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Report to the Australian International Food Security Research Centre (AIFSRC), ACIAR **March 2013**

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# Assessing research priorities for blue water use in food production in southern and eastern Africa

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# Foreword

The African Union's New Partnerships for Africa's Development (NEPAD) and its Comprehensive African Agricultural Development Program (CAADP) argue that the agricultural sector must grow on average by 6% per annum to play its role in Africa's development and the alleviation of poverty. They recognise the substantial gap that exists between agricultural potential and agricultural productivity must be bridged.

Bridging this gap requires not only identifying the necessary agricultural inputs, systems, services, government policy and private sector support; it equally requires farmers to adopt these inputs and services into farm practice. The Australia International Food Security Research Centre is working with researchers, policy makers, the private sector, NGOs and civil society to understand how to better achieve this adoption - at higher rates and over a shorter period of time.

This report is a contribution to this understanding. Irrigation development is considered a major strategy for adapting to climate change and has been identified as a mechanism to help lift Africa's agricultural productivity and reduce the current yield gaps. It is high on the agenda of many national governments and sub-regional organisations. However, benefits to farmers from irrigation use have not delivered the expected water productivity levels and past irrigation schemes have failed to deliver adequate returns with market integration and water governance remaining weak in many regions.

In this context, it is essential to first make sure that lessons learned from past irrigation activities are understood and applied to new activities to ensure they adequately meet expectations of enhancing food security and reducing poverty in the region.

This report explores the causes behind past poor performances in irrigation and presents the case for a new irrigation research agenda for Sub-Saharan Africa, emphasizing that both top-down organisational reform and bottom-up technology push are necessary for lifting irrigation productivity. The report, based on a six month scoping study, examines possible barriers to improved productivity and profitability along the value chain of irrigation production. As per their brief, the authors have recommended priorities for investment and identified mechanisms to increase the capacity of farmers, organisations and governments to adaptively manage water and contribute to meeting food security needs. They present a case for participatory on-farm water monitoring and Innovation Platforms comprising farmers, political representatives and players across the market value chain to identify institutional and market constraints and to stimulate opportunities for change.

We are pleased that the knowledge captured in this report has already been utilised in developing an ambitious new project aimed at stimulating positive change, "Increasing irrigation water productivity in Mozambique, Tanzania and Zimbabwe through on-farm monitoring, adaptive management and agricultural innovation platforms".

I wish to acknowledge the work of the authors and their colleagues in their respective agencies for the commitment and enthusiasm in which they approached the project, and for the high quality report they have produced.

Mellissa Wood
Director, Australian International Food Security Research Centre (AIFSRC)
ACIAR

# 1 Executive Summary

An estimated one in three people go hungry in Africa, the region with the largest proportion of people living in poverty. At the same time the agricultural potential of Africa is enormous, in terms of uncultivated farming land, reserves of exploitable water and in the levels of productivity that can still be achieved. Irrigation is under-developed in Sub-Saharan Africa, and could potentially make a significant impact on food security. Agricultural production is high on the agenda of national governments. Yet the existing irrigation schemes in the region have performed below expectations due to technical and governance problems, and water scarcity in key river basins.

This scoping study was commissioned by the Australian International Food Security Research Centre (AIFSRC) in May 2012, following its establishment in October 2011, to assess how the development of blue water resources can address the food security needs of the most vulnerable populations. We are asked to recommend priorities for Australian investments in irrigation research for development in Africa.

This study was undertaken by the UNESCO Chair at The Australian National University, CSIRO (both based in Australia), together with the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN; based in South Africa). The project was focussed on southern and eastern Africa as regions where Australia has longstanding engagements with national institutions and centres, specifically, on the agricultural programs under the auspices of CAADP in nine countries: Botswana, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe. This report includes the results of a literature review, assessment of African agricultural policies, consultations with key African experts and visits to key countries.

Our assessment identified a number of potential entry points for Australian investments in irrigation research. First, all indications are that the area of land equipped for large scale irrigation will increase rapidly in the near term, through the intervention of multilateral donors. Irrigation development is thought to have reached just 20% of its potential across the region and is considered a major strategy for adapting to climate change. At the other end of the scale there may be opportunities to enhance existing programs for delivering domestic water to supply household food gardens.

An emerging trend for Africa, which has already had major impact in Asia, is the use of small motorised pumps to exploit shallow ground water. Farmers who traditionally grow rain-fed crops can produce under irrigation in the dry season, creating new income opportunities. The great benefit of groundwater is that it responds much more slowly than surface waters to drought and is therefore a buffer against climate variability. Groundwater also covers large spatial areas, and if used sustainably provides opportunities for farmers to diversify their livelihood strategies without the social dislocation and land ownership problems that plague new surface water schemes.

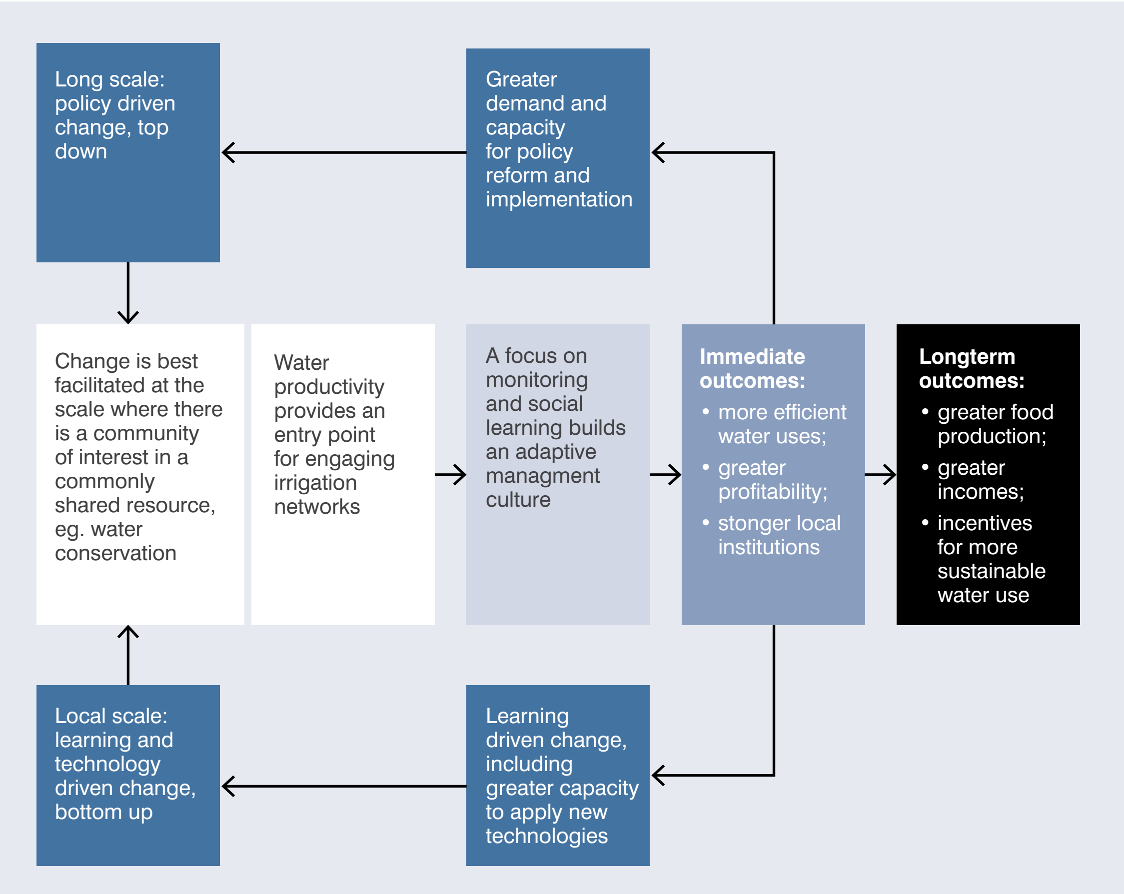
African governments are embarking on a massive expansion in irrigation without fully addressing the reasons why many previous schemes have been unsuccessful. It is essential that the mistakes of the last irrigation expansion of the 1960s to 1980sare not repeated, where low profitability did not allow the on-going investment into infrastructure and the associated institutions that govern equitable and sustainable use. Both a bottom-up technology push and a top-down organizational reform are necessary for lifting irrigation production. We report how the unfolding CAADP process has vast potential for focusing governments on rural development but turning these aspirations into on-ground action is a huge challenge. We recommend investment in a theory of change that recognises that if the technology is the hardware and the institutions are the software: these must work together if the whole system is to be more productive, equitable and sustainable.

Our theory of change is outlined in Figure 1. In order to implement this, we propose the scale of intervention as a water user association (blue outline) or other kind of community irrigation farmer organisation. This scale captures the interests of the community in terms of the shared resource and infrastructure, and also represents the financial interests of farmers who are making a living from irrigation. Enhancing these local institutions reinforces social capital and can be a force for equity. Furthermore we propose that the adaptive management approach is the methodology of choice when trying to bridge institutional and technical innovation (green outline). The issues raised by the water user association frame the problem in terms of their long term goals (purple outline), the policy and institutional environment (top down) and the current technology and aspirations of the farmers (bottom up). Problem framing helps the scientists to determine which aspects of the system need to be monitored in order to structure learning across the network. The information from the monitoring and subsequent learning fosters the intermediate outcome of building capacity in the local institutions and the skill of the farmers (red outline).

There are two key feedback loops. The first loop is directed upwards as the water user association better understands their requirements and obligations and articulates for better investment of funds or reform of policy. The second loop is directed downwards as farmers see how their practices impact individually on productivity and collectively on sustainability. This creates the awareness and appetite to employ better skills and technology. The process works towards the longer term outcome which includes more productive resources use, profitable and sustainable irrigation schemes and greater food security.

There are a number of 'equally right' options for investment in research and development in and ties to Australia, our recommended first priorities are: Mozambique, Tanzania, and Zimbabwe. Three more countries were identified as second tier priorities where work could be usefully undertaken should funds allow: Ethiopia, Malawi and Zambia.

**Figure 1. Recommended pathway to implementation.**



# 2. Context

## 2.1 Project background

The largest proportion of people living in poverty is in Africa, where an estimated one in three people go hungry. At the same time the agricultural potential of Africa is enormous, in terms of uncultivated farming land, reserves of exploitable water (in some areas) and in the levels of productivity that can still be achieved. Irrigation is under-developed in sub-Saharan Africa, could potentially make a significant impact on food security, and is high on the agenda of national governments. Yet the existing irrigation schemes in the region have performed well below expectations due to technical and governance problems, and water scarcity in key river basins.

This scoping study was commissioned by the Australian International Food Security Research Centre in May 2012 to assess how the development of blue water resources can address the food security needs of the most vulnerable populations following the establishment of the Centre in October 2011 with resources of AUD $36 million over four years (Gillard, 2011). We are asked to recommend priorities for Australian investments in irrigation research for development in selected Eastern and Southern Africa countries by addressing the following objectives:

1. Assess and recommend to the Australian International Food Security Centre a strategy for investment in blue water use in food production in selected southern and eastern African countries for up to five years;
2. Identify potential contributions from research on water and food for poverty reduction, food security, sustainability, climate change adaptation and enhanced governance on subjects where Australia has a comparative advantage;
3. Identify the added value of Australian investment and co-benefits for Australia and recipient countries;
4. Identify interventions that will improve the food security of the most people, especially poor people in situ through better water management;
5. Recommend priority countries for investment.

Food security through rural development is a central pillar of the Australian Government's support for developing nations. In particular, the government has established the Australian International Centre for Food Security that has an initial focus on Africa. The research in this study supports several of the AIFSRC's thematic and cross-cutting programs. It is of particular relevance to food availability (Program 1), since it should enable increased sustainable food production and better natural resource management by small-scale farmers, as well as enabling policies to enhance productivity. It also relates to the cross-cutting program of building resilience in food systems (Program 6), as the study incorporates aspects of training and assisting famers to deal better with climate variability and change.

This six month scoping study was led by the UNESCO Chair in Water Economics and Transboundary Water Governance at The Australian National University, in partnership with CSIRO and the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN).

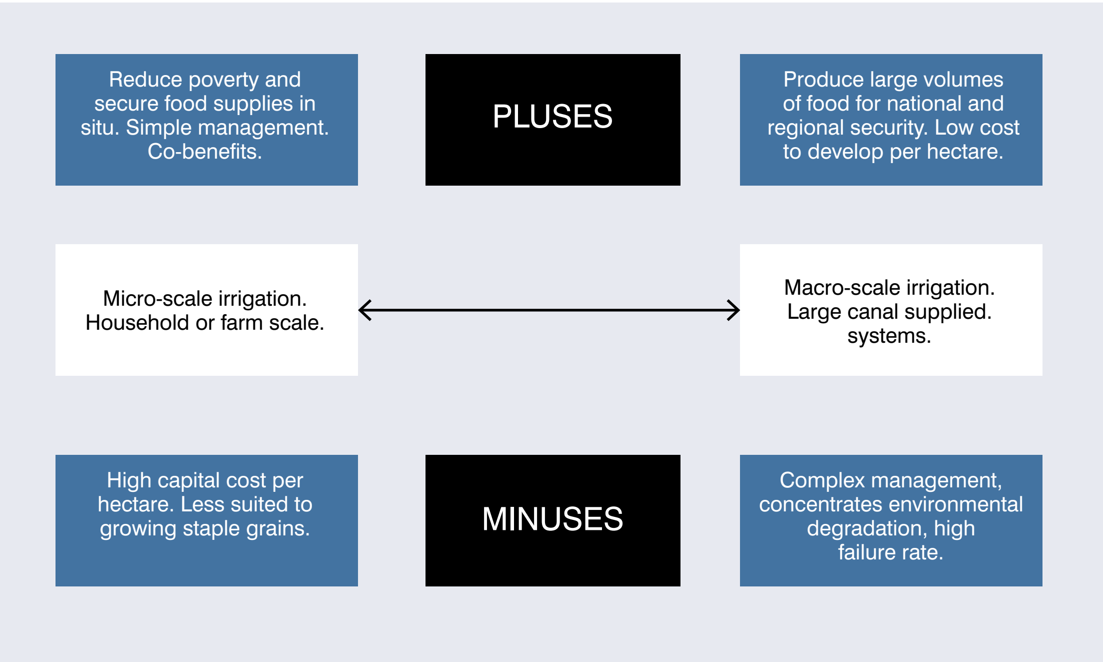
## 2.2 Conceptual issues

There is potential for irrigation and rainwater harvesting to improve food security in the context of sustainable river basin management. Dry land agricultural production relies on transpiration of rainfall, known as "green water". Irrigated agriculture involves the capture, storage and supply of water from aquifers, rivers and storages, referred to here as "blue water" (Falkenmark & Rockstrom, 2006). Waste or "grey" water may also be reused in agricultural production. AIFSRC mandated this project to focus on blue water.

Irrigation systems are varied in scale and in the application of technology that have implications for food security and poverty reduction (Figure 2). Lankford (2009) classifies irrigation into four types of technologies: small-scale technologically simple systems, small-scale smallholder-owned canal systems, pressurised irrigation systems built as donor- or government-sponsored smallholder schemes, and rehabilitated or newly-built large-scale canal systems as externally-funded smallholder schemes.

At the smallest scale there is the capture and storage of water around a home for application to a household garden. A modest increase in domestic supply to water a garden is often advocated as a cost effective first step up the 'water ladder' (van Koppen et al 2009). At the individual farm scale rain water may be collected in small dams or tanks, pumped from shallow groundwater or diverted from local schemes. Treadle pumps have been promoted as one mechanism for doing this (Lankford 2009). At these individual scales the institutional complexity in managing the water supply is very low and this water access may have many co-benefits in providing water for uses such as drinking, bathing and washing (that are not considered in agricultural economic assessments of deployment of these technologies). These are also technologies that may boost water supplies where people live across the landscape and thus increase local food security and reduce poverty. In section 4 we outline a number of lessons from programs promoting small-scale irrigation development. Yet these approaches are also criticised as very expensive per hectare of irrigated land and less suited to production of staple grain crops (Lankford, 2009).

**Figure 2. Spectrum of irrigation scale and technology versus policy objectives.**



At a medium scale of development are irrigation schemes based on pumping ground water or village-scale surface water systems which have the advantages of modest institutional complexity and some potential for dispersal across the landscape to minimise perverse environmental impacts while distributing food production over many locations. The largest, commercial scales of irrigation involve large canal systems commanding thousands of hectares with water often supplied from regulated rivers. Such schemes are the cheapest per hectare to construct and can supply large volumes of food to markets, yet as outlined in section 3 (below) they often fail to give adequate return on investment. Reasons for these failures include: an inability to link produce to profitable markets required to generate funds for re- investment in operating costs; deployment of technologies for which there is insufficient local expertise to readily maintain; unreliable energy supplies to operate key equipment; organisational complexity and failure; and a build-up of waterlogging or salinity that is difficult to manage at these large scales. Further, such large scale schemes are restricted to limited, suitable geographic locations and thus will not directly reduce poverty or increase food security in regions of a country that are physically unsuitable for such development.

Thus “food security” through irrigation can have different meanings and requires definition. Food security is defined by the Food and Agriculture Organization (FAO) as: “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.”[1] Agriculture and food security is one of Australia’s three sectoral priorities for assistance to Africa, with support to be “closely aligned with the African Union’s Comprehensive Africa Agriculture Development Programme” (CAADP) (AusAID 2010). The Australian International Food Security Centre says that: “Food security is underpinned by having sustainable, healthy food systems in place in-country, and access to regional and global food systems, including through trade. Improving food security requires improving the three interrelated elements of availability, access and utilisation.”[2]

The Australian Government emphasises that: “Climate change also looms as a major threat to food security and water resources” (AusAID 2010).

Irrigation for food security as part of poverty reduction through subsistence agriculture at a local scale requires an emphasis on technologies that may be applied at smaller scales in a broader range of localities where people live. AusAID’s focus on food security for adaptation to drought in the Horn of Africa appears to emphasise this approach. Alternatively, production of staples to secure food supplies and lower food prices at a national or regional scale suggests an emphasis on irrigation technologies that can be applied at key locations at a large scale. This is being proposed in a number of African countries that are not currently priority countries for AusAID, for instance, in Tanzania. The Australian International Food Security Centre says that: “Australia is supporting African efforts to improve food security by boosting long-term agricultural productivity and building resilience, while meeting the immediate needs of vulnerable people when humanitarian crises occur,”[3] suggesting that both strategies may be supported. Similarly, AusAID states that:

“Australia’s approach to food security is centred on increasing the availability of food through production and improving trade, while also increasing the poor’s ability to access food. Australia has prioritised three pillars to improve outcomes in food security:

- Lifting agricultural productivity through agricultural research and development
- Improving rural livelihoods by strengthening markets and market access
- Building community resilience by supporting the establishment and improvement of social protection programs.”[4]

In section 5 we outline CAADP and other agricultural policies of African governments which could be seen to favour large-scale irrigation developments. Consequently there are decisions the Australian Government and its African partners need to take as to what scale and type of irrigation technologies to invest in depending on the type of food security desired and the model favoured for poverty reduction. We begin to address these choices in section 3.

1 http://www.fao.org/cfs/en/, accessed 15 November 2012.
2 http://aciar.gov.au/aifsc/food-security-and-why-it-matters, accessed 15 November 2012.
3 http://aciar.gov.au/aifsc/food-security-and-why-it-matters, accessed 15 November 2012.
4 http://www.ausaid.gov.au/aidissues/foodsecurity/Pages/home.aspx, accessed 15 November 2012.

Greater water productivity is a priority in many regions of Africa where water is scarce or fully exploited, and where there are competing users, such as fisheries. By 2050 it has been estimated that water availability in North, Eastern and Southern Africa will fall below 1000 m3/capita/year, with the situation in West Africa only a little better off (Rijsberman 2006) and a growing number of river basins in Africa are closed (Smakhtin 2008).The Great Ruaha River in Tanzania was examined as part of this study and provides one such example of the trade-offs between increasing agricultural production versus the other ecosystem services supplied by a healthy river.

Consequently, this research was directed at helping Australian agencies consider how they may aid irrigated agriculture in Africa while drawing on water resources more sustainably.

## 2.3 Gender

Gender equity is a priority of Australian support for developing countries and this section considers its intersection with irrigated agriculture. Since the early 1970s when Esther Boserup began diagnosing the gendered nature of agricultural production systems, the significance of women's roles in agriculture in the developing world has become increasingly clear. Tools and techniques exist for mapping, analysing, and auditing gender. Incorporating gender into research and development has been approached from the point of view of efficiency (a better return on donor investment); equity (women should get their fair share); and empowerment (only a change in the balance of power will improve women's access and control of productive resources). Women have been trained, capacitated, and facilitated yet their lack of control of resources and limited voice in decision making processes continues to inhibit development.

