation of water use in the whole value chain, mainstreaming of marginalised participants in the economy by integration in the value chain, employment creation and poverty reduction through the value chain, and improving competitiveness in the value chain.

Estimated cost: R2 430 000
Expected term: 2007 - 2012

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; South African Sugarcane Research Institute; University of the Free State

No. 1805

Numerous options are being considered to address the over-allocation of water in catchments. This ranges from improvements in the efficiency with which water is used and managed, to the reduction of alien invasive plants in catchments, to the building of new dams or transfer schemes. However, even though the measures listed above will help address the over-allocation to some extent, it is likely that existing lawful users may need to be curtailed (i.e. have their water use licences reduced) in order to address the over-allocation. The general aim of the project is to evaluate the impact of curtailment of existing lawful water use on the economic and financial feasibility of irrigation farming. In the selected catchment of the Crocodile River in Mpumalanga Province, the current water situation will be assessed to determine the causes of water stress in the catchment. This will be done by reviewing available documents and reports and through discussions with DWA and the CMA. The ACRU and Mike Basin models will be configured to represent the current water users, water resources and operating rules in the catchment. This component can be described as catchment-scale hydrological modelling. The SKELETON model will be further developed to link with the Mike Basin irrigation module. In

particular the influence of the variable availability of water on optimum crop combinations and farming viability will have to be determined. This part of the modelling can be described as the farm-scale economic modelling. The integrated ACRU/Mike Basin/SKELETON model will be applied to evaluate the outcome of various curtailment scenarios. A report will be produced to document the findings for the Crocodile River specifying the potential impact of curtailments and changes in operating rules to support sustainable irrigation farming in future.

Estimated cost: R1 790 000
Expected term: 2008 - 2011

Technology transfer on the technical aspects and cost-estimating procedures of surface and sub-surface drip-irrigation systems

ARC (Institute of Agricultural Engineering); NB Systems; University of the Free State

No. 1806

Irrigated agriculture is the single largest user of water in South Africa. With expansion of domestic and industrial water use, competition for the existing lawful use in irrigation will increase. The National Water Act of South Africa (Act 36 of 1998) requires equitable, efficient and sustainable use of available water by all user sectors. Drip-irrigation is considered to be the most efficient method of irrigation. The increasing application of drip-irrigation systems necessitates the correct economic analysis and choice of not only the dripper, but also the filtration equipment to ensure that the water is used efficiently. The WRC has published 4 different reports on drip-irrigation. The results of these reports created useful information for the cost analysis, choice, operation and maintenance of drippers and filtration equipment. It is of the utmost importance that the results of these projects are disseminated by means of technology transfers and training sessions with designers and farmers. The main aim of the technology transfer project is to facilitate a process towards effective implementation and usage of surface- and subsurface drip irrigation systems in terms of technical and economic principles. To achieve this aim, the project will be undertaken in 5 distinct phases of preparation; testing and analysis; compilation of guidelines; technology transfer and a process of knowledge dissemination. The technology transfer phase will consist of organising courses for designers to train them in the selection and usage of surface- and subsurface drip irrigation systems with respect to the technical and economic principles and organising of field days for farmers, irrigation managers and trainers to present the principles of economics, operation and maintenance of drip and filtration systems and to practically demonstrate it to participants. The output of the project will be a manual with guidelines for costing, selecting, operating and maintaining surface and sub-surface drip-irrigation systems.

Estimated cost: R1 485 400
 Expected term: 2008 - 2011

Analysis of food-value chains in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy

University of KwaZulu-Natal (Institute of Natural Resources)
No. 1879

The inclusion of subsistence and emerging farmers in the mainstream of the economy is a nationally identified priority. Structural and cyclical obstacles must be overcome to accomplish this. These are mainly the dualistic nature of the agricultural economy and the recent occurrence of food shortages with high input costs. Although expectations are high for subsistence farmers to enter the market, experience shows that technical and business skills are required to obtain access to assets in agriculture by entering food-value chains. With high poverty levels and increasing unemployment, there is also a need to ensure growth with equity and therefore impacting on a wider group of people to promote rural economic development. Achieving this is a real possibility, since on the demand side there are different value chains, with consumers demanding food in different marketing outlets. On the supply side there are a large number of rural inhabitants, which includes groups who can be broadly categorised as subsistence, emerging and commercial farmers, who can potentially respond and enter any one or a combination of these value chains. The productive use of water in the value chain for both rain-fed and irrigated food production is of particular importance. The project will investigate factors such as needs and aspirations, technical capabilities, risks of crop production, food price expectations, water use security and incentives to increase water productivity which influence the decision of what value chain to enter and the degree of success obtained. The report will highlight innovative ways to promote integration of subsistence, emerging and commercial farming in food-value chains for crop and animal products with use of rain- and irrigation water.