### Great Ruaha River basin

*Of the 29 million hectares considered suitable for irrigation in Tanzania only 1 % is currently utilised. President Kikwete is a major supporter of agricultural expansion, backing the "Kilimo Kwanza" Transforming Agriculture plan. The most recent Five Year Development Plan commits to expanding irrigation areas from 330,000 hectares at present to 1,000,000 hectares by 2015/16. Tanzanian officials say that the scale of their land and water resources and their strategic location provides an opportunity for Tanzania to become a food basket for the Great Lake and other East African countries.*

*In south west Tanzania the upper Great Ruaha River basin is an area targeted for irrigation expansion as part of the Southern Agricultural Growth Corridor plan. In the river headwaters, 46% of the 1.5 million residents live in poverty. The average income is US$0.80 per day and it is a largely agriculture-based economy. Yet downstream of this area the river passes through the Usangu wetlands and Ruaha National Park before reaching the Mtera and Kidatu hydropower dams. The 284 MW power stations on the river generation nearly half of Tanzania's electricity. Between 1970 and 2002, the area devoted to irrigation increased from 10,000 ha to 45,000 ha. As a result, from 1993 river ceased to flow for an increasing period of time during the dry season (July – November). This had serious economic consequences as hydropower generation was reduced resulting in power rationing and blackouts. Further the lack of flows through Ruaha National Park impacted on wildlife and the tourism industry. In March 2001, Prime Minister Frederick Sumaye announced "that the Government of Tanzania is committing its support for a program to ensure that the Great Ruaha River has a year round flow by 2010" (Kashaigili, Rajabu, & Masolwa, 2009).*

*The conflict between agricultural production and river flows to downstream users is highlighted in a key tributary of the upper Great Ruaha River (visited for this study). Average flows on the Mbarali River are 16m3/s and irrigation users are already permitted to divert 12 m3/s. The government has supported the commencement of construction of an off-take canal for the proposed Mwendamtitu irrigation scheme, which would divert 6 m3/s to irrigate 3,000 ha. Yet the Rufiji River Basin Office confirmed that it has refused to issue a requested permit for this scheme as it would further dry out the river. There are currently limited ways of measuring water diversions for irrigation in the Great Ruaha River Basin and no effective incentives for farmers to use water more productively.*

Women's roles in food production in Africa are well documented. Since the last decade, FAO has shown the world that women produce over 70% of the food grown in Africa. Yet gender, the role expectations society has of men and women, continues to challenge and inhibit food security in Africa.

According to the World Bank (2009), food security has three main elements: availability of food, access to food and utilization. Given women's roles in providing food and water for families and households, their contributions to food security are significant. What is more difficult to know is how best to amplify women's voice in planning and decision making so that their constraints and needs are met. Farmers are a very diverse group, with their own particular goals, objectives and priorities, which change as time passes. Women farmers are the same, with no one approach adequate to address the needs of all women in a country, community or scheme.

This scoping study focuses on irrigation and options for increasing water use efficiency. Yet caution is advised, as development history is rife with examples of unintended consequences and elite capture of project benefits (World Bank 2009). While site and culture specific solutions must be generated, there are some basic practices for gender sensitive water investments.

The first and most well-known best practice is to accurately diagnose the gendered division of labour in agriculture in the local setting. In addition to actually seeing and verifying women's participation in agricultural production activities (land preparation, seeding, weeding, etc.) it is necessary to discern women's access to and control of productive resources as well as disposal of produce. Planners and implementers can—and do—make assumptions about these issues, based upon previous experience, leading to misdiagnosis.

Athukorala and Fernando (2012:104) identify improving women's "water literacy" as a minimum requirement for gender appropriate water-related developments. This entails enhancing women's knowledge and understanding of technical, legal and social aspects of water management and existing governance arrangements. They suggest that a foundation of water literacy allows women to make more informed choices, identify options, and understand where and how to apply pressure for more equitable access to water-related decision making processes.

Research and donors (van Koppen, et al 2009; World Bank 2009) now suggest that in order to maximize benefits to all users, design, implementation and governance of water projects should accommodate the reality of multiple-use systems. Such systems fit better within rural livelihood systems and can help combine different approaches to achieving food security.

Another critical aspect of gender awareness in irrigation related projects is ensuring equitable participation in water user associations (WUAs) or other decision making bodies. Quotas naming specific targets of women may reach equity in numbers, but equitable voice and contribution cannot be mandated. Criteria for membership in WUAs should be examined for discriminatory aspects, including membership only for landholders, which women might not be. Discrimination may happen by definition, when terms like irrigators or farmers are applied only or first to men and not the women who may undertake the bulk of day to day decision making and activities in a plot.

Women play significant roles in irrigation, food production and food security in eastern and southern Africa (World Bank 2009). The main challenge now is to remove barriers to their full participation in planning, implementation and decision making in irrigation. This suggests that all actors within the irrigation network be aware of prevailing gender issues and be equipped with strategies for amplifying women's voice and increasing their roles in decision making and control of resources. This study includes an assessment of the opportunities for greater gender equity in our country by country assessments (Appendix) with a view to applying the steps to reduce discrimination in follow up work.

## 2.4 Methodology

This scoping project was undertaken by combining the water and agricultural expertise of participating staff at The Australian National University and CSIRO (based in Australia), together with the agricultural expertise and networks of researchers and government members of the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN; based in South Africa). The project was focussed on Southern and Eastern Africa as regions where Australia has longstanding engagements with national institutions and centres on consideration of the agricultural programs under the auspices of CAADP and of nine countries: Botswana, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe.

Our research combined a number of parallel efforts. For section 3, CSIRO led a global literature review on the status, lessons and opportunities for enhancing productivity from irrigated agriculture in Africa, to identify areas where Australian supported research may add most value.

To draw on further experience from small-scale irrigation development, for section 4, FANRPAN assessed the outcomes of the Challenge Program on Water and Food that it led in the Limpopo Basin of southern Africa to derive lessons for further research. Placing these lessons in the context of CAADP and other agricultural policies of African governments, in section 5 FANRPAN assessed the agricultural policies of multilateral institutions in Africa and of the nine countries considered in more depth, enabling an initial selection of issues and places for intervention.

A range of African experts was consulted during the project, including consultation with experts from neighbouring countries in South Africa in August and visits by team members to a number of African countries in September 2012. Our initial conclusions were tested in a consultation session with African water and agricultural experts at a conference in South Africa in November 2012 and subsequently refined. The resulting analysis of issues for Australian support for irrigated agriculture in Africa is discussed in section 6, pointing to added value in funding work for more efficient use of water in irrigation in order to secure food production, including by enhancing adaptive management and profitability of irrigation schemes.

This analysis led to the selection of three African countries for further work, namely: Mozambique, Tanzania and Zimbabwe. For each of these countries a more detailed assessment was undertaken by team members and local experts to identify the current status of irrigated agricultural production, key institutions and opportunities for further work to enhance water-efficient production. These are in section 7. Our conclusions are then detailed. A separate project proposal has been prepared for AIFSRC’s consideration to follow up key elements of this research.

# 3 The case for a new irrigation research agenda for sub-Saharan Africa

## 3.1 Introduction

Over the past fifty years, increases in global food production have been able to outstrip population growth. Asia has been the star performer, with per capita food production doubling over the period. Africa on the other hand, shows no real progress. Food production per capita today is similar to what it was in 1961 and food imports have steadily risen. Total cereal production has increased more or less in line with population, but this increase is almost entirely due to cropping more land, not increasing yield per unit area. In Southern and Eastern Africa, per capita yields have even declined slightly over the last few decades (Pretty el al. 2011).

The Green Revolution package of improved varieties, agrochemicals and irrigation that has so impacted the rest of the world, has largely bypassed Africa. Even the two simplest ingredients of the package – improved varieties and fertiliser – have yet to have major impact. Irrigation is the hardest part of the package to implement successfully because of the high costs of developing irrigated land and the inability to generate sufficient profit to cover recurrent operation and maintenance expenses. Moreover the investment in irrigation can only be fully reaped once the other elements of the production package are in place. There is little point in adding water to low fertility soils growing low yielding varieties.

Irrigation also must also support a governance component that is not required for rain-fed farming. Water must be allocated, infrastructure maintained, fees collected and conflicts resolved. Government world-wide are handing over these responsibility to farmer groups, and Africa is struggling through this transition (Shah et al 2002). Typically, a large numbers of small holdings make up a scheme, so the transaction costs are large and these cannot be supported by the generally low productivity so common in sub-Saharan Africa. The food crises of the mid 1970's sparked the development of new irrigation schemes around the world, but the rate of new development has steadily declined. Lending to sub-Saharan Africa for irrigation projects from the World Bank dropped significantly due to perceptions of disappointing performance, and the vicious cycle of low cost recovery leading to lack of maintenance resulting in poor water productivity (World Bank undated).

The most recent food crisis has revived interest in irrigation in sub-Saharan Africa (SSA), especially in the light of FAO estimates that SSA has attained just 20% of its irrigation potential. It would seem that there is a critical role for irrigation to play in the on-going food security crisis, yet the costs of irrigation development in SSA are often reported as higher than anywhere else in the world and the performance of the irrigation schemes worse (Jones 1995). So can increased investment in irrigated agriculture really form a part of the food security plan for sub-Saharan Africa? What would this investment look like and what should the accompanying research agenda be to get the best food security and environmental outcomes from investment in irrigation?

## 3.2 Increasing supply: Exploiting more surface water

The governments of SSA face a distressing set of problems. The number of food insecure people nearly doubled in the 30 years post 1980 to 240 million (IFAD 2010). Many countries fall well short of national food sufficiency and calorific intake across the region is 20% below the world average. The Global Hunger Index, which combines under nutrition, low child weight and child mortality rates, reports numerous SSA countries in the serious and alarming categories (IFPRI 2011). These statistics translate not only into physical suffering, but also predispose the next generation to learning difficulties and disease.

The yields of rain-fed staple crops are low in SSA countries and the national annual production fluctuates widely, reflecting the difficult and highly variable growing environment. The potential role of irrigation to increase and stabilise food supply seems obvious and the comparisons with Asia inescapable. For example South Asia irrigates almost 40% of it cultivated land, whereas SSA irrigates just 4% (You et al 2010; Svendsen et al 2009). This proportion increases to 5 % when adding informal irrigation such as flood recession cropping, cultivated wetlands and spate irrigation (diversion floodwaters over extensive areas of floodplain).

The low development of irrigation in Sub-Saharan Africa does not appear to be rooted in scarcity of resources. The size of the renewable water resource on a per capita basis is slightly above the world average, but the exploitation of this water much lower. In fact the average global consumption of water is four to five times greater than the consumption by sub-Saharan Africans. The New Partnership for African Development (NEPAD) argues irrigation area needs to expand by 6% per year with an annual injection of $42 billion (quoted in Lankford 2005). This is six times the current rate of increase and governments of Africa and the donor community are now looking at serious new investments in irrigation infrastructure (Svendson et al 2009).

The political will to invest must be matched by a robust understanding of the size of the resource to be developed. The FAO AQUASTAT database estimates the total annual renewable water resource (TARWR) for each county, which is the sum of both surface water and groundwater resources. Surface water is made up of inflows to rivers and lakes and includes river flow entering from countries upstream less their obligation to supply a certain minimum flow to downstream countries. Renewable groundwater is estimated as the annual recharge to aquifers. When viewed as a whole, SSA utilises just 1.5 % of its total renewable resource, of which almost 90% goes to the agricultural sector. This is in stark contrast to North Africa, which currently consumes over 250% of its TRWR through over exploitation of groundwater reserves.

The TARWR can be a misleading figure. Places where water is abundant require little irrigation, whereas water resources in dry areas are often over-exploited. A country such as South Africa consumes 25% of its TRWR and is considered severely water stressed. In fact 25% would seem to be an upper limit of consumption, and even this requires major engineering works and inter-basin transfers. Averages are also highly misleading in hydrology, because in flood years the water cannot be used. Conversely, droughts can stretch over many years and over-exploited basins will fail to provide the minimum flows needed sustain ecological functions. Total dam capacity in SSA of is about 80% of the world average, equating to about 15 % of the average annual river discharge (Svendsen et al 2009). However much of this water is contained in a small number of large dams which are primarily used for hydro power generation, not irrigation.

You et al (2010) conducted an extensive modelling exercise to evaluate the NEPAD vision of increasing the irrigated area from 12 to 20 million hectares across SSA. They compiled a 10 km grid GIS map to show productivity of different crops and combined this with a hydrological model and an economic model. The hydrological model calculated runoff as the maximum potential supply of water. They separately calculated the potential new irrigable areas from dam-based systems and for small-scale systems. For dam-based systems, the irrigable land was limited by the topography and delivery costs around the dam site itself. For small-scale systems, the limit was the amount of available runoff water, and the constraint that irrigated areas had to be within five hours travel time to a local market.

Assuming a development cost of $3,000/ha for dam-based systems and $2,000 /ha for small-scale systems, they calculate that an extra 22 million ha could be irrigated, giving and internal rate of return on investment of at least 6%. The calculations incorporate a number of conservative assumptions, such as an overall irrigation efficiency of 0.4, attainable yields of 30-80% of the potential and that 30% of dam capacity was available for irrigation. These investment prices are low compared to other studies and probably only attainable if the cost of the dam was paid for by another sector, such hydropower generation. When You et al (2010) doubled the per hectare investment cost, the area that could be profitably irrigated dropped by nearly 50%. Nevertheless this area of irrigable land is above the ambitious NEPAD target, so at first cut the land and water resources do not seem to be the limiting factors.

## 3.3 Paying for irrigation infrastructure

Despite the renewed interest of large donors to invest in irrigation infrastructure, development costs in Africa have historically been higher than elsewhere. Jones (1995) reported that the average cost of irrigation development in sub-Saharan Africa was $18,000/ha compared to $4,800/ha in the rest of the world (1991 prices). This alarming statistic stimulated a major review by IWMI to confirm these figures and then to try to explain them (Inocencio et al 2007). They analysed 314 irrigation projects from Africa and around the world to try and tease out the factors that contribute to cost and performance of irrigation schemes. Inocencio et al (2007) then compare the case studies in SSA against the case studies from other developing countries which were drawn from the Middle East, Asia and Latin America.

The study showed that the average cost of new irrigation projects in SSA was $14,500/ha compared to $6,500/ha in the other developing regions, more or less confirming the common perception. Not only were the development costs higher, but the probability of a successful project in SSA was 56% compared to an average of 72% in the other regions. The condition for 'success' was set at projects which produced an Economic Internal Rate of Return (EIRR) greater than 10%, which is widely accepted by donors as the threshold for public investment.

High costs combined with high failure rates seem to spell doom for irrigation investment in SSA. However if the irrigation projects were divided into those considered a success and those considered failure, it may be possible to diagnose and overcome the problems. The calculation of EIRR takes into account the total cost of the development, operation and maintenance costs and returns due to water provision over the lifetime of project (assumed 30years) and the gestation period of the investment.

When projects considered a failure on EIRR grounds were eliminated from the case studies in SSA, the investment costs per hectare were markedly lower. The cost of successful new construction projects dropped from $14,500/ha to $5,700/ha in SSA and in the rest of the regions from $6,500 to $4,600. This suggests that irrigation projects in SSA are not intrinsically more expensive than everywhere else. It appears that the costs are skewed by a group of expensive projects at a development cost of over $20,000/ha that failed to reach the threshold EIRR. Projects in SSA were also smaller in size, developed in much drier regions requiring more water per hectare (700 mm vs 1200 mm in the other regions) and in very poor countries with higher costs for doing business. All these factors appear to contribute to higher costs (Inocencio et al 2007).

The cost of all new projects studies declined in SSA from $18,000 in the 70's to $9,000 in the 90s (other regions the change is just from $7,000 to $6,000/ha). At the same time the EIRR increased in SSA on new construction projects from 6% in the 70's to 25% in the 90's and the success rate in SSA increased from 42% to 86% over the same period. What factors have contributed to this success?

Firstly, successful projects had greater effort put into appraisal, implementation and supervision by donors, and this has eliminated some of the more spectacular failures of the early years. Secondly, the tasks of operation and maintenance shifted from solely the responsibility of government more fully involving the farmers. Thirdly, successful projects had a greater share of the total costs allocated to the 'software' components. The 'hardware' of irrigation projects represents the engineering infrastructure, whereas the software includes better technical assistance, design and management in construction phase as well as better agricultural support, institution building, training agency staff and farmers after construction (Inocencio et al 2007).

Although the greater spending on the software component could almost double the costs of the entire project, the investment was more than rewarded by the improved performance and hence the higher EIRR. Increased farmer contribution to the project was also correlated success, not because it reduced the costs significantly, but because it improved subsequent project performance. Other factors correlated with success were projects that used both surface and groundwater, a shift towards horticultural crops and a shift towards development in wetter sites (Inocencio et al 2007).

## 3.4 Managing demand: Using current water more efficiently

The supply side of the irrigation equation, i.e. providing more water infrastructure, is the easiest option for increasing food supply from irrigation. It is favoured by politicians because it makes for highly visible new development activities and by donors because it is amenable to the usual planning, monitoring and evaluation protocols. Addressing the demand side for water is more difficult. Here the aim is to derive more economic benefit from the same amount of water or the same benefit from a reduced supply by addressing inefficiencies in the existing system.

Consider a typical situation where water is delivered to the farm through open unlined channels. On reaching the farm, the water may be stored in a small dam before being moved to individual fields in earthen canals. Then water is applied to the crop by flooding the field. Water is lost at each of these three steps through leakage, evaporation and drainage. For example it would not be unusual to lose 20% of the water in conveyance to the farm and a further 30% when storing and moving water around the farm. Since it is difficult to uniformly replenish the rooting zone by flood irrigation, a further 40 % can be lost through drainage below the root zone and water running of the end of the field. The biggest loss is often through direct soil evaporation, where half the water applied to the field can be lost before it is transpired.

Since each of these losses is in series, the overall efficiency is the product of each of the individual steps in getting water from a dam to a transpiring leaf (Hsaio et al 2007). In the above example, just 17 litres would be transpired of the 100 litres that were released by the dam. However, not all losses are the same. Perry et al (2009) divide up the gross withdrawal from the dam into beneficial consumption by the crop via transpiration and non-beneficial consumption via weeds and soil evaporation. The proportion of water withdrawn from the dam that is not consumed is divided into water that makes its way back to the river or groundwater and thus can be recovered, and water that is not recoverable because it ends up in salty or inaccessible aquifers.

Modernising the irrigation system by piping water, using a pressurised irrigation system will dramatically cut non-beneficial consumption and non-recoverable return flows. Planting the right varieties on time, scheduling irrigation, supplying nutrients and protecting crops completion from weeds and attack from pests and disease can double or even quadruple yields. When putting the engineering and agronomic aspects together, remarkable improvements can be attained. Hsaio et al (2007) calculate that if each of the steps in the chain from dam to final harvest fell into the 'poor' category, we might only grow 24 grams of food from every 1,000 litres of dam water. However if each step was elevated into the good practice category, each 1,000 litres could produce 1,220 g of food.

The 50 fold difference between good and bad practices makes one wonder why there would be such a focus on simply doubling the area of irrigated land – the so-called "supply" solution. The reason is that addressing many of the inefficiencies is expensive and rarely cost effective when the price of water is low. Furthermore, improving yields through better on farm water and agronomic management requires an enormous effort in training. The local knowledge and capacity to provide such training is very short supply.

It seems that irrigation schemes inevitably go through a lifecycle starting with an exploitation phase and only moving into a conservation phase when water becomes a limiting resource. As the supply becomes scarcer still, a scheme moves into the reallocation phase, where water use shifts to more profitable users (FAO 2012). This could be mean changing from irrigating stable crops to horticultural crops or competition from other sectors for water, such as mining, industry or domestic users. SSA is still largely in the exploitation phase.

## 3.5 Big is beautiful?

One of the main findings of Inocencio et al (2007) was that the success of an irrigation project was strongly dependant on the total cost which, from the case studies, was strongly correlated with project size. Large projects almost by definition are cheaper on a per hectare basis simply because the infrastructure costs can be divided over a much larger area. Projects in SSA were on average only one sixth of the size of those in the other regions, and this flowed through to higher cost and ultimately lower internal rates of return, leading to the suggestion that 'big is beautiful'.

Although there are efficiencies in scale when conducting engineering works, the situation plays out quite differently from a hydrological perspective over the longer term. For example the Chokwe irrigation area on the Limpopo River in Southern Mozambique is one of the largest schemes in southern Africa. It covers an area of 34,000 ha, but 11,000 ha have been abandoned because of waterlogging and salinity. Of the remaining 23,000 ha, only 7,000 hectares (21%) are actually being used because infrastructure has fallen into disrepair, and was further damaged by the floods in February 2000 and January 2012. Estimates are that Chokwe needs $45 million just to upgrade the existing infrastructure (Chilundo et al 2004).

The Islamic Development Bank is funding the repair work on 7,000 ha and the Chinese government has plans to repair a further 10,000 ha, but no scheme can rely on outsiders to keep bailing it out. It is expected that once 20,000 ha are under cultivation, and farmers pay $108 /ha for the water, the scheme could pay its way. However, the farmers will need to lift their current rice yields from 4 to 6 tot/ha to be able to afford such charges.[5]

But what of the remaining 14,000 hectares, mostly affected by salinity and waterlogging? It is one thing to rebuild canals and dig out the surface drains, but dealing with high water-tables presents a problem of a different order. The heavy salt laden soils along the southern area of the scheme have low hydraulic conductivity and are very difficult to drain. Growing one crop of rice per year using 10 ML/ha across 20 000 ha of Chokwe using Limpopo water at 300 mg/L salt means that 60,000 tonnes of salt are added to the land each year. If all this salt can be flushed back to the river, the system or parts thereof will continue to fail.

This story has been repeated all over the world. For example, the cheapest way to expand irrigated land in the lower Murray of South Australia was to develop along the river. In the Loxton area irrigation was developed over a naturally saline water table approaching the level of sea water. Within two decades the extra hydraulic loading from irrigation started to push this salty water into the river, increasing the daily discharge from 10 to 100 tonnes of salt per day. Since 1980 the MDBC have spent over $200 million in salt interception schemes to counter this (Newman et al 2012). The lesson is clear: over the time period that internal economic rates of return are calculated, big schemes make a lot of sense because they are cheaper to construct. Yet schemes that drown in their own salt either because of bad locations or simply because of their own size have far greater costs down the line.

Whereas Chokwe is by far the largest scheme in Mozambique, the country has developed 159 schemes coving 118,000 ha. Although there is significant potential to increase this area, 66% of the land with existing irrigation infrastructure lies unused. About 5% of the area is comprised of relatively small schemes of less than 50 ha and here the unused portion is just under 50% (Chilundo et al 2004). The trend seems to be - the larger the system, the greater the problems. In contrast, the small wetland and 'dambo' hydrological settings common in Mozambique are intensively used by smallholder farmers, particularly when located near markets. Although tiny in scale and with huge variations in water availability during the year, these systems are well exploited by farmers. One of the main findings of Inocencio et al (2007) was that the success of an irrigation project was strongly dependant on the total cost which, from the case studies, was strongly correlated with project size. Large projects almost by definition are cheaper on a per hectare basis simply because the infrastructure costs can be divided over a much larger area. Projects in SSA were on average only one sixth of the size of those in the other regions, and this flowed through to higher cost and ultimately lower internal rates of return, leading to the suggestion that 'big is beautiful'.

5 See: http://allafrica.com/stories/201205290141.html, accessed 26 November 2012

## 3.6 New opportunities for irrigation development

At this point there is conflict between the high level assessments which favour big schemes on rivers and empirical evidence that smaller schemes can function better. Attention has recently shifted towards the more widespread groundwater resource. There are several advantages here for small scale irrigators. Farmers who traditionally grow rain-fed crops can produce under irrigation in the dry season, creating new income opportunities. They could also provide supplementary irrigation to rain-fed crops when rains fail during part of the cropping season. The great benefit of groundwater is that it responds much more slowly than surface waters to drought and is therefore a buffer against climate variability. Groundwater also covers large spatial areas, and if exploitable provides opportunities for farmers to diversify their livelihood strategies without the social dislocation and land ownership problems that plague new surface water schemes.

Understanding the size of the groundwater resource and the rate at which groundwater is replenished is the first step in developing a strategy for sustainable utilisation. Surprisingly, the first quantitative continent-wide assessment of ground water resources in Africa was only recently published (MacDonald et al 2012). The average rainfall across the African continent is 660 mm, of which about 130 mm is considered to reach rivers, lakes and groundwater and thus represents a renewable resource. The groundwater resource is estimated to comprise an equivalent water depth of 22 m, or 170 times greater than the renewable resource. This groundwater is unequally distributed, with the huge sedimentary aquifers across North Africa holding the equivalent of 75 m depth of water, whereas storage in the widespread Precambrian basement rocks aquifers may be less than 0.5 m.

The aquifers across North Africa are recharged at below 5 mm per year and though a huge resource, are exploited for irrigation much faster than they are replenished. However many of aquifers in the rain fed cropping zone are replenished at 25 to 100 mm per year and are shallow enough to be exploited by relatively small pumps (MacDonald et al 2012). Away from urban areas, groundwater is usually free from human pathogens because of the natural filtering provided by the soil above. However water quality can be an issue, both excessive salt level or toxic ions such as fluoride and arsenic. Poor quality water does not appear to be a major issue across the region, although much testing remains to be done.

Assuming groundwater is of suitable quality and close enough to the surface for economical drilling and pumping, then the productivity of the aquifer determines the suitability of the resource for irrigation. Large centre pivot type irrigation systems may need bores that yield around 50 litres per second, and such aquifers are rare in Africa. Bores for household water supplies need only have yields of around 0.3 L/s and such aquifers are widespread across SSA. Ideally irrigation would need a supply of around 5 L/s, but this is not common. However large areas fall into a zone where bore yields are between 0.5 and 5 L/s, where correctly sites bores could supply sufficient water for community gardens and supplemental irrigation (MacDonald et al 2012).

Low to moderate productivity bores will prevent the concentration of irrigation in certain areas and thus help mitigate the ever present threats of salinity and water logging. Small pumps servicing irrigation areas widely spread across the landscape means that expensive and often wasteful reticulation systems are no longer required, and farmers have unprecedented control over their water resource. If they own their own pump they effectively have water on demand, unlike the schemes where water is available on a rotational basis (often once per week) which can lead to conflicts between users in different parts of the scheme. Although the additional pumping costs cut into profit, it can also guard against excessive water consumption. The groundwater resource is, of course, very vulnerable to the tragedy of the commons, as the users are not necessarily formally linked in such a way to avoid overexploitation.

Large irrigation schemes based on rivers and dams and widely distributed small areas fed from groundwater are two ends of the spectrum. In between lie various forms of water harvesting and capture ranging from in-field run-off run-on systems to storage tanks and lined dams. Here there is a trade-off between the upfront investment cost and the reliability of supply. In-field rain water harvesting is not expensive, but neither is there a guaranteed supply of water. Excavated dams measuring 100m x 70m x 7m holding 50,000 cubic meters cost around $1,000,000 to construct. The cost of storage is therefore $20 per cubic meter and assuming the dam is completely filled twice times over during the year, 20 ha of land could be supplied with 500 mm of irrigation water. This equates to a development cost of $50,000 per hectare, ten times higher than the cost of developing larger schemes from rivers. Plastic or ferro-cement tanks have even higher storage costs, with a capital outlay of $50 per cubic meter or more (Makurira 2012).

Small scale storage systems make sense in the context of multiple use systems where water is provided for domestic and productive purposes. The basic domestic supply of 20 L per person per day is sufficient for drinking and personal hygiene and has a huge impact on disease reduction and releasing women from the time consuming chore of fetching water. If this is increased to 50 L per person per day then there is sufficient water for laundry, livestock and some fruit trees around the home. Increasing the water supply to 100 or even 200 L per day can supply a vegetable garden or even a small irrigation enterprise. The progression is called climbing the multiple water use ladder (van Koppen et al 2009).

There is a huge cost in providing reticulated water to meet the basic domestic demand at the base of the ladder. The marginal cost of supplying more water to households, especially if directed towards growing fruit and vegetable which provide the nutritional supplements so often lacking in a cereal based diet, may well be worthwhile. Backeberg and Sanewe (2010) report on the huge potential of homestead farming for food security in rural South Africa where 65% of the land available for small scale farming is made of plots smaller than 0.5 ha around existing dwellings. Providing treated water for agricultural purposes is an unnecessary expense, but there may soon be economical options for treatment at the home itself. Given that water and sewerage treatment plants in Africa often do not work reliably, it may be possible to do the tertiary treatment using a filter or membrane on one tap in the home. Then the reticulation system provides a much larger quantity of primary treated water, and the drinking water undergoes final treatment at a single tap in the home.

## 3.7 A new water research agenda for sub-Saharan Africa

There is political will to develop irrigation in SSA through the NEPAD strategy and there appears to be sufficient water and land available. Moreover, SSA has shown great improvements in irrigation performance in recent decades due to the combination of better planning and better management, such that the performance of larger schemes is catching up with the rest of the world. The current value of irrigated agriculture in SSA is about 25% of the total agricultural output. This contribution is comes from just 3.5% of the cultivated land area (or 4.5% if we add the informal sector) meaning that there is a five to seven fold increase in value of irrigated agriculture over dryland agriculture because of higher yields and more profitable crops (Svendsen et al 2009). This calculation is in stark contrast with the rest of the world where the comparable ratio is around 2.

There are also new opportunities fast approaching. The trend in Asia towards small scale private irrigation is now starting in SSA where farmers are using their own initiative and financial resources. The movement started with the use of treadle pumps which can irrigate around 0.2 ha for a cost of $50-100. However, as occurred in Asia, motorised pumps costing less than $250 that can irrigate 1 to 2 ha are proving the most profitable option (Giordano et al 2012). Whereas groundwater supplies 60-80% of irrigation water in India and Bangladesh, it probably accounts for less than 10% in SSA. Giordano et al (2012) estimate annual net revenues of $20 billion flowing from the development of small reservoirs and a further $22 billion from expanding the use of small motorised pumps, benefiting hundreds of millions of small scale farmers through secure access to water.

If the above opportunities can be realised, they will have a major impact of food security in SSA. But there are formidable obstacles. Firstly, crop yields still fall well below potential. Small holder irrigated agriculture cannot be a subsistence activity, because profits are needed operation and maintenance costs. Low productivity feeds into the second problem, which is the abandonment of irrigated lands when infrastructure fails. Van Averbeke et al (2011) show as stark example of this among smaller holder schemes in South Africa. Of the 67 gravity fed flood systems 20% had fallen into disuse, and 56% of pressurised systems were non-longer operational. Even in a country with relatively good extension support, it seems that only the simplest of systems can be maintained.

Thirdly, salinity and waterlogging remain ever present threats. Somewhere between 20 and 30% of the world's irrigated land is currently seriously affected by salinity and or waterlogging and between 1.5 and 2.5 million hectares are abandoned by irrigators each year (Khan et al 2008; Kijne 2006). The example of Chokwe in Mozambique is a stark reminder that SSA will not be immune from the hydrological problems facing irrigation across the rest of the world. Fourthly, despite the apparent abundance of water resources, the transition to water scarcity occurs quickly as irrigation develops, and it is already acute in some areas. The institutional and governance arrangements that can frame the development needs of the country within the constraints of the resource are weakly developed, as are the water user associations that oversee the operation and maintenance costs of the irrigation systems themselves.

The ability to improve productivity and profitability of irrigated agriculture whilst operating within the sustainable limits of the catchment to supply water and dispose of salt, remains the grand challenge for irrigation. Historically irrigation has been dominated by an engineering paradigm of pipes and canals and 'look-up' tables that profess to advise farmers how much water to use. In practice very few components of the water cycle are measured and few schemes would have much idea about how much food is produced for a given quantity of water, what the potential might be and what steps would be needed to get there.

Moreover there remain huge barriers between the world views and expertise of the multiple stakeholders, from small scale farmers to agricultural advisors, hydrologists, donor agencies, and the host of institutional structures trying to manage water and food security from local to national and even international scales. Institutional diversity is important in managing common pool resources well, and under the right conditions may build social capital, equity and resilience (Ostrom et al 1999), but has rarely been achieved with modern irrigation schemes in Africa.

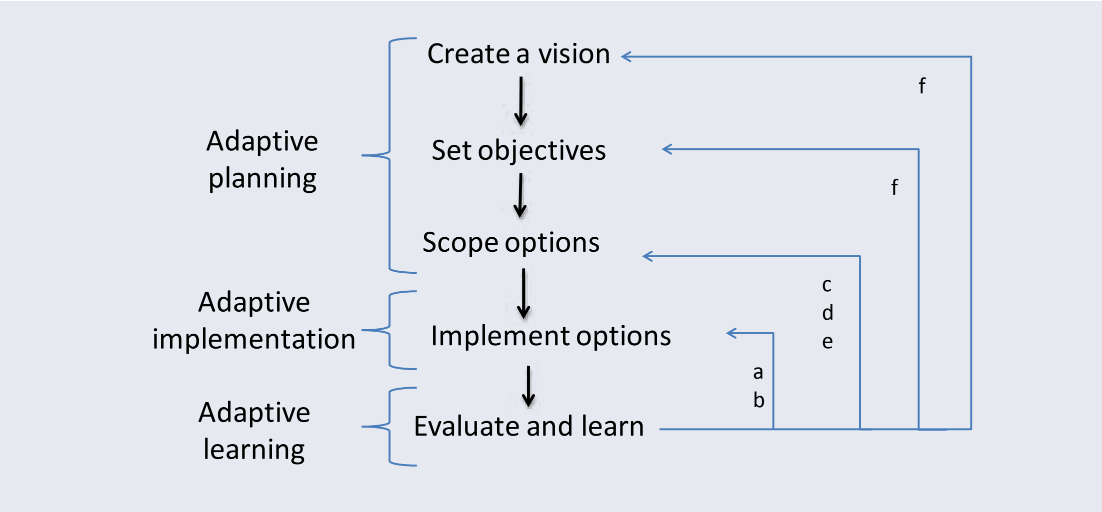
The dilemma described above lands the irrigation problem in the centre of social-ecological complexity. The social complexity arises from multiple stakeholders who hold different worldviews, may have different value systems and whose interests cover very different time or spatial scales. The ecological complexity arises from the uncertainties of climate and water availability and the fate of excess water and solutes in the landscape. Under these circumstances there is no optimal solution, but instead a need for on-going learning and adaptation (Pahl-Wostl & Hare 2004, Roux and Foxcroft 2011). This realisation led to the development of the field of adaptive management which is built on the premise that we have to use real-life management of the system as a whole and turn it into an experiment by asking the right questions, implementing decisions, collecting the right data and learning from the experience (Holling 1978; Lee 1993).

Adaptive management is defined by (Meffe et al 2002) as the process of treating natural resource management as an experiment such that the practicality of trial and error is added to the rigour and explicitness of the scientific experiment, producing learning that is both relevant and valid.

South African scientists have practiced a form of strategic adaptive management for both managing rivers and natural resources (Biggs & Rogers 2003). The reference to strategic means it is forward looking in that it asks the stakeholders to settle on some on a longer term vision that captures values of the majority or at least encapsulates some common purpose. Once the vision is agreed, the planning phase sets the objectives needed to attain the vision and finally a scoping of the options available to meet those objectives. Within this planning process, it is important to set measureable targets so everyone can see how things are progressing. These targets may revolve around, inter alia, river flow, groundwater depth and quality, water use efficiency and crop productivity.

During the implementation phase the preferred options from the planning phase are enacted and the monitoring data collected. The critical last step is the learning and evaluation phase where four feedback loops are critically examined as described in Figure 3 by Roux and Foxcroft (2011).

**Figure 3. The strategic adaptive management learning cycle, adapted from Roux and Foxcroft (2011).**




- **a** Is the monitoring adequate, cost effective and feasible?
- **b** Has the intended plan of operation materialised?
- **c** Were the selected options appropriate?
- **d** Were the predicted consequences correct and, if not, why?
- **e** Were the consequences actually acceptable?
- **f** Even if the predicted consequences were correct and are acceptable, are the objectives and vision being met?

According to Stankey et al (2005) the principles of adaptive management are widely acclaimed but are difficult to achieve in practice. One of the reasons for this is that monitoring is expensive.

A bigger problem is that scientists often want to measure too many things and so the learning process becomes overloaded with information. The key is to identify and monitor 'slow' or underlying variables that integrate system behaviour.  All stakeholder should share a common conceptualisation of the problem and have some expectation of how their management options will affect the processes they are measuring, allowing the group to learn in a structured way (Stirzaker et al 2010).

Many elements are now in place to make adaptive management a methodology of choice for improving water productivity in sub Saharan Africa. Firstly, the concept of social-ecological complexity it is widely recognised and many people are willing to work across traditional disciplinary boundaries. Second, processes that link institutional and technical innovation are needed to succeed in areas where the straight technical or silver bullet solutions have failed. Third, monitoring equipment is becoming simpler and more cost effective and when combined with smart phone will revolutionise data collection, display and sharing.  The most recent FAO report concerning 'coping with water scarcity' urges us to move in this direction

"*Planning and management systems need to be flexible, adaptive and based on continuous social and institutional learning. Adaptive management recognizes the high level of uncertainty associated with future situations, and places emphasis on flexible planning that allows regular upgrading of plans and activities. Such a level of responsiveness is only possible if information and knowledge are updated, and if monitoring and information management systems continually provide decision-makers with reliable information*" (FAO 2012).

# 4. Lessons from water and agricultural assessments

The section reviews the relevant outcomes for irrigated agriculture in Africa from two major, global assessments on water and agriculture, namely the Challenge Program on Water and Food and also the Comprehensive Assessment of Water Management in Agriculture.

Earth's land and water face increasing pressure. At 7 billion today, global population is expected to approach 9 billion in less than 40 years. The additional 2 billion people will require 70% more food than is presently consumed (Fisher and Cook 2012). With agricultural already using 70% of the world's fresh water resources, increasing food production by a further 70% will require major investment in new technologies, techniques and approaches to growing more food with less water (Fisher and Cook 2012). Increases are necessary in water productivity and water use efficiency.

## 4.1 Challenge Program on Water and Food

The Challenge Program on Water and Food (CPWF) of the Consultative Group on International Agricultural Research (CGIAR) was designed to investigate the water and food nexus in river basins around the world. Launched in 2002, the CPWF seeks to understand issues around development, poverty and water productivity.

Phase I of the CPWF (2002-2007) consisted of 68 research projects, undertaken across ten river basins in Africa, Asia and Latin America. The African river basin case studies were the Limpopo, Nile and Volta. These projects explored an extensive set of water and food issues, from a variety of disciplinary perspectives and partnerships. The goal of this phase was to identify successful strategies for improving food security and reducing poverty. This work generated creative ways to define water and food problems and began developing new kinds of partnerships for addressing them.

Relevant lessons are attributed to CPWF Phase I work:

6. Improved water productivity coupled with empowerment, equity, market access, and ecosystem conservation enables food producing communities and ecosystems to become more resilient.
7. Development and adoption of rainwater management systems based on multiple uses of small reservoirs can result in improved livelihoods for small holder farmers in SSA.

Phase I context was provided by a series of nine Basin Focal Projects (BFPs), which analysed water availability, water access, water productivity, water-poverty linkages, and water governance. The BFPs were analysed and summarized (Fisher and Cook 2012)—with the take home message that despite similarities, each basin presents different underlying problems, which must be addressed systematically and contextually to improved food security and reduce poverty.

BFP Findings include:

1. Large scale irrigation investments should be reconsidered, intended benefits rarely accrue to the intended audiences as anticipated.
2. Increased investment should be made to help the poor cope with all nature of water crises: drought, flood and water quality issues.
3. The Limpopo BFP specifically identified institutional development, capacity building and integration as key to improving access to and productivity of water resources in the basin.

Phase II of the CPWF (2009—2013) takes a slightly different approach and organizes research around a context specific, basin development challenge. Each of the six Phase II Basin Development Challenges (BDCs) was developed in a consultative process that included review of previous research, meetings, and consultative workshops with basin stakeholders. BDC development included articulating theories of change, including impact pathways, by which research was expected to lead to outcomes.

The process by which each BDC laid out a theory of change, impact pathways and outcome logic models (OLMs) allowed each to link their activities to outputs, intended outcomes and impact with likely audiences. The first step in the process was for each project team to imagine a point in the future, when their project work had been successfully completed. This step articulated the change each project team envisioned from their work—in the longer term. From the overall vision each project derived a limited number of outcome pathways, corresponding with their major research activities.

Each outcome pathway was then described in detail including:

1. Actor(s) who will change
2. Change in actor practice/behaviour
3. Change in knowledge, attitude and/or skills in actor(s) required to achieve practice change
4. Project strategies for achieving these changes in KAS and practice
5. Process output(s) involved in change
6. Risks and assumptions

Each of these pathways was accompanied by a narrative that spelled out the sum total of the vision of that particular pathway. While these outcome logic models are not sufficiently detailed for monitoring, they serve as clear guide posts for regular reflection and learning by project teams. The OLMs are useful for linking outputs to specific audiences for outcomes, including targeted output packaging and communications—a step frequently left out in research efforts.

The Limpopo, Nile and Volta river basins in Africa have been engaged in the CPWF for a decade. The three basin programmes have evolved over that time and are building significant bodies of outputs and evidence about the relationships between water and food, and poverty and food insecurity.[1] Taken together with accumulated evidence from the Andes in Latin America, and the Ganges and Mekong is Asia, the CPWF has generated a series of programme-level messages of relevance going forward.