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

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

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

Managing salinity associated with irrigation in selected areas in South Africa

University of the Free State (Department of Soil, Crop and Climate Sciences)
No. 1647

Because crops use water consumptively it is an inevitable consequence of irrigation that the salts in irrigation water are being concentrated in the soil. Since crop yield, in turn, is reduced at high soil salinity levels, it is a prerequisite for sustainable irrigation (and to protect the soil resource base) that soil salinity be managed to remain at levels that support acceptable crop yield. Current practice is to achieve this by applying water in excess of crop requirement, whereby some of the accumulating salt is leached from the root zone. The practice to leach salt from soil, which ensures the sustainability of irrigation from an agricultural perspective, has the undesirable side-effect of salinisation of ground and surface waters. The negative impact irrigation return flows have on water quality is observed in practically all irrigation schemes. Because of the negative impact that 'irrigation wastewater' (leachate and drainage water) has on other water resources, there is an increasing range of initiatives that are being investigated both locally and internationally to improve the way in which to manage this impact at both farm and scheme level.

Even though there is concern about the environmental impact of irrigation, the need for increased agricultural production and assurance of supply seem to necessitate the continued expansion of irrigation on a global basis. In view of the increasing demand for water resources and irrigation's relative inability to compete with other sectors for high quality water sources, it is foreseen that in the case of South Africa the future expansion in irrigation area will increasingly have to rely on poorer quality water. By making use of poorer quality (waste) water, irrigation would also be able to free up better quality water for other productive uses. However, such a move will make even greater demands on the ability of irrigators and water managers to manage salinity and its effects on crops and environment. It is thus clear that the sustainability of irrigated agriculture will to a large extent be determined by our collective ability to manage the problems associated with salinity. Much of the success of such management strategies will depend on the success with which the 'wastewater' can be utilised within irrigated agriculture. Although much in this regard has already been learnt locally and internationally, the practical application of these lessons is lagging behind. It is thus envisaged to conduct a project that would synthesise current knowledge and select the appropriate practices for application and testing in a number of case study areas with existing problems. It is anticipated that this evaluation would enable the development of specific guidelines for the management of the case study areas with as aim to bridge the gap between existing knowledge and its application, the formulation of generalised recommendations about the implementation of sustainable solutions to the management of salinity on irrigation schemes, the identification of incentives that can be applied to modify the behaviour of water managers at

farm and scheme level and the identification of research or knowledge gaps.

Estimated cost: R2 480 000
Expected term: 2006 - 2010

Methodology to monitor the status of water logging and salt-affected soils on selected irrigation schemes in South Africa

ARC (Institute for Soil, Climate and Water)

No. 1880

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

Estimated cost: R3 693 800
Expected term: 2009 – 2014

Programme 2: Impact assessment and environmental management of agricultural production

Modelling non-point source (NPS) pollution in \ agriculture from field to catchment scale

Aurecon SA (Pty.) Ltd.

No. 1516

It is increasingly recognised that non-point source (NPS), or diffuse pollution, plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore increas-

ingly accepted that it is unfeasible to properly manage water quality without addressing the contribution from non-point-sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. Since most of the land area is utilised for agricultural activities, agriculture has both locally and internationally been implicated as a major source of NPS pollution. It is therefore necessary to assess the contribution that the different agricultural activities make to the different manifestations of NPS pollution, to devise the means through which these can be controlled and to determine and predict the effect that control measures will have to reduce NPS pollution. Understanding the production, delivery, transport and use components of agriculture-derived NPS loadings of water resources and having a predictive ability about the fate of agriculture-related NPS constituents are discrete research themes that will enhance the usefulness of the existing guidelines in the agricultural domain. The contribution of irrigation activities towards the salinisation of water resources has been studied for quite some time and is currently still receiving attention. Other water quality issues of concern that are potentially aggravated by agricultural activities are eutrophication (through fertiliser leaching and wash-off from human settlements), sediments (as a result of erosion), pathogens (from intensive animal production units), pesticides (through the application of insecticides, fungicides and herbicides) and some heavy metals. Although agricultural activities that give rise to the latter water quality issues have been the subject of previous studies, the present level of knowledge concerning them is not as advanced as for irrigation-induced salinisation of water resources. The project will address those issues that require priority attention, with regard to NPS pollution.