The overall message currently emerging from the CWPF suggests that despite areas and instances of physical scarcity, the planet has enough water to meet the full range of human and ecosystem needs for the foreseeable future, with a number of caveats. The challenge is going to be equitable access, requiring judicious and creative management; trade-offs must be made and ecosystems must be maintained.

6 See: http://www.fanrpan.org/projects/lbdc/; http://nilebdc.org/; http://volta.waterandfood.org/.

More specific messages from CPWF Phase II include:

1. Sustainable intensification of smallholder systems may be available through more efficient use of scarce dry season water – to access high value market chains.
2. Policy processes—based upon collaboration and dialogue—should encourage more equitable benefit and risk sharing.
3. Transboundary and multi-sectoral institutional arrangements are needed to foster more equitable development, improve governance, and support innovative technical solutions.
4. Innovative partnerships are critical to converting science based evidence into outcomes and impact on the ground. Theories of change and outcome mapping can help pave this pathway to achieving impact in the short term.
5. Emerging findings from the Limpopo Basin suggest that basin water levels can support further resource development, but that catchment level analysis must be matched to proposed technologies
6. Further experience from the Limpopo illustrates the value of diverse partnerships and networks to move from research for publications to research evidence for outcomes and impact.

## 4.2 The Comprehensive Assessment of Water Management in Agriculture

Undertaken by IWMI, the 2007 Comprehensive Assessment of Water Management (CA) in Agriculture (IWMI 2007) reviewed 50 years of development investment and efforts and assessed opportunities going forward. The CA suggests, like the CPWF and others that great potential lies in addressing the yield gap between high and low efficiency farmers. This will require better water management, better (including more equitable) policies and implementation, and improved production techniques.

The CA recommends changes in technique, technologies and policy, grounded in reality, and responsive to different situations—one size does not fit all—with both humans and socio-ecological systems changing all the time. The CA recommends eight policy actions, summarized here:

1. Change thinking about water and agriculture: In order to ensure food security, reduce poverty and conserve ecosystems, rainwater must be governed and managed to support multiple use agro-ecosystems.
2. Improve access to agricultural water: Secure water access for small holder farmers via legal and physical means (rights, storage, and delivery) so that they can more fully engage in growing market opportunities.
3. Agriculture and ecosystems: Integrate ecosystem thinking into agricultural planning, development and implementation.
4. Increase water productivity: Invest in technologies and systems that will deliver greater yields from less water, reducing future demand, ecosystem damage and competition.
5. Upgrade rain-fed production systems: Rain-fed agriculture supports the majority of Africa's small holder farmers, with the greatest potential for production and productivity increases.
6. Adapt yesterday's irrigation to tomorrow's needs: Modernization of traditional irrigation for multiple services and diverse livelihoods can generate higher value agricultural production and profits.

7. Target state institutions for reform: State water institutions must engage in and with coalitions to reform water governance in general, and as it pertains to agriculture in particular. Linking idiosyncratic water, food and environment policies is a time consuming and frustrating process.

8. Trade-offs and difficult choices: Water allocation and use is driven by competing demands and the need for trade-offs. This negotiation process must be transparent and include all stakeholders in meaningful and relevant ways.

The Australian investment could specifically address increasing water productivity, delivering higher yield from less water, reducing water demand, ecosystem damage and competition. It may also begin to adapt yesterday's irrigation to tomorrow's needs. By focusing on learning and adaptive management, today's farmers can build their livelihoods for tomorrow, based upon more efficient water use, greater productivity and more profitable agriculture. Individual gains are expected to be buttressed by stronger local and catchment level institutions and governance structures—helping ensure sustainability of the learning.

In summary, food security and poverty reduction requires additional investments in agricultural water management in SSA. History has shown that there are no silver bullets for food security and poverty reduction. Rather, agriculture water management investments should be tailored to the specific needs and situations in different countries. For example:

- *Where irrigation infrastructure has been developed and fully utilized* —with limited scope for expansion to increase food security and reduce poverty, the goal should be to improve efficiency and management of existing systems, increasing productivity of land and water resources through strengthening institutions and related software.
- *Where water resources are available but less developed*—where water is considered economically rather than physically scarce, investment should be made in both large and small-scale irrigation. Of primary importance is prioritized investment in capacity and institutional development for scheme staff, entrepreneurs and farmers in collective management of water resources.
- *Where water resources are scarce* — areas of physical water scarcity — require pro-poor investments in land and water conservation technologies and practices, use of marginal quality water, integration of crops, fisheries and aquaculture, tree/livestock systems to increase the economic value and livelihoods per drop of water.
- *Policy and Market Integration* – agricultural water development within enabling policy environment and linked to input and output markets—critical to the success of any commercial venture is the necessary incentive structure for engaging small holder farmers, and keeping them engaged in commercially viable enterprises. This includes secure tenure, access to finance, and input and output markets to sustain the initial investment and enthusiasm.

Two common themes emerging from these recommendations for enhanced irrigated agricultural production are the need to enhance institutions and water productivity.

# 5. Agricultural policies in Africa

## 5.1 Introduction

To better prioritise additional support for irrigated agricultural production, in this section we review the policies of African governments to identify those places and aspects where Australian investment may add most value. The picture of agriculture in Sub-Saharan Agriculture (SSA) may appear dynamic locally and regionally, yet seems to remain static and low producing in the aggregate. This reflects ever increasing population and high risk reliance on rain-fed agriculture with pockets of highly productive commercial irrigation and a disappointing history with small scale irrigation.

Agriculture supports the livelihoods of more than 415 million people in SSA, some 55 % of the total population (Decision Support Monitor 2012). The importance of irrigation to people and the economies of the nine focal countries are shown in Table 1. The majority of these farmers are engaged in mixed crop-livestock, rain fed, smallholder farming characterised by low productivity. The portion of land irrigated by small holders is shown in Table 2 but there are not reliable and consistent statistics on the numbers of small holder farmers. In fact, per capita food production in Africa has stagnated for more than 20 years. This stunted growth can be linked directly to a lack of rural infrastructure, and agricultural inputs and technology, as shown in IFAD's recent report on rural poverty (IFAD 2011).

The majority of these 415 million farmers face unreliable rainfall, reduced soil fertility, and unfavourable land, water, and trade policies. They have little to invest in infrastructure development or maintenance and have limited access to context specific technologies and knowledge.

While the UN reports reduced poverty levels globally from 1990 to 2000, the number of poor living on $1 in SSA increased from 227 million to over 300million in that decade. SSA remains the world's poorest region, with 34 or the world's 50 poorest countries. This can be partially attributed to low and unpredictable rainfall, recurrent weather events and wide spread reliance on a poor performing small holder agriculture sector (Hanjra and Gichuki 2008).

Successful large scale commercial farming in SSA can be competitive with global production standards. Yet smallholders living next door are vulnerable to sporadic or failed rains, long term droughts, natural hazards, disease and even death. Chronic exposure to overlapping or simultaneous risk traps small holder farmers in a cycle of poverty and food insecurity. It is therefore thought that significant investment in agricultural water management for small holder farmers can help pave pathways to food security and away from poverty.

Hanjra and Gichuki (2008) suggest that investment in agricultural water management (including irrigation) can positively change the opportunity structure for rural populations, particularly when made in concert with secure tenure rights, basic education and healthcare, supporting infrastructure and markets.

Donor funded irrigation in SSA has struggled to be sustainable and maintain peak production levels over time, but there have been successes and lessons learned. Among such programmes implemented between the late 1960s and the early 2000s, researchers identified a number of factors behind poor performance:

» Inadequate design and planning that led to high costs, delays and cost over runs;

» Hardware before software: emphasis on large-scale high tech irrigation systems rather than small scale appropriate tech; inadequate investment in software component;

- Design and planning based upon inadequate hydrological, soil, topographic and environmental data, leading to fundamentally unsound irrigation planning, operation and management;
- Insecure land tenure, unexplored institutional issues, and non-existent governance structures;
- Planning and investment weighted toward design and building, insufficient planning and investment in O & M, and financial plan for continued O & M, upgrades and depreciation;
- Lack of local community, traditional authority or farmer involvement and contribution to project activities; and
- Poorly understood sociopolitical and cultural factors (Hanjra and Gichuki 2008:190).

Available water resources in the nine focal countries are shown in Table 3. According to AICD, an estimated 39 million ha of agricultural land in Africa is physically suited for irrigation. Yet only 6 million ha, around 5% of that total, is actually under irrigation (You 2008). The areas of the nine focal countries irrigated by ground versus surface waters is shown in Table 4, whereas irrigated agricultural development, plans and potential is shown in Table 5. Of that 6 million ha, Madagascar, South Africa and Sudan together account for nearly 4 million ha, leaving the rest of SSA with just 2 million ha of irrigation. Irrigated agriculture outputs in SSA account for 25% of the total value of agricultural outputs, illustrating that irrigation increases the economic productivity of land. South America, East and South-East Asia and South Asia being claim 10 %, 29 % and 41 % of arable land under irrigation respectively (Development Support Monitor 2012).

**Table 1. Population and GDP of the nine focal countries**

| Country | Population (million) 2011 | Population density (people per sq. km) 2010 | Rural population % | GDP per capita (USD) 2011 | Agriculture's contribution to GDP (%) |
|---|---|---|---|---|---|
| Botswana | 2.03 | 3.54 | 31 % | $16,200 | 2% |
| Ethiopia | 84.73 | 82.95 | 82 % | $1,100 | 41% |
| Kenya | 41.62 | 71.18 | 79 % | $1,800 | 19% |
| Malawi | 15.38 | 158.05 | 82 % | $900 | 30% |
| Mozambique | 23.93 | 29.74 | 71% | $1,100 | 32% |
| Tanzania | 46.22 | 50.62 | 75 % | $1,500 | 28% |
| Uganda | 34.51 | 167.28 | 87 % | $1,300 | 22% |
| Zambia | 13. 47 | 17.39 | 61 % | $1,715 | 22% |
| Zimbabwe | 12.75 | 32.2 | 66 % | $500 | 20% |

(Source: www.tradingeconomics.com, accessed 8 March 2013).

**Table 2. Area irrigated by small holders versus total irrigated area**

| Country | Small holder (ha) | Total (ha) |
|---|---|---|
| Botswana | n/a | n/a |
| Ethiopia | 191827 | 289530 |
| Kenya | 48045 | 103203 |
| Malawi | n/a | n/a |
| Mozambique | 6389 | 118120 |
| Tanzania | n/a | n/a |
| Uganda | 100 | 9150 |
| Zambia | 11000 | 155912 |
| Zimbabwe | 81575 | 175513 |

(Source: FAO AQUASTAT www.fao.org/nr/water/aquastat/main/index.stm, accessed 8 March 2013).

### Table 3. Water resources in the nine focal countries

| Country | Total renewable water resources: (cu km) | Total water withdrawals as % of TARWAR | Total ag water withdrawals as % of TARWAR | Per capita water use (cu m/yr) 2000 |
|---|---|---|---|---|
| Botswana | 14.7 (2001) | 1.6 % | 0.7 % | 107 |
| Ethiopia | 110 (1987) | 5.1 % | 4.7 % | 72 |
| Kenya | 30.2 (1990) | 9.0 % | 7.2 % | 46 |
| Malawi | 17.3 (2001) | 5.8 % | 4.7 % | 78 |
| Mozambique | 216 (1992) | 0.3 % | 0.3 % | 32 |
| Tanzania | 91 (2001) | 5.7 % | 5.1 % | 135 |
| Uganda | 66 (1970) | 0.5 % | 0.2 % | 10 (‘02) |
| Zambia | 105.2 (2001) | 1.7 % | 1.3 % | 149 |
| Zimbabwe | 20 (1987) | 21.0 % | 16.6 % | 324 (‘02) |

(Source: The World Factbook www.cia.gov/library/publications/the-world-factbook/index.html; IFPRI www.ifpri.org/publication/2009-global-hunger-index, accessed 8 March 2013).

### Table 4. Portion irrigated by ground versus surface water

| Country | Ground water %/area (ha) | Surface water %/area (ha) |
|---|---|---|
| Botswana | 44.3 | 51.8 |
| Ethiopia | n/a | n/a |
| Kenya | 1 | 99 |
| Malawi | 0.05 | 99.95 |
| Mozambique | n/a | n/a |
| Tanzania | n/a | n/a |
| Uganda | n/a | n/a |
| Zambia | 12 | 88 |
| Zimbabwe | n/a | n/a |

(Source: FAO AQUASTAT www.fao.org/nr/water/aquastat/main/index.stm, accessed 8 March 2013).

**Table 5. Irrigation and agricultural productivity in the nine focal countries.**

| Country | Area under irrigation (ha) | National targeted area | Total % of irrigation equipped area/ cultivated area | % Irrigated equipped area actually irri-gated /total equipped area | Value of irrigated output as share of total agricultural output (%) | Share of irrigation potential (%) | Average rate of growth of irrigated area (2000-2003) |
|---|---|---|---|---|---|---|---|
| Botswana | 1,439ha, 620 ha functional | Irrigation potential is estimated at about 13,000 ha. Target of rehabilitation of 1,000 ha (Government of Botswana 2008). | 0.4 | 43.0 | 16.6 | 11 | 0.0 |
| Ethiopia | 289,530 ha | 510,603 ha of new irrigation under construction or planned. | 2.5 | — | — | 11 | 0.0 |
| Kenya | 103,203 ha | Increase Area under irrigation by 140,000 ha by 2012. | 2.0 | 94.2 | 9.5 | 29 | 5.8 |
| Malawi | 56,390 ha | Malawi plans to double its area under irrigation, adding a further +50,000 ha (unpublished data, this study). | 2.3 | 96 | 8.7 | 35 | 0.6 |
| Mozambique | 118,120 ha | 3.3 million ha potentially irrigable, about 120,000 ha with irrigation infrastructure of which only 50,000 ha is currently used (section A1, below). | 2.7 or 3 | 33.9 or 34 | 4.8 | 4 | 0.0 |
| Tanzania | 184,330 ha | 2.3 million ha classified as high potential, 4.8 million haas medium potential, and 22.3 million has low potential. The 2002 National Master Irrigation Plan set target at 25,000 ha new irrigation development per year (Therkildsen 2011). | 3.6 | — | 10.0 | 9 | 2.3 |
| Uganda | 9150 ha formal | 253,250 ha (Republic of Uganda 2011). | 0.1 | 64.5 | 0.5 | 10 | 0.0 |
| Zambia | 155,912 ha | 200,000 by 2010 (Kodamaya 2009). | 3 | 100.0 | 28.2 | 30 | 3.7 |
| Zimbabwe | 175, 513 ha | Zimbabwe has 366,000 ha of irrigation potential; 175,000 ha of land are developed. Currently, 102,000 ha are operational and the other 73,000 ha are equipped but, require rehabilitation. | 5.2 | 71.4 | 25.9 | 47 | 0.0 |

(Sources: Svendsen et al (2009); National Investment Brief Kenya 2008 www.sirtewaterandenergy.org/docs/reports/Kenya-Draft2.pdf, accessed 8 March 2013; Tanzania CAADP http://publications.iwmi.org/pdf/H039824.pdf, accessed 8 March 2013; FAO AQUASTAT www.fao.org/nr/water/aquastat/main/index.stm, accessed 8 March 2013).

Across SSA agriculture, water and environmental policies are not harmonized to any meaningful degree within countries or across river basins—so planning and development of each sector remains isolated from the others. Basin, national, provincial and local development of agriculture is often conceptualized and planned in isolation from corresponding water interests. Irrigation Water User Associations are one of few instances where agriculture and water interests are represented at the same table—albeit at a very local level.

The risks of continued isolation of water and agriculture planning and management are becoming clearer as competition for available resources increases.  The global shift toward integrated water resources management (IWRM) since its appearance in 1993, has reached water resources planning and management in Africa. In 2010, Global Water Partnership published an evaluation of progress toward a number of milestones in IWRM planning—across southern and eastern Africa (GWP 2010). The nine priority countries for this study are presented in Tables 6 and 7 below, assessed according to progress toward an enabling environment and IWRM planning.

The country ranking vis-à-vis each milestone is not necessarily critical for this study. Rather, the assessments serve as a starting point for cross country learning along each of these fields and activities.

Table 6 summarises national progress toward the following questions reflecting establishment of an enabling environment for implementing IWRM:

1. Are appropriate policy and legislation in place to support IWRM?
2. Is an adequate water resources infrastructure platform in place?
3. Is there sufficient sustainable financing for the implementation of IWRM?
4. Is the institutional capacity, particularly in relation to human resource capacity, sufficient to implement IWRM?
5. Is the institutional capacity, particularly in relation to human resource capacity, sufficient to implement IWRM?

**Table 6. Progress on enabling environment & institutional arrangements to improve Africa's water security.**

| Country | Policy & Legislation | Infrastructure Platform | Sustainable Financing | Institutional Arrangements | Institutional Capacity |
|---|---|---|---|---|---|
| Botswana | | | | | |
| Ethiopia | | | | | |
| Kenya | | | | | |
| Malawi | | | | | |
| Mozambique | | | | | |
| Tanzania | | | | | |
| Uganda | | | | | |
| Zambia | | | | | |
| Zimbabwe | | | | | |

(Source: GWP (2010)).

**Key** Little progress achieved   Some progress, limited achievements   Substantial achievements

The Table 7 assesses the nine target countries against management instruments for IWRM. Of particular interest to this study is the substantial achievements toward water use efficiency by Tanzania and Zimbabwe's lack of progress in that regard. Table 7 also offers an assessment of the monitoring and information management capacity of the countries, with Zimbabwe having substantial achievements in this field. If facilitated strategically, teams from the three target countries can share and learn a great deal from their IWRM experiences to date.

Reliable, systematic data on actual investment in irrigated agriculture is difficult to locate. Our research found ad hoc reports of investments by China and Middle Eastern donors in Mozambique. We reviewed FAO agricultural aid data for the nine focal countries, as shown in Table 8. A number of categories of this aid are shown that are clearly water related but it is not possible to distinguish where other agricultural aid categories include irrigation related funding. The major aid donors are listed in order of the size of the aid. Web searches on the largest aid agencies did not locate irrigation related projects. In this context strategic, irrigation related aid from Australia could fill unmet needs.

**Table 7. Progress on the implementation of management instruments for IWRM**

| Country | IWRM Planning | Water Use Efficiency | Stakeholder Engagement | Allocation Mechanisms | Monitoring & Info | Environmental Sustainability |
|---|---|---|---|---|---|---|
| Botswana | Some progress, limited achievements | Some progress, limited achievements | Little progress achieved | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements |
| Ethiopia | Little progress achieved | Little progress achieved | Little progress achieved | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements |
| Kenya | Little progress achieved | Little progress achieved | Little progress achieved | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements |
| Malawi | Little progress achieved | Substantial achievements | Little progress achieved | Little progress achieved | Some progress, limited achievements | Some progress, limited achievements |
| Mozambique | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements | Some progress, limited achievements |
| Tanzania | Little progress achieved | Little progress achieved | Little progress achieved | Little progress achieved | Some progress, limited achievements | Some progress, limited achievements |
| Uganda | Little progress achieved | Little progress achieved | Little progress achieved | Some progress, limited achievements | Little progress achieved | Some progress, limited achievements |
| Zambia | Little progress achieved | Some progress, limited achievements | Little progress achieved | Substantial achievements | Some progress, limited achievements | Substantial achievements |
| Zimbabwe | Some progress, limited achievements | Substantial achievements | Little progress achieved | Some progress, limited achievements | Little progress achieved | Some progress, limited achievements |

(Source: GWP( 2010)).

**Key** Little progress achieved Some progress, limited achievements Substantial achievements

**Figure 4. Irrigation investment needs required to realize irrigation potential in SSA by country (Source: You (2008:9)).**

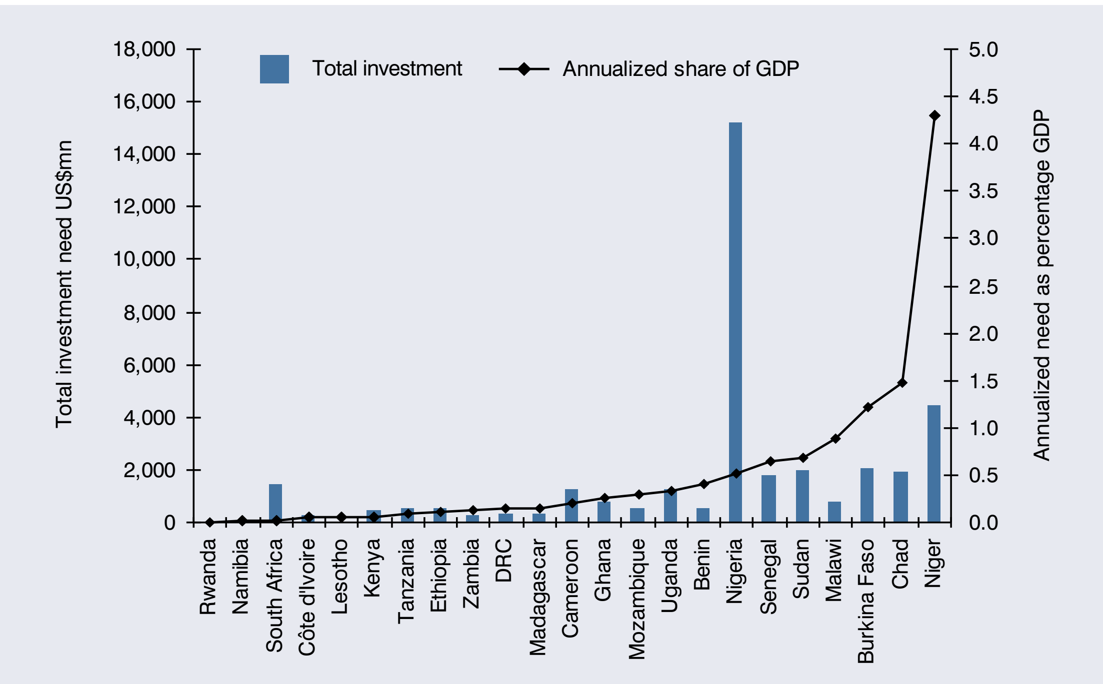


**Table 8: Water related agricultural aid for the nine focal countries**

| Agricultural Aid 2006-2010 | Botswana | Ethiopia | Kenya | Malawi | Mozambique | Tanzania | Uganda | Zambia | Zimbabwe |
|---|---|---|---|---|---|---|---|---|---|
| Total agricultural aid (USD$ million) | 102.32 | 5607.3 | 2676.95 | 929.37 | 1488.94 | 1722.01 | 1796.64 | 587.71 | 1233.38 |
| Portion of agricultural water-related aid (% of total aid) | 2.79 | 2.31 | 8.78 | 5.32 | 12.11 | 11.73 | 3.15 | 6.39 | 0 (no relevant areas listed) |
| -Water resources policy and management | 2.79 | - | - | 5.32 | 6.02 | 11.73 | 3.15 | 6.39 | - |
| -Agricultural water resources | - | 2.31 | 8.78 | - | - | - | - | - | - |
| -River development | - | - | - | - | 6.09 | - | - | - | - |
| Five largest donors | United States<br>IDA<br>EU institutions<br>Canada<br>UK | United States<br>IDA<br>EU Institutions<br>Canada<br>United Kingdom | United States<br>IDA<br>Japan<br>EU Institutions<br>Denmark | United States<br>EU Institutions<br>IDA<br>Norway<br>AfDF | United States<br>Italy<br>Sweden<br>IDA<br>EU Institutions | IDA<br>Denmark<br>United States<br>Norway<br>Japan | United States<br>IDA<br>AfDF<br>EU Institutions<br>United Kingdom | United States<br>Finland<br>Norway<br>Japan<br>EU Institutions | United States<br>EU Institutions<br>United Kingdom<br>Australia<br>Germany |

Notes:

AfDF: African Development Fund (soft loan window of the African Development Bank group)

EU institutions: European Union Institutions

IDA: International Development Agency (Concessional lending arm of the World Bank)

(Source: FAO Agricultural Development Assistance Mapping Tool www.fao.org/tc/adam/data/index.html, accessed March 3, 2013).

While the water sector is working toward IWRM planning, the agriculture sector has engaged in a continent-wide planning process and framework. Within the last ten years investment in African agriculture has been increasingly informed and guided by a planning process and framework known as CAADP.

## 5.2 Comprehensive African Agriculture Development Programme

The Comprehensive Africa Agriculture Development Programme (CAADP) is a planning and development framework for the African agriculture sector. It was designed to advance agriculture as a driver of economic growth; and to help raise agricultural productivity thereby reducing hunger and poverty on the continent. CAADP was formulated by the African Union Commission (AUC) under the New Partnership for Africa's Development (NEPAD), and was endorsed by the African Heads of State and Government at the African Union Summit in Maputo in July 2003.

The CAADP framework seeks to guide country strategies and investment programmes; stimulate and support policy dialogue, organisational and capacity development, and peer learning; multi-stakeholder engagement (government, civil society and private sector); and support alignment and harmonisation between local and international institutions, think tanks, and development partners. CAADP encourages strategic and organized investment in agricultural sector support and development in Africa. Through CAADP, African governments committed to increasing public investment in agriculture to a minimum 10% of national budgets, and to achieve a minimum 6% annual growth in agriculture by 2015.

While CAADP planning and implementation are done mainly at the national level, those processes are meant to be aligned with regional policies and groupings. Regional Economic Communities (RECs) are developing Regional CAADP processes in an effort to better integrate agricultural growth and trade across borders, share lessons, strategies and experiences, and assist with implementation. RECs work in support of the CAADP agenda by guiding country activities, coordinating regional implementation, monitoring and evaluating progress toward implementation, building partnerships and directing investment to facilitate national processes. At the continent level, the AU and NEPAD facilitate broad partnerships and technical support for the RECs and country processes.

At the national level, CAADP Compacts are high-level agreements between governments, regional representatives and development partners for coherent implementation within countries. National CAADP Compacts reflect national investment and development priorities and lay out entry points for various stakeholders to engage with development processes; they identify actions, commitments and partnerships. Ideally compacts guide country policy and investment responses; planning for development assistance; and public private partnerships to support investment.

CAADP is organized into four pillars—or entry points, described below (NEPAD 2012):

1. Sustainable land and water management.
2. Improving rural infrastructure and trade-related capacities for market access.
3. Increasing food supply and reducing hunger.
4. Agricultural research, technology dissemination and adoption.

Pillar 1 - Extending the area under sustainable land management, promotes technologies and approaches related to water and irrigation, and conservation agriculture investment in sustainable land management. Under this pillar, NEPAD coordinates, aligns and manages knowledge initiatives across Africa, encouraging investment in CAADP aligned priorities and minimizes constraints to such investment.  Unpublished data (2012) summarising 20 national CAADP implementation plans suggests that 6% of the agriculture investment of these countries is devoted to sustainable land and water management.

Pillar 2 - Rural infrastructure and trade-related capacities for market access, targets improved market access by improving rural infrastructure and other market and trade-related interventions, include policy and regulatory frameworks. This pillar focuses on what it takes to get better quality outputs to markets, and get better information up and down value and supply chains. This pillar promotes sound trade policies across all levels; strengthens capacity to negotiate trade; facilitates partnerships with private sector; and encourages domestic and foreign direct investment in agriculture.

Pillar 3 – Food and nutrition security is aligned with the first Millennium Development Goal (MGD) of halving extreme poverty and hunger by 2015. This pillar seeks to increase food security and reduce hunger by raising smallholder productivity and improving responses to food emergencies. It specifically targets vulnerable populations and the chronically food insecure. Pillar 3 combines the CAADP vision of increased productivity, integrated markets and greater food and income security for vulnerable groups.

Pillar 4 – Research and training for technology dissemination and adoption, recognizes the role of research in reducing poverty and hunger. It aims to improve agricultural research and strengthen dissemination systems, while promoting the uptake of appropriate technologies. Pillar 4 aims to increase support available to help farmers adopt improved options, for scaling up and scaling out.

CAADP formulation and implementation is done through strategic functions, by a broad range of actors grounded within the 4 pillars identified above. As an Africa-wide framework, the African Union (through the NEPAD Planning and Coordinating Agency) is tasked with overall coordination. RECs develop regional compacts and agricultural investment plans for implementation while linking and supporting their member states with national level activities. At country level, government leads formulation and implementation of national compact and investment plan development. The broader international community provides technical and financial support to CAADP processes.

Strategic functions for the CAADP agenda are led by NEPAD and include (NEPAD 2012):

1. Promoting CAADP principles in country development and implementation activities by leveraging technical expertise and supporting RECs.

2. Managing communication and information in support of CAADP implementation and partnerships; includes awareness campaigns and knowledge sharing.

3. Facilitating and coordinating monitoring and evaluation with an eye toward impact assessment and peer review of processes and outcomes.

4. Linking resources with programs—directing potential investors to well suited opportunities.

5. Harness key thinking and experience—knowledge management to help strengthen the CAADP agenda by sharing best available information.

The formulation of national and regional investment plans is one of the most important activities to implement CAADP after the definition and signature of the compact. As of September, 2012 some 30 African countries have signed national CAADP compacts and are at various points in the CAADP process. The process includes:

1. CAADP Process Launch.

2. Development of the Compact.

3. Signing of the Compact.

4. Investment plan development.

5. Business meeting.

Table 9 shows progress toward CAADP implementation in less than ten years. Countries highlighted were those of initial interest to AIFSRC for further investigation. Top tier countries of Zimbabwe, Mozambique and Tanzania are each at different stages of the implementation.

**Table 9 Progress toward CAADP Implementation, as of September 2012**

| Countries still to launch CAADP (12) | Countries working towards signing CAADP Compacts (6) | Countries with signed CAADP Compacts (30) | | |
|---|---|---|---|---|
| | | Countries only signed CAADP Compact (7) | Countries with Investment plans (4) | That have held Business Meetings (19) |
| Algeria, Angola, Botswana, Cameroon, Chad, Egypt, Gabon, Madagascar, Mauritius, Namibia, Sao Tome & Principe, South Sudan | Comoros, Congo-Brazzaville, Lesotho, South Africa, Sudan, Zimbabwe | Central Africa Republic, Democratic Republic of Congo, Djibouti, Mozambique, Seychelles, Swaziland, Zambia | Burkina Faso, Guinea, Guinea Bissau, Ivory Coast | Benin, Burundi, Cape Verde, Ethiopia, Gambia, Ghana, Kenya, Liberia, Malawi, Mali, Mauritania, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Tanzania, Togo, Uganda |

(Source: NEPAD. The Comprehensive Africa Agriculture Development Programme (CAADP). Countries with Investment Plans. www.caadp.net/pdf/Table 1 Countries with Investment Plans ver15 (2).pdf, accessed 8 March 2013).

## 5.3 Lessons Learned

CAADP development and implementation focuses on national level process—accommodating needs of each individual African country. National round table processes were designed as an initial step in the process responsible for: aligning state policies with regional priorities; identifying and strategizing around economic bottlenecks; identifying funding gaps; and initiating monitoring and evaluation of CAADP progress. Having learned through experience, the CAADP process has shifted since early implementation; specific aspects of this shift are shown in Table 10.

**Table 10. Shifts in CAADP implementation by 2009**

| From–initial CAADP process design | To–adapted CAADP process design |
|---|---|
| One administratively appointed focal point person to drive CAADP within each country | A country implementation team to manage the process strategically and professionally.<br>» Facilitation of dialogue and consultations for informed decision making on government and stakeholder buy-in.<br>» Internalised CAADP functions including aligning relevant decision making bodies. |
| Facilitation through RECs | Facilitation, support and capacity development of the country teams through a CAADP Resource Group and, within that, country support teams composed of RECs, AU, NEPAD, pillar institutions taking joint responsibility with clear performance criteria. The CAADP Resource Group acts as a fast learning group where lessons and experiences can be rapidly shared and performance enhanced |
| The compact agreement as a major focus of the CAADP process | Focusing on the impact and outcomes of the process, negotiated with countries and leading to improved performance and capacities to reach the 6% growth target |
| The primary implementation focus on government | Government leadership but including ownership and responsibilities across a wider network of players such as parliamentarians, civil society and other actors. A focus on collective responsibility for implementation and delivery from all major stakeholders. Capacity and institutional arrangements and implementation modalities are part of planning. |
| 'Instruction' to implement CAADP from the higher level with resistance from middle levels | Exploring CAADP's value addition with countries and using a flexible implementation design accordingly, building on the buy-in of technocrats and their institutions. |
| A mechanical and rather static 'roundtable' process | Flexible mainstreaming and alignment of CAADP into national development strategies (reviewing the value of CAADP against existing strategies and plans/programmes). Focusing on organisational development and the quality of a strategic process for design and management, as well as building competence and engaging in continuous learning. |
| Use of 'isolated consultants' for an initial stocktaking exercise | Use of the existing knowledge system and institutions to build fundamental relationships, arrangements and capacities which link planning to knowledge, information and networks ('Building functioning systems'). Expanded stocktaking, diagnosis and an analysis base linked to an on-going analysis of and support for information needs. A focus on building and nurturing local/systemic capacity for analysis and knowledge generation. |
| Analytical work in the roundtable process heavily based on econometric modelling | Analytical work based on a wide angle of perspectives: policy, institutions/capacity, finance/economics, ecosystems, technology. |
| Isolated donor support for country implementation. | Workplan-based funding from the Multi Donor Trust Fund, building on donor alignment in individual countries. |

(Source: www.caadp.net/pdf/CAADP_imp_guide_WEB.pdf, accessed 8 March 2013).

The changes in CAADP processes and approaches indicate structured sharing and learning from experiences has taken place. Initially designed with a CAADP focal person for each country, the process has shifted to country implementation teams with wider reach, greater expertise, and broader networks within and across agriculture.

Early CAADP activities focused on generation of the CAADP Country Compacts as an end in and of itself. While the compact signals consensus and willingness to engage in a shared way forward, it gives little in the way of guidance, structure or implementation plans for achieving 6% growth. The CAADP Roundtable Process was seen as a mechanical and static, at the risk of resting outside mainstream government planning and activities. The current approach focuses rather on mainstreaming and aligning CAADP processes with national development plans and strategies.

Other shifts in the CAADP process seem to reflect 'whose knowledge counts' as more emphasis is being put on enhanced consultation, locally relevant situation analysis, and developing the local capacity to lead these processes.

The next big hurdle for country CAADP processes will be getting broad based buy in to implementing the agreed upon investment plans. This will be another significant step away from business as usual and less integrated development planning and implementation. Yet optimism is called for considering the progress on CAADP in the last five years.

## 5.4 Pathways from Irrigation to Food Security

Scientists from the Challenge Program on Water and Food and the International Water Management Institute have published research suggesting that we can meet our growing population's needs, but in order to do so we must improve water use in agriculture (Fisher & Cook 2012; IWMI 2007). Food and agricultural production currently takes 70% of fresh water withdrawals from rivers and ground water. Therefore mounting population pressure and corresponding consumption patterns will increase competing demands on the natural resource base and serve as incentive to more efficient water use.

Pathways to food security vary across time and space and implicate scales from household to countries, regions and continents. Therefore, the emerging agenda must be based upon the recognition of existing diversity and dynamism of smallholder socio-ecological systems.

Better water management, changes in the enabling and policy environments and improved production techniques will be required to close productivity gaps. Increasing water use efficiency on existing and planned irrigated land alone would significantly reduce the gap.

Linking improved plot level water use efficiency to scheme level, watershed and basin level is the next big challenge for research, investment and implementation. This challenge will be met by establishing appropriate and necessary incentive structures such that all decision makers share risks, responsibilities and benefits (Chilonda et al 2012).

Hanjra and Gichuki (2007) suggest that investment in irrigation water management contributes primarily to poverty reduction (with implications for food security) through a number of pathways, including:

» Increased wage labor opportunities: Greater local labor demand due to construction needs and ongoing system maintenance, linked to intensified economic activity due to extended growing season;

» Higher income and consumption: Based on the assumption that higher income leads to increased consumption, more food stuffs become available, this may improve nutrition security as well by supporting more meals per day and improved intra-household allocation.

- Improved income and nutrition set the stage for improved access to and benefits from education for all children, with particular attention to girls.
- Investment in irrigation infrastructure lowers risk of production loss to climate variability, mainly drought and flood. It also reduces susceptibility to seasonal income troughs.
- Greater equity: investment in irrigation development generates economic activity in proximity to the scheme. In addition to increased money in the area, increased food, information, and services become more readily available to the poor.

Drawing on this information on the situation of irrigated agriculture in Africa, the next section analyses the thematic and geographic issues to identify where Australia may best add value in supporting food production in Africa.

# 6. Analysis

## 6.1 Australia's added value

This study has been directed to consider how Australia may best add value through its support to Africa to enhance food security with respect to blue water use for irrigated agriculture.

Australian Government agencies already invest (or have invested) in a range of major projects supporting dryland and livestock agricultural production and marketing in Africa (Pittock 2011). Australian support is also being provided via GTZ and SADC for enhancing transboundary river basin management organisations in Southern Africa. In our discussions with officials, no major current projects were identified where Australian aid is directly supporting irrigated agricultural production. Further, of 220 Australian companies registered with the Department of Foreign Affairs and Trade as having businesses in Africa, 200 are engaged in mining and few appear to be involved in agriculture. Thus this study is to identify potentially complementary areas for Australian investment to support irrigated agriculture in Africa, starting from a situation where there are no constraints from previous engagements.

In the introduction we began by asking what type of irrigation supports food security and identified that different types of irrigation farming systems have different food security and other socio-economic outcomes. These range from small-scale irrigation supporting household scale poverty reduction and resilience to climate variability on the one hand, through to expansive commercial irrigation schemes growing bulk commodities for national and international markets on the other hand. The Australian Government has not explicitly expressed its objectives for food security in these terms nor a preference for one type of farming system or another. Instead, we address this question of focus in terms of how Australian investment may add most value.

Australia's aid to Africa is modest but increasing rapidly in recent years from a low base. The AIFSRC has a budget of AUD $36 million over four years, complemented by further AusAID investment in food security. Thus there are enough resources to make a significant difference but only if they are targeted in defined areas where Australia could add most value. While difficult to quantify in the case of irrigated agriculture – as shown with the analysis of aid for irrigation in Table 8 - US, European, Chinese and international financial intuitional donors are making substantial investments estimated by FANRPAN to be around USD $100 million per year. Australia should aim to complement rather than duplicate investment by other donors. Much of the other donor aid appears to be directed at expanding areas of irrigated agriculture and on agronomy and particular technologies. For example, USAID's program "Global Hunger and Food Security Research Strategy: Climate Resilience, Nutrition, and Policy" announced in September 2012 allocates USD$12.5 million over five years to "Small-Scale Irrigation Technologies and Agricultural Water Management Practices" focussed on supply side technologies.

As a rule, Australian aid is directed at priorities identified by recipient countries. In the case of agriculture the African government's CAADP policy and the national policies developed under this framework articulate the priorities of these nations. Higher investment in agriculture and greater agricultural production are priorities. As outlined in section 5, many African governments have ambitious targets for expansion of irrigated agriculture. In many but not all instances the focus on large scale irrigation is expressed in part in terms of rehabilitating unused and degraded irrigation areas, and sometimes in terms of greater water productivity. Our assessment of these irrigation expansion plans is that the governments concerned have not articulated means by which the problems of past irrigation development will be avoided with this new expansion. In our view Australia should not invest in research on irrigation expansion, as others are doing so. Instead we consider that improving the poor productivity of existing schemes is an area where Australia can add considerable value. It has the advantages of making better use of existing investments in infrastructure in Africa as well as developing new ways of helping irrigation schemes to become sustainable that would have broader application to existing and new irrigation schemes across the continent. In our view Australia has greater irrigation expertise at this larger scale, and as a result, expertise gained by Australians in work in Africa at this scale may also have greater relevance for application in Australia.

We further consider that investment in irrigated agriculture may best be directed at improving water productivity as this is an area where Australia has particular expertise that is relevant to the types of farming systems found in Africa. Especially in the Murray-Darling Basin, the history of investment in greater irrigation productivity, incentives for water efficiency based on water markets, landcare movement as part of the polycentric governance system, and plans linking water and agricultural production, means that Australian researchers could add value by working in collaboration with African water and irrigation institutions. Greater water productivity is a priority in many regions of Africa where water is scarce or fully exploited, and where there are competing users, such as fisheries. In this research we found widespread recognition that greater water productivity was required but few ideas on how to create incentives and other institutions that may achieve this.

In summary, thematically we consider that Australian research investment supporting irrigation in Africa would be best focussed on systems for improving productivity of existing medium to large scale irrigation schemes. We further point to Australian expertise in water productivity gains and suggest that this is an important, neglected niche where investment could add great value in Africa as well as in Australia. The scale at which this would occur is considered next followed by our assessment of the pathway to implementation.

## 6.2 Theory of change - our pathway to implementation

A history of projects failing to live up to the expectations laid out in the proposal is common in developing country contexts, particularly SSA. For this reason more effort is going into articulating the expected path to impact and how we believe change can happen (theory of change).

Section 3 confirms that there is vast scope for improving water productivity in SSA. Although the research community has developed technologies with proven ability to improve yields, too little of this potential has been captured by farmers. This has called for a rethink of the 'technology push' approach and put the focus on organizational and institutional blockages to progress (Byerlee 1998). The Forum for Agricultural Research in Africa (FARA) among others, has argued for a change in the way research projects are traditionally carried out (Clark 2002, FARA 2006). In particular they ask the research community to move away from the business as usual model of knowledge generation by scientists – knowledge transfer by extension – knowledge adoption by farmers in favour of an Integrated Agricultural Research for Development (IAR4D) approach. Very recently this has evolved into the proposals for Innovation Platforms, comprising farmer, suppliers, transporters, processors, retailers, insurers, credit providers, government agencies and local political representatives along the value chain in order to identify obstacles and opportunities for change.