Estimated cost: R5 000 000
Expected term: 2004 - 2009

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

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)

No. 1646

The South African climate is highly variable over short and longer periods. This inter- and intra-seasonal variability is likely to be amplified by the global change in climate. Agricultural production is intrinsically linked to climate variability. Many agricultural decisions are made based on climate (short, medium and longer term) information and assumptions. Farmers need information to help them plan for planting, irrigation and harvesting of their crops. Weather forecasting can aid users to make more informed decisions and assist in planning activities. They have the potential to reduce risk in the long term and improve water-use efficiency. Forecasting involves computer models,

observation and knowledge of trends and patterns. Using such tools, meteorologists can reasonably forecast weather conditions up to 5 days in advance. Longer lead-time forecasts (weeks, months) are referred to as climate forecasts. Such forecasts, usually made in terms of categories (above, near and below normal) and probabilities, are becoming more skilful as research progresses. However, gaps exist between the weather and climate forecasts and linking them to agro-hydrology and applications in agricultural decision-making. The project aims to develop techniques and models for translating forecasts of up to 1 year in advance into applications for decision support.

The WRC has funded several projects over almost 2 decades on research on climate variability with a focus on forecasting, modelling and database development. These include inter alia:

- Development of a Raster Database of Annual, Monthly and Daily Rainfall for Southern Africa (WRC Report No. 1156/1/04)
- A Flood Nowcasting System for the eThekweni Metro: Volume 1 and 2 (WRC Report No. 1217/1/04 and 1217/2/04)
- Spatial interpolation and Mapping of Rainfall (Simar): Volume 1 – 3 (WRC Report No. 1151/1/04; 1152/1/04 and 1153/1/04)
- Regional Model Development for Simulating Atmospheric Behaviour and Rainfall over Southern Africa (WRC Report No. 1261/1/05)
- Dynamic Modelling of the Present and Future Climate System (WRC Report No. 1154/1/04)

These and other projects have resulted in more comprehensive datasets and a better understanding of weather and climate variability and refined forecasting tools. It is therefore in the interest of the WRC to see this research utilised. The 2001 Strategic Plan for South African Agriculture states that one 'component of the comprehensive risk management strategy is an early-warning system that includes adequate access to and utilization of timely, accurate, relevant, and free information about the weather'. Since the end of 2002, the National Department of Agriculture has been advising farmers on climate conditions and practices to follow, based on a long-term climate outlook. It is envisaged that this project will develop an early warning system with different lead-times that could reduce farmers' susceptibility to adverse weather conditions. Although the project will focus on 2 or 3 critical catchments, the findings of this study will be extrapolated to other catchments.

Estimated cost: R5 700 000 (incl. leverage)
Expected term: 2006 - 2011

The impacts of unpaved access roads on runoff, sedi-

ment fluxes and soil water movement within timber plantations

Aquagreen Consulting; University of KwaZulu-Natal
No. 1807

Despite wide acceptance that access roads in timber plantations are important hydrological pathways that affect the volume and distribution of overland flow and corresponding sediment fluxes, there is little quantitative information to account for this process in South African catchments. Water flowing unrestricted on unpaved road surfaces directly to the stream network is effectively lost to forestry compartments and potential uptake by tree roots, which in turn has a bearing on timber production. The main aim of the project is to evaluate the direct contribution of unpaved forestry access roads as a potentially ready source of runoff and sediment through physical on-site measurements and modelling at the plot and road segment scale. Based on field assessments done in close co-operation with the forestry industry, 2 catchments will be targeted for further monitoring and detailed modelling. Each of the catchments will represent a different bioclimatic zone, have varying ages of timber stands and have different soil types. Once the target catchments have been identified a detailed geographic information (GIS) coverage of the soils, topography, age, species and size of forestry compartments, extent of the riparian zone and the stream and road networks will be sourced or developed. Based on the findings of the modelling, verified by actual measurements, a research report will be produced on the feasibility of redirecting runoff from access roads to down-slope forestry compartments and practical strategies that could be used by the industry to accomplish this.

Estimated cost: R1 700 000
Expected term: 2008 - 2011

Impact of wastewater irrigation by wineries on soils, crop growth and product quality

ARC (Infuritec, Nietvoorbij)
No. 1881

The Department of Water Affairs is considering the issuing of a general authorisation (GA) for the irrigation of agricultural crops, e.g. vineyards, with treated and augmented winery wastewater. This GA entails that the wastewater be treated to a specified quality standard, before storage in irrigation dams and mixing with raw irrigation water. In order to attain the specified wastewater quality standards, it is envisaged that wineries will adopt cleaner production approaches and replace chemicals that are detrimental to soils and crops with chemicals that will produce a wastewater rich in essential plant nutrients. Irrigation with the wastewater would thus be comparable to fertigation. While the effects of most of the winery constituents on soils and crops are fairly well known and

their effect on soils and crops can thus be predicted with a fair degree of confidence, the same cannot be said for the organic content of wastewater, as measured by its chemical oxygen demand (COD). This project will consequently investigate the sustainable use of winery wastewater for irrigation of vineyards with respect to the effect it will have on soils, vineyard performance and wine quality. While the study will focus specifically on the effect of COD, it will also consider the effect of salinity, pH, sodium adsorption ratio (SAR), nitrogen, phosphorus and potassium contained in the wastewater. The research output will promote the beneficial reuse of winery wastewater, and the reclamation and protection of soil and water resources. This will inform legislation on wastewater management regarding regulations that promote the beneficial use of wastewater for productive purposes and lead to improved industry guidelines and practices for managing winery wastewater.