Even if the bottom-up technology push is being discredited, the top-down organizational reform is no panacea. The preceding discussion on the CAADP process shows the vast potential for focusing governments on rural development, but highlights the problem of turning these aspirations into on-ground action. Our theory of change is based on a meeting of bottom up and top down approaches following the analogy of Woodhill (2010) that the technology is the hardware and the institutions are the software and these must work together if the whole system is to be more productive, equitable and sustainable.

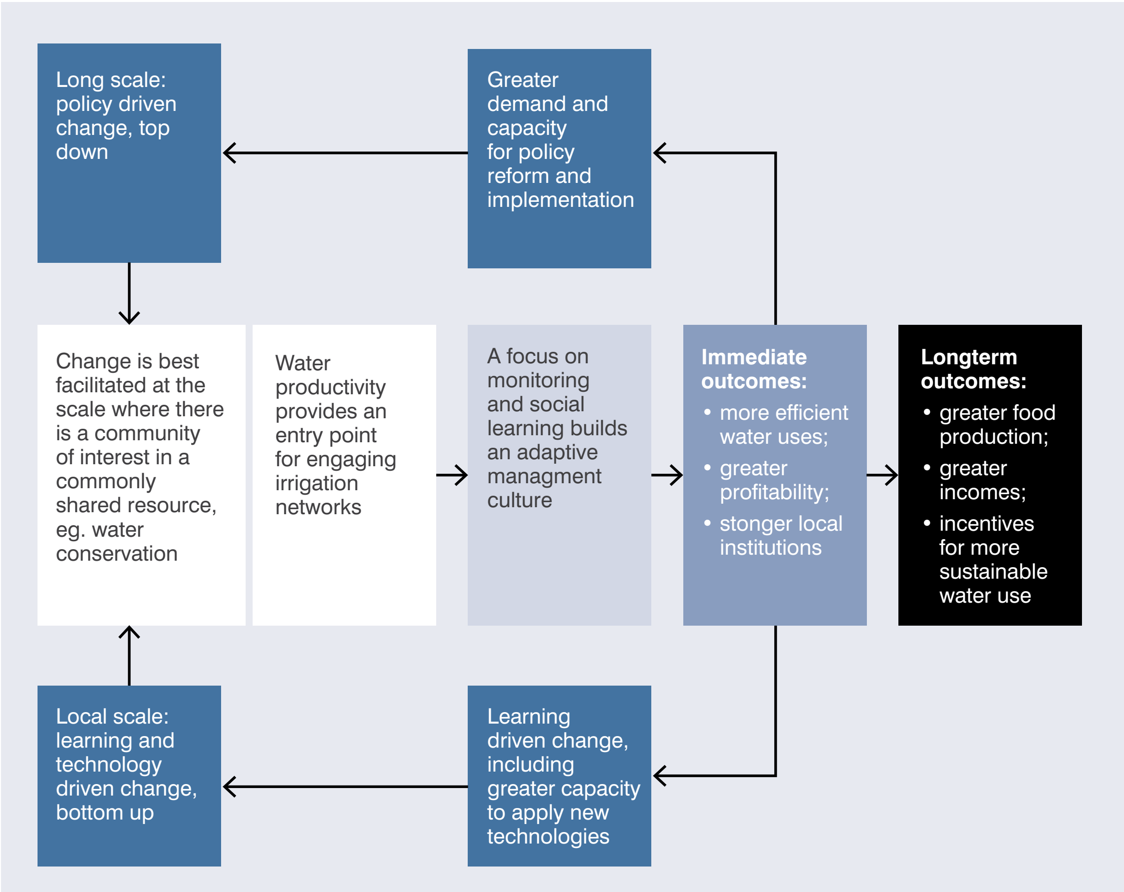
Our theory of change is outlined in Figure 5 and is consistent with an Innovation Platforms approach. In order to implement this, we propose the scale of intervention as a water user association (blue outline). This scale captures the interests of the community in terms of the shared resource and infrastructure, and also represents the financial interests of farmers who are making a living from irrigation and associated institutions. This is a key point where equity in institutions needs to be assured to ensure that women and other disadvantaged groups participate, influence and benefit from change processes. Furthermore we propose that the adaptive management approach is the methodology of choice when trying to bridge institutional and technical innovation (green outline). The issues raised by the water user association frame the problem in terms of their long term goals (purple outline), the policy and institutional environment (top down) and the current technology and aspirations of the farmers (bottom up). Problem framing helps the scientists to determine which aspects of the system need to be monitored in order to structure learning across the network.

The information from the monitoring and subsequent learning fosters the intermediate outcome of building capacity in the local institutions and the skill of the farmers (red outline).

The important part of Figure 5 is the two feedback loops. The first loop is directed upwards as the WUA better understands their requirements and obligations and articulates for better investment of funds or reform of policy. The second loop is directed downwards as farmers see how their practices impact individually on productivity and collectively on sustainability. This creates the awareness and appetite to employ better skills and technology.

Focussing on WUAs helps build social capital to better manage common pool resources, such as water resources (Ostrom et al 1999). In strengthening social learning in these local institutions greater resilience and adaptability to change will be enhanced, for example, in adaptation to climate change.

**Figure 5. Recommended pathway to implementation.**



## 6.3 Where to invest

The location and scale at which Australian investment in irrigation research may yield best results is now discussed. This has a number of elements, namely: regional focus, country focus and geographic and institutional scales of intervention.

Australian support for work in Africa is welcome but limited and thus a choice of geographic focus is required to maximise impact. One element of the choice is work in places which complements existing Australian engagement with African countries. In terms of long term engagement through people to people ties and the Commonwealth, priority countries for AusAID investment, and nations where AIFSRC and Australian Centre for International Agricultural Research (ACIAR) supported research is underway, the southern and eastern African regions were selected as a focus for this work. Africa is a very diverse continent and it has a number of strong regional organisations of nations in addition to the African Union and its subsidiary structures like CAADP. Work in countries in Africa will have greater potential for dissemination if it connects with agricultural and water institutions in the regional organisations, such as the Southern African Development Community and the East African Community.

In our research brief we were asked to select countries for further work from the following nine countries: Botswana, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe. The logic for this choice is that research funds will be limited so that any future research should be focussed on around three states and possibly up to six. There are many criteria for selecting priority countries for investment that involve informed value judgements. These recommendations are based on:

» Existing ties with Australia;
» Extent of existing and proposed irrigated agriculture - potential to produce more food (as outlined in section 3);
» Extend of the rural population who may benefit from poverty reduction (as outlined in section 3);
» Currently favourable policies and other institutions;
» Sufficient local expertise and stable governance structures;
» Links to on-going research networks and work on which to build;
» Links to regional organisations.

Our assessment is that the priorities for Australian funded research can be classified as follows.

## 6.3.1 First priorities: Mozambique, Tanzania, and Zimbabwe.

Mozambique is a priority country for AusAID. There are already ties between Australian and Mozambican agricultural businesses and also researchers. The nation has large areas of existing irrigation schemes that lie unused as well as ambitious plans to further expand the area under irrigation. Extensive rural poverty could be reduced through stronger growth in agricultural production. Further, rapid economic growth is creating greater institutional capacities and also markets for agricultural production. Researchers in Mozambique are strongly linked to SADC institutions.

Tanzania is not a priority country for AusAID but we consider it should be a priority for support in agricultural research for a number of reasons. The nation has ambitious plans to further expand the area under irrigation backed up by government policies and other support. There is the potential for production in Tanzania to underpin food security in more arid, less stable and more densely populated countries in East Africa. Extensive rural poverty could be reduced through stronger growth in agricultural production. Further, past policies to reduce gender inequity in Tanzania provide a strong basis for seeking greater equity in irrigated agriculture. Researchers in Tanzania are strongly linked to both EAC and SADC institutions.

National agricultural planning documents suggest Tanzania intends to develop significant irrigation lands. Government documents suggest that Tanzania is endowed with 94.5 million hectares of land, 44 million hectares of which are classified as suitable for agriculture. Just over 29 million hectares are suitable for irrigation and of these, 2.3 million hectares are classified as high potential, 4.8 million hectares as medium potential, and 22.3 million hectares as low potential.

However, only 345,690 hectares have been provided with improved irrigation infrastructure. The country is also endowed with numerous and diverse water resources in the form of rivers, lakes, wetlands and aquifers. There is therefore a need to have a good management and utilization of land, water resources and forest cover for sustainable agriculture (United Republic of Tanzania 2011:24).

Zimbabwe is a priority country for AusAID and despite being the poorest considered, there is potential to draw on a well-educated population to advance agriculture in the reconstruction of the country after previous political issues. There are already extensive ties between Australian and Zimbabwean non-government institutions. While there are not recent, reliable statistics or targets for Zimbabwe, there is a history of innovation in irrigation and agricultural production is expanding rapidly. Rural poverty could be reduced through growth in agricultural production. Researchers in Zimbabwe are strongly linked to SADC institutions.

Zimbabwe has approximately 366,000 hectares of irrigation potential of which 175,000 ha is developed. Approximately 102,000 hectares are operational and the other 73,000 ha are equipped but the equipment was damaged during land reform, thus requiring rehabilitation.

The draft Zimbabwe Agricultural Investment Plan has allocated budget for revival of irrigation on at least 70,000 hectares of land that was previously irrigated and expansion of contract production of sugar cane for ethanol production (Government of Zimbabwe 2012).

Given the land reform of the last decade in Zimbabwe, the irrigation water distribution system and the type of irrigation technologies require urgent review to make them suitable for smallholder farmers.

**Table 11 Government of Zimbabwe Public Expenditure in Agriculture since 2009**

| Item | 2009 | 2010 | 2011 | TOTAL |
|---|---|---|---|---|
| Input Support | 60,000,000 | 87,400,000 | 45,000,000 | 192,400,000 |
| Extension & Other Support Services | 13,390,040 | 93,617,472 | 103,853,800 | 210,861,312 |
| Irrigation Development | | 843,000 | 11,763,500 | 12,606,500 |
| Total | 79,040,040 | 300,206,439 | 238,167,300 | 617,413,779 |

(Source: Government of Zimbabwe (2012:24)).

### 6.3.2 Second priorities: Ethiopia, Malawi and Zambia.

Ethiopia is a priority country for AusAID. The nation is investing in expanding the area under irrigation to a greater extent that most other nations. Greater resilience to climatic variability may be enhanced and extensive rural poverty could be reduced through stronger growth in agricultural production. On the other hand irrigation development in Ethiopia is more centrally directed than the other states and we consider that this may make the type of research prioritised in this study less likely to be successful.

Malawi is a priority country for AusAID. The government has some well-crafted policies and few resources to implement them compared to most of nations. Proportionally the nation has highly ambitious plans to further expand the area under irrigation but the total area concerned is small and for that reason Malawi is considered a second priority here.

Zambia is also priority country for AusAID. It is also expanding the area under irrigation to a great extent that most other nations. Work in Zambia would also be beneficial but it is considered secondary here as a wealthier nations with a lower population.

### 6.3.3 Third priorities: Botswana, Kenya and Uganda.

Botswana is not priority country for AusAID. It is not considered further here as the area under irrigation is small and the country is among the wealthiest per capita in Africa.

Kenya is a priority country for AusAID. While there could be good reasons to work in Kenya there is less potential for irrigated agriculture. Further, with the commencement of a new constitution in Kenya in 2013 that will devolve many agricultural and water functions to district governments, we judge that it would be better to wait until the new institutions are fully operating.

Uganda is not priority country for AusAID. It is not considered further here as the area under irrigation is small.

Thus we advise an initial focus on investment in Mozambique, Tanzania, and Zimbabwe.

# 7. Conclusions

We were asked to recommend priorities for Australian investments in irrigation research for development in selected Eastern and Southern Africa countries by addressing the following objectives:

1. Assess and recommend to the Australian International Food Security Centre a strategy for investment in blue water use in food production in selected eastern and southern African countries for up to five years.

African government have extensive plans to expand irrigated agricultural production (section 5) however plans to avoid the economic, social and environmental failings of past schemes have not been articulated. In particular, productivity of existing irrigation in Africa is low and in many places water resources are already scarce. Our assessment (in section 3) identified some options for Australian investments in irrigation research. In terms of expanding the area of irrigation production one opportunity is to enhance existing programs for delivering domestic water to supply a bit more for household gardens. At a larger scale, greater use of groundwater in Africa may enhance agricultural production in systems that are simpler to manage, dispersed across the landscape where they may spread benefits for people and minimise environmental impacts, and thus are less likely to fail.

Our recommended focus is on increasing water productivity in existing irrigation schemes. Irrigation water users are not compelled to use water resources as efficiently as possible: local level learning can help identify those incentives and help scale them out to other users and up into policy processes. We consider the pathway to implementation involves engaging water user associations in monitoring their water use as the first step in establishing an adaptive management cycle of societal learning that enhances agricultural production. Women's participation in these institutions is essential to ensure gender equity.

The resulting'water literacy' may then catalyse a number of beneficial changes, including more productive water use, profitable and sustainable irrigation schemes and greater food security. Success at this level is anticipated to influence farmers to take up new farming methods. Importantly it is also expected to positively influence governance institutions, including by emphasising the need to establish incentives for more productive water use. Separately we are submitting to AIFSRC a project proposal for such work.

2. Identify potential contributions from research on water and food for poverty reduction, food security, sustainability, climate change adaptation and enhanced governance on subjects where Australia has a comparative advantage.

Australia and Southern and Eastern Africa share some of the most variable climates in the world.  Australian governance, research and farming institutions have a lot of experience in adapting to water scarcity, climatic variability and change. Key areas of Australian expertise relevant to Africa include: incentives for water efficiency, water allocation and markets, infrastructure renovation, rural community based natural resource management, catchment planning, and nested governance structures. Yet Australia's development support is also limited and there are other donors to Africa. For these reasons we recommend that Australian agencies do not invest in the planned expansion of irrigation schemes but instead focus on research and development of greater water productivity and adaptive learning processes at the water user association scale. We consider that these capacities that initially improve poverty reduction and increase food security would have flow on benefits for climate change adaptation and also for better governance.

3. Identify the added value of Australian investment and co-benefits for Australia and recipient countries.

Greater water productivity and adaptive learning processes for irrigated agriculture are recognised as priorities in Africa. Our research found that there are virtually no incentives for increasing water productivity now in most African countries. Further, a failed 'extension' model is relied upon rather than instilling capacity for social learning for adaptive management in farming communities. These are areas where Australia has considerable practical expertise in adaptation to hydro-climatic variability and change that could assist in Africa. At the same time lessons learnt in Africa have application in Australia as we strive for more sustainable farming systems. In particular, successes of community scale initiatives in African societies where there are fewer government resources may hold lessons for Australia.

4. Identify interventions that will improve the food security of the most people, especially poor people in situ through better water management.

Our thinking on this question evolved over the course of the project. To reduce poverty and increase resilience to climate change variability for poor people in situ we considered options for expanding the area of irrigation production through household gardens and also through greater use of groundwater in Africa. There are many NGOs working on these options, and while they have co-benefits, for agriculture the initial capital cost of small scale schemes is high per hectare.

A complementary approach recommended here is increasing water productivity and adaptive learning on existing irrigation schemes. This has the advantage of increasing benefits from existing resources. It does favour commercial production such that food security is increased on a national or regional scale and poverty reduction is a less direct outcome.

5. Recommend priority countries for investment.

There are a number of 'equally right' options for investment in research and development in irrigation in Africa. We applied a number of criteria to settle on the following. Based on extensive current and future irrigation schemes that could help reduce poverty and increase security for many people, as well the capacity of local institutions and ties to Australia, our recommended first priorities are: Mozambique, Tanzania, and Zimbabwe. Our report provides more details of the irrigation situation in these countries in the appendix. Three more countries were identified as second priorities where work could be usefully undertaken should funds allow: Ethiopia, Malawi and Zambia.

African governments are undertaking a massive expansion in irrigation without addressing the reasons why so many previous schemes have been unsuccessful. Collaborative research between Australian and African institutions could play a major role by increasing productivity of small holder irrigation farming and thus improve food security.

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# Appendix: Implementation

The study assessed the viability of each of the nine focal countries presented above and determined that there were adequate networks, partnerships and capacity to conduct high quality relevant research in Mozambique, Tanzania and Zimbabwe.These countries are considered by ReSAKSS among SSA's most dynamic economies, each having registered average GDP growth rates above 5% from 2003-2010. Each of these countries has reached the CAADP 6% agricultural growth target at least once between 2006 and 2009. However, none of these three were able to meet the target of doubling irrigation area under the RISDP (Chilonda et al 2012). The agricultural policies of these three nations developed within the CAADP process are now summarized in the first part of the country analyses below.

For each of these countries a more detailed assessment was undertaken by team members and local experts to identify the current status of irrigated agricultural production, key institutions and opportunities for further work to enhance water-efficient production. This forms the second part of the country analyses below. Local experts were asked to answer a set of questions for each country that would provide initial data needed to design a project that looks at how to enhance water use efficiency in irrigated agriculture starting at the water user association scale. This data is intended as a basis for commissioning follow up research work.

# A.1 Mozambique

## Policy overview

Mozambique Government approved the Strategic Plan for Development of Agriculture Sector (PEDSA, 2011-2020) on 3 May 2011 (Government of Mozambique 2011). PEDSA emerges as a guiding framework, synergies driver and harmonizing tool to promote agriculture development whose target is to achieve an average annual agriculture growth of 7%. PEDSA is a result of a process led by the Government with participation of the private sector, the civil society, education institutions and development partners. PEDSA vision falls under 2025 Vision for Mozambique and the perspective: "A prosperous, competitive and sustainable agriculture sector, capable of providing sustainable responses to food security and nutrition challenges and targets agriculture markets globally". To realize the agriculture sector vision, the strategic plan has this mission: "Contribute to food security and income of agriculture producers in a sustainable and competitive manner ensuring social and gender equity".

In Mozambique, the national CAADP Compact was signed on 9 December 2011, and will be implemented through the Strategic Plan for the Development of Agriculture Sector (PEDSA). The country is one of many in the region that is failing to reach the 10% target investment in agriculture in the Maputo Declaration. During the period 2003-10, Mozambique averaged 6.21%. However, Mozambique has been one of few success stories in terms of consistent agriculture GDP growth rates of more than 6 percent in most years between 1995 and 2009.

Agriculture growth needs a long-term perspective and multi-sectoral coordination to achieve the targeted impact concerning poverty alleviation and food security and nutrition in the country. Therefore, operationalisation of CAADP through PEDSA aims at improving agriculture sector performance with the following basis:

1. Identification of development options that prioritize implementation of actions with impact on poverty, food security and nutrition and other indicators enabling the country to achieve the Millennium Development Goals, in particular, the goals one and seven (MDG 1 and 7). The Multi-sectoral Plan for Combating Chronic Malnutrition is an example.
2. Design of a medium-term and long-term investment plans in the light of PEDSA objectives and results.
3. Use of evidence to guide strategies and policy implementation and design for decision-making at sector level.

Mozambique's current strategic plan aims to increase agriculture sector growth through: increased use of improved technologies; enhanced availability and improved management of water resources; and development of improved varieties for greater yields and nutrition.

***Priority Actions under CAADP in Mozambique***

CAADP implementation in Mozambique seeks to increase productivity and competitiveness of the agriculture sector in order to ensure food and nutrition security, poverty reduction, and increased incomes and job creation. It will be necessary to carefully manage the means of production to keep costs in line with international trends.

Agriculture sector growth in Mozambique will be anchored to PEDSA pillars, looking toward a number of targets in the medium term (Government of Mozambique 2011):

1. Infrastructure: Construct dams for water storage for agriculture and fisheries activities promote expansion of infrastructures in areas with productive potential through public and private investment.

2. Value chain development: Support development of value chains for basic agriculture products with technological support; develop a network of agriculture input providers to extend access in a sustainable manner. Ensure increased agriculture income through better marketing of products.
3. Linking learning systems: Create effective and sustained linkages between researchers, rural extension services, smallholder farmers, fishermen and other stakeholders; consolidate agriculture research centred on production and productivity.
4. Gender equity: Encourage women farmers' participation through removal of obstacles to credit access, technologies, information and inputs, markets and products (Gemo, 2011).

## Expert assessment

***What are the national policy settings for: a) irrigation; b) water; c) integrating water and ag governance?***

**Agricultural Policy Setting in Mozambique**

Mozambique has enormous potential for irrigated farming, with an estimated 3.3 million ha potentially irrigable. The area with irrigation infrastructures in about 120,000 ha of which only 50,000 ha is currently irrigated (60% is used for sugarcane production). Only 8.8% of family sector farmers use some form of irrigation.

The Government of Mozambique designed and has been implementing a series of policies, strategies and programmes with the purpose of fighting against the absolute poverty, achieving food security and promoting sustainable socio-economic development. These instruments, taken together, comprise the guiding framework for public sector action in the various branches of the country's economy. Key sources of data for this assessment are: INAG (2011), MNAG (2011, 2012) and Munguambe et al (2009).

In the case of agriculture, and particularly regarding issues related to intensifying and diversifying farming and livestock production, the framework is built from the guidelines contained in seven key documents namely: (i) The Agricultural Policy and Implementation Strategy (PAEI); (ii) The Absolute Poverty Reduction Action Plan (PARPA); (iii) The 5-Year Government Programme 2010-2014; (iv) The Green Revolution Strategy; (v) The Food Production Action Plan (PAPA); (vi) The Rural Development Strategy (EDR); and (vii) The Food and Nutritional Security Strategy (ESAN).

i. **The Agricultural Policy and Implementation Strategy (PAEI)** was approved in 1996 and is still in force. The PAEI integrates agriculture into four (4) main areas of Mozambique´s economic development objectives: (a) Food security; (b) Sustainable economic development; (c) Reducing the unemployment rate; and (d) Reducing the levels of absolute poverty. Thus, it is recognized in the PAEI that the expansion of productive capacity and improvement of agricultural productivity depends on appropriate strategies and objectives that include among others: Access to land its planning and developing; Food production for self-sufficiency and food security; Restructuring the agro-business sector; Development of efficient professional training, research and extension services; Plant and animal protection; and Infrastructure development.

ii. **The Absolute Poverty Reduction Action Plan – PARPA I**, the 2001-2005 was Mozambique´s first poverty reduction strategy and it focused on institutional reform aimed at providing an appropriate environment for private and public investment in human capital and productive infrastructure, as a way of facilitating economic growth. The implementation is organized into 6 strategic areas specifically: macro-economic financial management; education; health; agriculture and rural development; basic infrastructures and good governance. PARPA II, 2006-2009 define the country´s medium term strategy for promoting growth and reducing poverty, through activities grouped into three pillars: Governance; Human Capital; and Economic Development. With regard to rural development, the Government´s main goal was to increase income-generating opportunities, particularly for the family sector.

iii. **The Government 5-Year Plan 2010-2014 (PQG)** centres government action on the “combat against poverty to improve the living standards of the Mozambican population, in a climate of peace, harmony and tranquillity”. The PQG reiterates the importance of agriculture as the basis for developing the domestic economy, offering high potential for fighting poverty. The goal continues to be the structural transformation of subsistence agriculture into prosperous, competitive and sustainable agriculture, making an increasing contribution to GDP through implementing the Green Revolution, which highlights agricultural research, water resource management and animal traction. The PQG establishes the following strategic objectives for the agriculture sector: (a) Ensure the growth of production and food security; (b) Raise the productivity of farming activity and its whole value chain; (c) Encourage the increase of agricultural production for the market; (d) Promote the sustainable use of land, forests and wildlife; and (e) Develop the human capital and institutional capacity of the agriculture sector. Mozambique is currently preparing the Poverty Reduction Plan (PARP) for 2010-2015. The PARP is a medium term planning instrument for socio-economic management intended to materialize the 5-Year Government Plan.

iv. **The Green Revolution Strategy,** approved by the Council of Ministers in 2007 is considered to be both a national policy instrument and simultaneously a mechanism for speeding up fulfilment of the goals of the previous Government 5-Year Programme (2005-2009), which aimed to increase production and productivity of basic food products and introduce cash crops to ensure food security and surpluses for export. The primary objective of the Green Revolution in Mozambique is therefore to stimulate growth in small producer production and productivity, increasing the supply of food in a competitive and sustainable way. Taking into account the main constraints to the development of the agriculture sector, the Green Revolution´s implementation strategy is based on five (5) pillars: (a) Natural resources (land, water, forests and wildlife; (b) Improved technologies; (c) Markets and up to date information; (d) Financial services; and (e) Formation of human and social capital. An integrated production and value chain approach is fundamental in order to achieve the Green Revolution, together with the involvement of all actors from both public and private sectors and civil society organisations. With regard to the State institutions, the participation of the following Ministries is crucial: Ministries of Planning and Development, Finance, Industry and Trade, Public Works and Housing, Fisheries, Health, Science and Technology, Education, Culture, Mineral Resources, Labour and State Administration, coordinated by the Ministry of Agriculture.

v. **The Food Production Action Plan 2008-2011 (PAPA)** comprises the main instrument for operationalising the Green Revolution Strategy. The PAPA establishes national programmes and production targets aimed at guaranteeing the increased availability of food through growth in agricultural production and productivity. Operational Plans were drawn up, with specific targets by province and district including implementation mechanisms.

vi. **The Rural Development Strategy (EDR)** approved in 2007 aims to improve the quality of life and develop the rural areas, through: (a) Competitively, productivity and the accumulation of wealth; (b) Productive and sustainable management of natural resources and the environment; (c) Diversification and efficiency of social capital, infrastructures and institutions; (d) Expansion of human capital, innovation and technology; and (e) Good governance and planning for the market.

vii. **The Food and Nutritional Security Strategy II 2008-2015 (ESAN)** aimed to guarantee that all citizens have physical and economic access at all times to sufficient food for an active and healthy life, in fulfilment of their human right to adequate food.ESAN II underlines that food and nutritional security is a crosscutting issue that involves sectors such as agriculture, livestock, fisheries, commerce, transport, education, employment, social security and the environment, and its implementation must therefore be done in coordination with a broad range of actors (various ministries and governmental institutions, the private sector and civil society).

The National Irrigation Strategy adopted in 2011 aims to contribute to increase agricultural production and productivity through better use of hydro-agricultural potential within agricultural activities. Strategically it suggests the investment and financing; Policy / Regulations / institutional framework of the Irrigation Subsector; Provision of irrigation services; and harnessing the management and sustainable use of irrigation.

Furthermore, the Government of Mozambique through the Ministry of Agriculture (MINAG) has developed the Agricultural Strategic Development Plan (PEDSA) to tie up all other policy and strategies mentioned previously. PEDSA was developed to address the following key constraints within the sector: (a)Low Agricultural Productivity; (b) Weak Market Access; (c) High Food Insecurity; (d) Access to Land, Water and other Natural Resources; and (e) Institutional Coordination Complex Environment. Thus, the above mentioned constraints constitute the pillars of implementing PEDSA.

Moreover, the Ministry of Agriculture is in the process of drafting the National Investment Plan for Agricultural Sector (PNISA) which recommends five strategic objectives as a way of responding to the pillars listed in the PEDSA document. The strategic objectives comprises: (a) Increasing food production; (b) Increasing production oriented to market; (c) Improving the competitiveness of agricultural producers; (d) Sustainable use of soil, water and forests resources; and (e) Development of the agricultural sector institutional capacity. Thus, PNISA has five (5) major components namely: Component 1: Production and Productivity; Component 2: Access to Market; Component 3: Food Security and Nutrition; Component 4: Natural Resources; and Component 5: Reform and Institutional Strengthening. Under Component 1 it's where irrigation plans and programmes are developed being the major challenges: (a)Empower and operationalize public irrigation services (based on the Irrigation Strategy); (b) Expand the current irrigated area by at least 50 000 ha; and (c) Raise the level of irrigation utilization from the current 60% to 80%. This will be done by the National Irrigation Institute (INIR) which was created in April 2012 but still not established. The main INIR objective is to plan, develop and manage the use of water resources in agriculture, including the harmonization of interventions with regard to irrigation.

Another subprogram is the Institutional Capacity Building of the Irrigation Subsector which will comprise the following interventions: (a) Restructure the current service capacity and make them dynamic and proactive; and (b) Improve the provision of technical services and others to complement and accelerate the good and proper implementation of programs and projects of the Subsector. Specifically the activities will include but not limited to: (a) Installation of INIR Headquarters and Delegations and strengthening management capacity; (b) Training of INIR Headquarters and Delegations staff; (c) Establishment of irrigation Database; (d) Development of Rules and Regulations for Construction, Operation and Maintenance of Irrigation Schemes; (e) Technical Assistance to INIR; (f) Functional mechanisms of institutional interaction in the Irrigation Subsector; and (g) Provision of incentives for teaching and research in water management techniques in agricultural production. On the other hand, there is also a Subprogram to expand sustainably the management of irrigation systems which will include: Irrigation development studies; rehabilitation and construction of irrigation infrastructures; and Irrigation management.

The institutional foundations of agriculture and rural development in Mozambique are mainly comprised by public sector actors, in particular the MINAG. MINAG´s main functions include the analysis, formulation and monitoring of sectoral policies (land and agricultural); service provision (research and extension); the establishment of internal and external regulatory and auditing mechanisms. The Ministry of Public Works and Housing (MOPH) is responsible for water policy and management and the network of rural roads. The Ministry for Environmental Coordination (MICOA) coordinates all matters related to the sustainable use of natural resources and the protection of Mozambique´s ecology and ecosystems. The Ministry of Industry and Trade (MIC) is responsible for trade policies including the regulation of agricultural markets. The Ministry of Planning and Development (MPD) has general responsibility for national planning and resource mobilization. The Ministry of State Administration (MAE) has responsibility for promoting rural development and coordinating the decentralization process. With regard to the irrigation policy and programme, there is close collaboration between MOPH and MINAG around the use of water resources for agriculture.

Within the African context, Mozambique is participating in the New Partnership for African Development, NEPAD. NEPAD´s agricultural programme, the Comprehensive Agriculture for Africa Development Programme (CAADP), has four pillars that are mutually reinforcing and on which the improvement of Africa´s agriculture, food security and trade balance is based: (a) Expand the area under sustainable land management and create safe systems of water control to reduce the dependence of agricultural production on irregular and unpredictable rainfall; (b) Improve rural infrastructures and capacities related to commerce and access to the market; (c) Increase the availability of food and reduce hunger; and (d) Agricultural research and the dissemination and adoption of technology.

***Water related policy and strategies***

Following the adoption of the Millennium Development Goals (MDGs) and WSSD in 2002, SADC formulated the Regional Water Policy and Strategy (Resolution Nr. 46/2007) to which all the SADC Member States including Mozambique are formally committed. The SADC Water Protocol on shared watercourses was also developed and signed in 2000, to materialize the implementation of the MDGs in the region. The legal framework for water resources management in Mozambique is also going through a reform process, as part of the public sector reform however, the major policy and strategy framework of the water sector in Mozambique are the: Water Law (1991); Institutional Framework for Delegation of Water Supply Management (1995); Implementation Manual for Rural Water Supply (1997); Water Tariff Policy (1998); National Irrigation Policy (1998); Rural Water Transition Plan (2001); Strategic Plan for Urban Water Supply & Sanitation (2006); Strategic Plan for Rural Water Supply & Sanitation (2007); Mid Term Expenditure Framework 2008-2010 (2007); National Water Policy (2007); and National Water Resources Management Strategy (2007).

The Water Law of 1991, NWP of 1995 and the NWRMS of August 2007 have foreseen the establishment of decentralised water resources management including water supply and sanitation services. Thus, the National Directorate of Water (DNA) and the Regional Water Administrations (ARAs) are responsible for the progressive implementation of the water resources plans and recommendations. The majority of water resource management activities are performed at the River Basin Management Unit (UGB) level. To date, all the five ARAs have been established, viz. ARA-Sul, ARA-Centro, ARA-Zambeze, ARA-Centro-Norte, and ARA-Norte. The institutions and their respective role on water resources management in Mozambique are provided in Table 12.

**Table 12. Roles of the major institutions of the country's Water Sector (Source: Munguambe et al 2009).**

| Institutions | Role |
|---|---|
| 1. Ministry of Public Works and Housing (MOHP) | Government institution responsible for all water related issues, specifically:<br>» To promote the best use of national water resources;<br>» To propose policies for the development of water resources and their respective implementation;<br>» To propose the establishment of an inventory of water resources, demand and balance at national level and river basin<br>» To regulate the use of water resources. |
| 2. National Water Council (CNA) | Advisory body for the Council of Ministers responsible for inter-sectoral co-ordination and strategic decision-making. |
| 3. National directorate for water (DNA)<br>» Department of water Supply (DAR)<br>» Department of Urban Water (DAU)<br>» Department of Sanitation (DES)<br>» Department of Water Resource Management (DGRH)<br>» Office of International Rivers (GRI)<br>» Public Works Office (GOH)<br>» Office of Control and planning (GPC)<br>» Department of Administration and Finance (DAF)<br>» Department of Human Resources | The main institution under the MOPH responsible for the management of the Water Sector in the country through nine created departments. The DNA is responsible for:<br>» Define policies;<br>» Stock taking of water resources and requirements at all levels;<br>» Prepare and implement general systems;<br>» Execute investments in studies and projects;<br>» Prepare legislation and inspect enforcement. |
| 4. Regional Water Administrations (ARA's) | Responsible for carrying out operational management of water resource at regional scale, including the collection of hydro-meteorological, data storage, dissemination, development of Flood Advisory System, registration of water users, billing and collection of water use charges, implementation of basin plans including the promotion of stakeholders participation. |
| 5. Council for Regulation of Water Supply (CRA) | Ensure balance in quality of service provided to safeguard the interest of water users and the economic sustainability of the water supply systems. |
| 6. Investment Fund and Assets for Water Supply (FIPAG) | Promoting management of funding in the autonomous efficient and lucrative way through various types of contracts with private operators. |

To operationalize the NWP, a National Water Resources Management Strategy (NWRMS) was developed in Mozambique in 2004, and then adopted in August 2007 and its main objective is to effectively guarantee the implementation of the NWP. It covers in general the whole range of water resources (i.e., surface and groundwater); water quality and protection of ecosystems; use of water by the various national economic sectors; legal and institutional framework; institutional capacity building as well as issues related to national development and regional integration. The NWRMS noticeably covers all relevant aspects of IWRM including the need for gender mainstreaming in water resources management. The harmonization of the water sector legal framework and others considered relevant, i.e., Agriculture, Industry, Energy, Environment, Health, Planning and Urban Development, Tourism, etc., is one of the state's essential principles on water management. Therefore, the following sectoral policy and legislation is also considered important in the water sector: (a) Land Law of 1997 and the respective regulations;(b) Environmental Law of 1997 and its Policy of 1995; (c) Mining Law (Nr. 14/2002); (d) Fisheries Law (Nr. 03/90); (e) Rural Development Strategy (09/2007); and (f) Green Revolution Strategy (2007). Thus, the water sector policies and legislation provides the country with a solid base for institutional reform and IWRM planning and implementation.

***What catchment management and water users organisations exist? Who trains the key people?***

The National Water Administration (ARAs) bodies are responsible for water management at a regional level (Southern, Centre, North, and Centre-North). ARAs that have been established to date include: ARA-Sul, ARA-Centro, ARA-Zambeze, ARA-Centro-Norte, and ARA-Norte. However, in each ARA there are several River Basin Management Committees responsible for a specific catchment management. Training and other capacity building needs represents the major challenges for an effective implementation and management of water resources in the country. This is applicable for all the established ARAs. The existing river basin management committees/unit include: ARA – Sul: Incomáti River Management Unit; Limpopo River Basin Management Unit; Umbelúzi River Basin Management Unit; Save River Basin Management Unit; Maputo River Basin Management Unit; ARA-Centro: Púngoè River Basin Management Unit; ARA- Zambeze: Zambeze River Basin Management Unit; ARA-Norte: Rovuma River Basin Management Unit. The Committees are advisory bodies of the River Basin Management Units.

Some irrigators in most of the public irrigation schemes are organized in water users associations (e.g., AREDONZE at Chókwè Irrigation Scheme in the Limpopo River Basin; etc.) but its functioning is still limited. Training activities regarding irrigation water management or other irrigation related issues is basically provided on ad-hoc basis by extension officers with also limited knowledge and capacity.

***Who (agency) does ag extension in these countries?***

In Mozambique, agricultural public extension is mainly provided by the Ministry of Agriculture (MINAG) through the National Directorate of Agricultural Extension (DNEA) which has provincial and district branches and officers. However, the quantity and the qualification of the existing human resources are limited particularly with regard to irrigation. Some limited NGOs such as the Word Vision, Save the Children among others have been assisting some farmers in agricultural practices linked to the promoted crops.

***Who trains ag extension officers?***

Extension officers training occurs basically through on-job training but also via identified consultant and/or senior Extension Officers. But there are not regularly/planned provided.

***Who are the significant universities in agriculture and water?***

University Eduardo Mondlane – Faculty of Agronomy and Forestry Engineering; Catholic University (Niassa Province - Cuamba District); University of Zambeze - Agricultural High School (Zambézia Province, Mocuba District); Polytechnics High Schools (Gaza, Manica and Tete Provinces).

***Who are the significant NGO's working on ag and water?***

***What ag and water data is collected? How publicly available is it? How is it used?***

In both situations you need to write a letter in order to purchase and access the data for a specific use.

***How are ag water allocations made and measured? (eg. Volumetrically, by land area, etc).***

This scenario is different on the private schemes, particularly those producing sugar cane. More than 60% of their fields are irrigated by pressurized technology such as central pivot and conventional sprinklers.

***How is ag productivity measured? How does ag productivity compare to potential yield?***

Agricultural productivity is measured in terms of yield/area, i.e., tons/ha. Generally, the actual yield is about 1/3 of the potential. Just to have an idea for maize in the Chókwè Irrigation Scheme, the average yield for the current used cultivars is 1.5 to 2.5 ton/ha and the potential is close to 6-8 ton/ha. This obtained yield involves all other production factors including water.

***How could gender equity be advanced through this ag and water project?***

80% of the Mozambican population depends on agriculture activity and more than 60% are women. Women are eager to test new technologies.

***Is there a sub-basin in the country that lends itself to an ag water productivity case study***

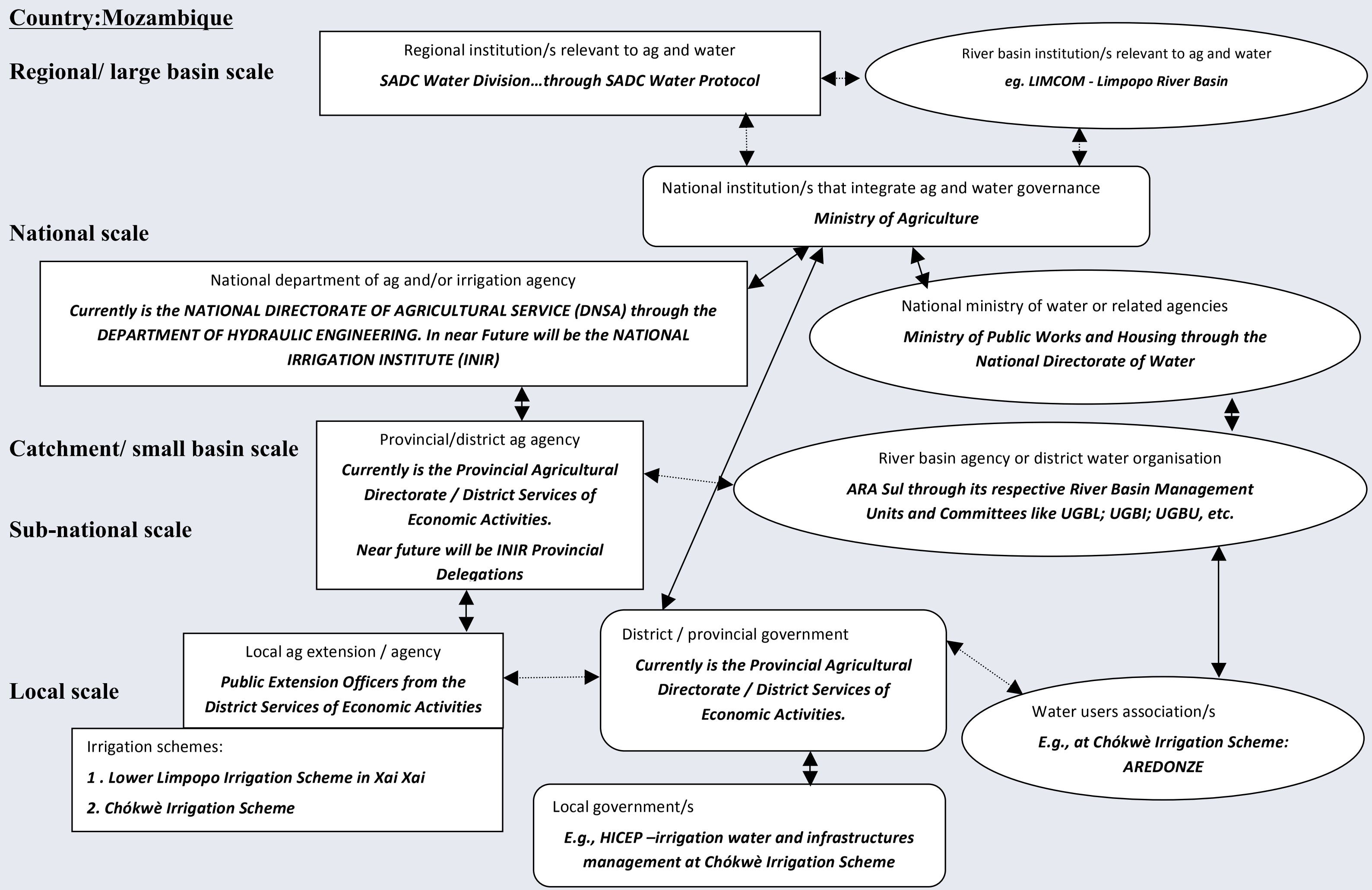
Chókwè can be a good location to put in place this initiative, because there is a quite a lot of information available, although not systematized, for the baseline sort of understanding the system.