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

Adaptive interventions in agriculture to reduce vulnerability of different farming systems to climate change in South Africa

University of Cape Town (Climate Systems Analysis Group)
No. 1882

South Africa has a high risk agro-hydrological environment which is likely to be exacerbated under conditions of climate change. It is widely recognised that ongoing changes in climatic conditions will generally have an adverse effect on, amongst others, agricultural production, biodiversity and water resources. Agriculture is a key sector in the economy with regard to rural livelihoods and food security and it is therefore vital to proactively 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 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 000 000
Expected term: 2009 - 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

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

University of Pretoria (Department of Human Nutrition)
No. 1954

One of the main food security challenges facing South Africa is the need to increase the ability of vulnerable groups to meet their minimum daily requirements for adequate nutrition. More research is thus needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices. It is important to know what food crops are currently available but also what alternative food crops can be considered that will address the nutritional imbalances. In order to improve nourishment of people, supplements are required over the short-term; fortification over the medium-term; and better nutrition behaviour over the long-term. Information is available on what people should be eating but not what people are actually eating. There is a need to understand the linkages between diet, nutrient intake, foods, crop and animal products, processed and unprocessed food products. In addition, very little local knowledge is available on nutritional water productivity (i.e. nutrition per volume water expressed as nutritional units (kJ of energy; grams of protein; RE for vitamin A; mg of Fe or Zn) per m³). Both water and fertiliser management will determine the productivity of water and quality of crop food products. The contradiction between rural poverty, food insecurity, inadequate nutrition and under-utilisation of natural resources raises a number of funda-

mental research questions. Clearly, there is an important need to understand the aspirations of people to bridge the gap between, for example, usual and adequate nutrition, food intake and food demand. This scoping study seeks to understand the gaps in knowledge before formulating more focused research project(s).

Estimated cost: R1 000 000
Expected term: 2010 - 2010

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

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

Baseline and scoping study on the development and sustainable use of storage dams for inland fisheries and their contribution to rural livelihoods

Rhodes University (Department of Ichthyology and Fisheries Science)

No. 1957

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

Estimated cost: R2 000 000
Expected term: 2010 - 2014

Programme 2: Integrated water management for profitable farming systems

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

KSA 4: Water Utilisation in Agriculture

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

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

Development of technical and financial norms and standards for drainage of irrigated lands

ARC (Institute of Agricultural Engineering)

No. 2026

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

Estimated cost: R4 000 000

Expected term: 2010 - 2015

Programme 2: Impact assessment and environmental management of agricultural production

Improving the livestock carrying capacity with rain-water harvesting and conservation on grasslands for extensive and/or intensive livestock production and biogas generation from manure in rural areas of South Africa

University of KwaZulu-Natal (Department of Grassland Science)

No. 1955

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

Estimated cost: R5 000 000

Expected term: 2010 - 2015

Investigation of the contamination of water resources by agricultural chemicals and the impact on environmental health

CSIR (Natural Resources and the Environment)

No. 1956

Agricultural activity is potentially a source of a number of hazardous chemicals in water resources. Concerns have been expressed that some of the pesticides used in agricultural practice for crop spraying and animal disease control may enter and pollute the rivers and dams and cause endocrine disrupter effects in animals and humans that use the water for drinking and recreational purposes. A scoping study (WRC Report No. 1774/1/08) indicated that there is no clarity on the extent and level of contamination of water resources by agricultural products with ED (endocrine disrupting) properties. However, a number of WRC studies have been done identifying different chemicals in different areas that are hazardous as well as having ED properties. Some studies identified EDCs in water resources and indicated ED effects in sentinel species in and around contaminated water resources. Most of these

studies in South Africa are not specifically focused on the link between the chemicals used in agricultural practices and the impact on human health with water as a pathway. This research report will document the impact which agricultural chemicals have on human and animal health. Guidelines will be compiled for South African authorities to direct the safe use of agricultural chemicals in water resource management.

Estimated cost: R4 109 825
Expected term: 2010 - 2015

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