***Which government and academic organisations would you include in a national water productivity advisory group?***

Ministry of Agriculture, through the National Directorate of Agricultural Extension (DNEA) including the new National Irrigation Institute (not yet in place); Faculty of Agronomy and Forestry Engineering at the University Eduardo Mondlane; The Polytechnic High School in Gaza; ARA Sul.

***Which (sub) Africa-wide ag and water networks are important for your country?***

Figure 6. Institutional framework for irrigated agriculture and water management.



# A.2 Tanzania

## Policy overview

Tanzania signed its National CAADP compact on 10th July 2010, and is one of a very few among 30 countries in Africa that has made progress of implementing its compact. The country has agreed on priority investment areas, designed comprehensive bankable investment plans, has discussed with development partners and investors, and has designed implementation plans for rolling out the investment plan. Tanzania has produced a roadmap that clearly highlights its implementation strategy, and has involved broad multi-stakeholder participation. The stakeholder actors involved include public institutions alongside Non-State Actors (NSA) such as Civil Society Organisations (CSOs), farmer and producer organisations, researchers, parliamentarians, the private sector and the media.

Implementation of CAADP in Tanzania has recorded a commendable status. The buy in process, stock-taking and analytical work was accomplished by March 2010, and was followed by intensive consultative process with various stakeholders, signing of the compact in July 2010 and formulation of the Investment Plan known as Tanzania Agriculture and Food Security Investment Plan (TAFSIP) (United Republic of Tanzania 2011). This is a sector wide investment framework for the agricultural sector for implementation of the CAADP in Tanzania.

With a total budget of USD 5.4 billion, TAFSIP focuses on seven strategic investment areas, namely:

1. Irrigation Development, Sustainable Water Resources and Land Use Management (CAADP Pillar I)
2. Agricultural Productivity and Commercialisation (CAADP Pillar I)
3. Rural Infrastructure, Market Access and Trade (CAADP Pillar II)
4. Private Sector Development ( CAADP Pillar II)
5. Food and Nutrition Security ( CAADP Pillar III)
6. Disaster Management, Climate Change Adaptation and Mitigation ( Cross cutting)
7. Policy Reform and Institutional Support (CAADP Pillar IV)

To generate greater private investment in agricultural development, scale innovation, achieve sustainable food security outcomes and reduce poverty, G8 members have committed about US$897 million through the "New Alliance for Food Security and Nutrition" and the Grow Africa platform to provide support to accelerated implementation of the TAFSIP during the period 2011 - 2015 (United Republic of Tanzania. 2011). Better management of water is not explicitly addressed in this G8 program.

## Expert assessment

***What are the national policy settings for a) irrigation; b) water; c) governance?***

***National:***

The Ministry for Agriculture includes a Department of Irrigation. There is a national agricultural policy for substantial growth in irrigation (United Republic of Tanzania 2011). Separate policies for the mainland and Zanzibar. There is also the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) proposal.

The Ministry for Water has a national water policy. Little coordination is evident between the policies of the two ministries.

Three types of land tenure exist nationally: Reserved, Village and General. National government can lease General land to investors for large scale schemes. There is increasing investment from the Middle East, South Africa and Europe (biofuel crops). Small holder schemes usually build on traditional irrigation areas. Large scale paddy irrigation schemes are often leased to external companies for 33-99 years.

***Great Ruaha River basin:***

Demand in upper Ruaha basin from traditional irrigators for enhanced irrigation schemes but not in the lower basin. There are conflicts between institutional investors and local people. Rufiji Basin Water Office is refusing to issue new permits due to drying up of the river through the Ruaha National Park to the Mtera hydropower scheme but the Ministry of Agriculture is supporting more schemes.

***What catchment management and water users' organisations exist? Who trains the key people?***

Nationally 9 River Basin Organisations are in place, eg. Rufiji Board, under auspices of the Ministry for Water. Subsidiary Water User Associations are being developed: 24 so far in the Ruaha. Rigorous systems to develop these, which were aided by WWF in the Ruaha. Focus on water diversions rather than agronomic uses.

***Who (agency) does ag extension in these countries?***

Nationally 9 River Basin Organisations are in place, eg. Rufiji Board, under auspices of the Ministry for Water. Subsidiary Water User Associations are being developed: 24 so far in the Ruaha basin. There are rigorous systems to develop these, which were aided by WWF in the Ruaha. Focus on water diversions rather than agronomic uses.

***Who trains ag extension officers?***

Ministry of Agriculture has around 15 institutes that train extension staff to certificate and diploma level. Each institute has a different curriculum and focus. Within the Ministry of Agriculture the Department of Irrigation proposes to establish an irrigation research centre.

***Who are the significant universities in agriculture and water?***

Sokoine University of Agriculture for agriculture, University of Dar es Salaam for water, together with Ardhi University looking at climate change adaptation and crop productivity.

***Who are the significant NGO's working on ag and water?***

WWF for water and agriculture in Ruaha Basin, IUCN for water in the Rufiji and Pangani basins, World Vision for agricultural development and CARE for payment for ecosystem services.

***What ag and water data data is collected? How publicly available is it? How is it used?***

Locally owned schemes usually produce a wet season rainfed food crops (rice) and on few occasions high value vegetable crop (onions, tomatoes, green beans and leaf vegetables).

Crop per hectare is data collected by district extension staff and sporadically available. No crop per unit of water data even though both ministries agree that this is important. In the best schemes (eg. Igomello) there is a focus on maintaining soil fertility with organic manures.

The Department of Water has a small number of gauging stations on major rivers but does not thoroughly monitor irrigation diversions.

***How are water allocations made and measured? (eg. Volumetrically, by land area, etc).***

Water is allocated volumetrically as rates of flow by the Department of Water to irrigation projects. Rivers have gauging stations but data is not always recorded reliably (few stations use electronic logging). Agricultural diversions are only measured through hydrological calculations when the few River Basin Organisations have an opportunity to inspect diversion points.

Majority of diversion canals for irrigation lack continuous monitoring of diverted water. Diversion allocations are not enforced (eg. breach of Ruaha 1 July canal closure rule).

Great Ruaha basin: As there is no storage there are major issues with dry season water diversions depleting river flows.

## How is ag productivity measured? How does productivity compare to potential yield?

Crop per unit hectare data is recorded and schemes are compared (Ruaha example for rice). There is great variability in productivity (factor of 2-3). Soil fertility is given as one reason. No crop per unit of water data- one small research project (Dr Makarius, Ardhi University) and previous measurements under RIPARWIN project for the Kapunga Scheme.

Emphasis by District Council and Zonal Irrigation remains on increasing water supply over investment into water productivity, even though all agree that the latter is a priority.

***How could gender equity be advanced through this ag and water project?***

Women are traditionally responsible for food security but may not have held land title. Under current Tanzanian law women have equal rights to legally own land. There is equal representation of men and women in WUAs. Some enhanced schemes have parcelled out land equally between men and women members ofcooperatives (eg. Igomello). Higher incomes are more likely to see girls receive higher education.

***Is there a sub-basin in the country that lends itself to an ag water productivity case study?***

The upper Great Ruaha River basin.

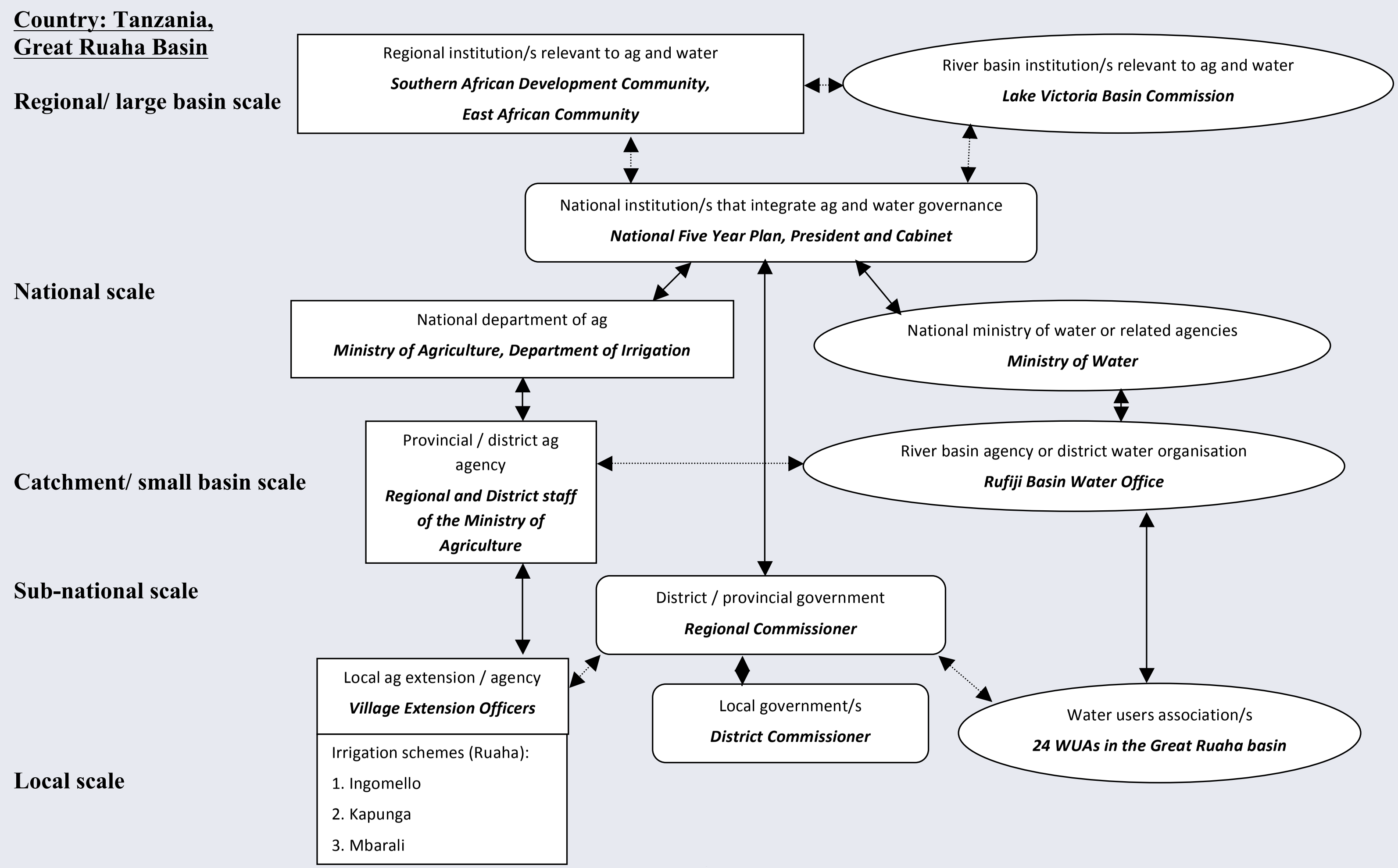
***Which government and academic organisations would you include in a national water productivity advisory group?***

» Minstry of Agriculture.
» Ministry of Water.
» Ardhi University.
» Sokoine University of Agriculture.

***Which (sub)Africa-wide ag and water networks are important for your country?***

» SADC Water Division.
» East African Community.
» FANRPAN.

Figure 7. Institutional framework for irrigated agriculture and water management.



# A.3 Zimbabwe

## Policy overview

Zimbabwe has high levels of poverty (80% in 2008) and food insecurity (8% in 2011). Since most of the population (70%) is in rural areas, the fastest way to reduce poverty and food insecurity is to increase and sustain high level of agriculture sector growth. In this regard, Zimbabwe has endorsed the MDG and CAADP targets to reduce food insecurity and poverty by 50% by 2015. In order to ensure that the agriculture sector grows by at least 6% per annum, Zimbabwe has also endorsed the AU/NEPAD recommendation to allocate at least 10% of the national budget to development of the agricultural sector.

Because of the major socio-economic and political crisis that the country has faced since 2000, the agriculture sector has been one of the most affected. National agriculture GDP growth rates were negative between 2003 and 2009, whilst government investment in the sector averaged 5.28% during this period.

Zimbabwe has made significant progress towards finalising its national compact that is expected to be signed before the end of 2012. At the same time, the Zimbabwe Agricultural Investment Plan (ZAIP) 2012-2016 has also been developed to operationalize the national CAADP compact (Government of Zimbabwe, 2012). In line with CAADP, the development of ZAIP is based on the success stories in other countries and sector-wide consultations with key stakeholders in the agriculture sector, including the representatives of the Government and non-state actors. Moreover, ZAIP is complementary and not a substitute to the national programme, the Medium Term Plan 2011-2015 (Government of Zimbabwe 2011).

Despite damage to some agriculture infrastructure (over 30% of the irrigation infrastructure was vandalized) and the lack of investment over the past decade, the basic infrastructure is still in place to enable farmers to increase productivity to 50% - 75% of the levels that were attained on large scale commercial farms, within 5 years.

The overall objective of ZAIP is sustainable increase in crop and livestock productivity based on the regional comparative advantage. The specific objectives are to increase access to:

1. Practical skills of farmers in sustainable crop and livestock production.
2. Appropriate agricultural finance services for crop and livestock production.
3. Appropriate input and product markets in major production areas.
4. Water for irrigation in areas with comparative advantage.
5. Practical skills and information on sustainable land and forestry management and utilization

(Excerpted from: Zimbabwe Agriculture Investment Plan. 2012-2016 ZAIP. A comprehensive framework for the development of Zimbabwe's agriculture sector. August 2012 Draft).

## Expert assessment

***What are the national policy settings for: a) irrigation; b) water; c) integrating water and ag governance?***

Irrigation policy is under formulation.

a. Min. Agriculture, Mechanisation and Irrigation Development; Department of Irrigation Development: Dr C. Zawe (Acting Director).

b. Ministry of Water: Mr R.J. Chitsiko (Permanent Secretary).

Zimbabwe National Water Authority & Catchment Councils,and National Development Agency.

***What catchment management and water users organisations exist? Who trains the key people?***

Zimbabwe National Water Authority (ZINWA).
Irrigation Management Committees (IMCs).

Government trains the key people through the Department of Irrigation Development.

***Who (agency) does ag extension in these countries?***

Department of Agriculture, Technical and Extension Services (AGRITEX) for cropping; Department of Livestock Production and Department of Veterinary Services for livestock, and Department of Irrigation for irrigation water management.

***Who trains ag extension officers?***

AGRITEX, FAO, ICRISAT and some NGOs.

***Who are the significant universities in agriculture and water?***

- University of Zimbabwe.
- Chinhoyi University of Technology.
- Midlands State University.

***Who are the significant NGO's working on ag and water?***

- World Vision.
- CARE International.
- AFRICARE.
- Action Contre la Faim (ACF).
- Catholic Aid for Overseas Development (CAFOD).
- Catholic Relief Services (CRS).

***What ag and water data is collected? How publicly available is it? How is it used?***

Crop assessment (area cultivated for main crops-maize, wheat, expected yield) is publicly available from Ministry of Agriculture.

Data is used for early warning forecasting.

***How are ag water allocations made and measured? (eg. Volumetrically, by land area, etc).***

Water is measured using area cultivated per year and administered by Zimbabwe National Water Authority (ZINWA).

***How is ag productivity measured? How does ag productivity compare to potential yield?***

In terms of yield, average maize yield ca. 1 t/ha yet potential is 7 t/ha under rainfed conditions. In irrigation schemes yield higher (ca. 3-5t/ha!) but still below potential.

***How could gender equity be advanced through this ag and water project?***

Training women and youths in water management, crop management, soil fertility management, and market research and development.

***Is there a sub-basin in the country that lends itself to an ag water productivity case study***

Limpopo, Zambezi (Gwai-Shangani, Manyame) and Save river basins.

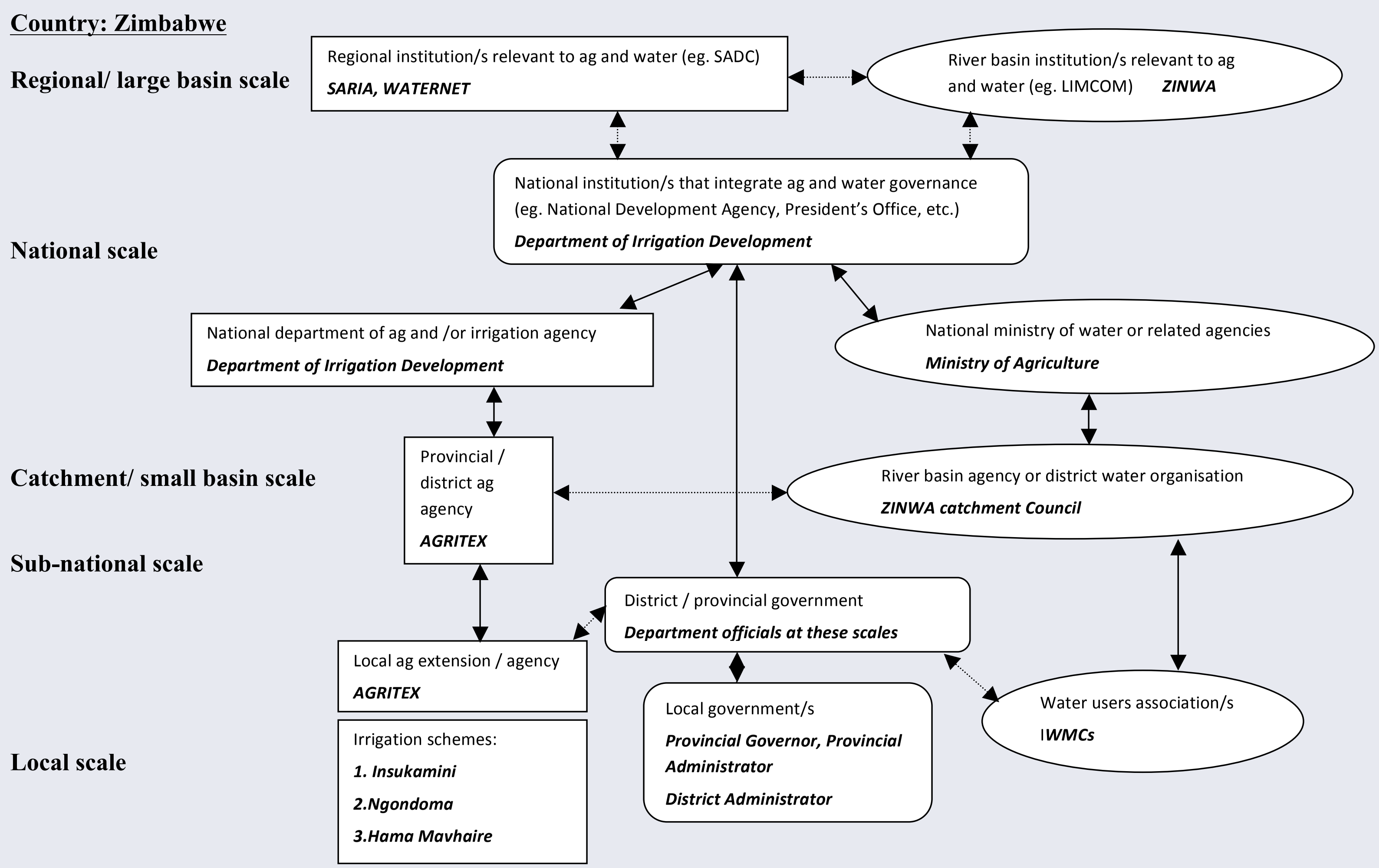
***Which government and academic organisations would you include in a national water productivity advisory group?***

- Ministry of Agriculture (Department of Irrigation Development, AGRITEX).
- University of Zimbabwe.
- Chinhoyi University of Technology.

***Which (sub)Africa-wide ag and water networks are important for your country?***

- Southern Africa Regional Irrigation Association (SARIA).
- WATERNET.

Figure 8. Institutional framework for irrigated agriculture and water management.



Australian Government

Australian Centre for International Agricultural Research

Australian International Food Security Research Centre

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