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The Commission for Africa

Rural infrastructure to contribute to African agricultural development: the case of irrigation[1]

Dr Bruce A. Lankford
(with Thomas Beale, Research Assistant)

Overseas Development Group,
University of East Anglia, Norwich, NR4 7TJ, UK
Email: b.lankford@uea.ac.uk

[1] *Lankford, BA (2005) Rural infrastructure to contribute to African agricultural development: the case of irrigation. Report for The Commission for Africa, ODG, University of East Anglia, Norwich.*

Foreword

The Commission for Africa "Rural infrastructure to contribute to African agricultural development: the case of irrigation"

This report was submitted to the Commission for Africa in December 2004 to NRI. The original citation given in the CFA report is "*Westby A, BA Lankford, JF Coulter, JE Orchard and JF Morton (2004) Rural infrastructure to contribute to African agricultural development: the cases of irrigation and post harvest. Report for The Commission for Africa, NRI, University of Greenwich and ODG, University of East Anglia, Norwich*".

The citation for this abridged report (which omits the post-harvest section and has had some minor corrections made) is:

> *Lankford, BA (2005) Rural infrastructure to contribute to African agricultural development: the case of irrigation. Report for The Commission for Africa, ODG, University of East Anglia, Norwich.*

The report represents an outline of a project of considerable ambition – the expansion of irrigation in Africa from a current 12-13 million ha to 18 million ha. This was the 'vision' of the Commissioners of the CFA[2] rather than of NRI, ODG or myself. I have attempted to respond to the question of how to expand irrigation by establishing a critical and comprehensive framework of intervention, rather than recommending an approach which emphasises one particular technology or approach, for example micro-irrigation. I argue that this balanced strategy is a more useful as a way of framing the way ahead.

The report here argues that a target of 5 million hectares is possible – however I believe this is an optimistic upper limit, and represents a considerable increase in rate of expansion from 1% per year to 3.8% per year for the next 10 years. Clearly, success in achieving this target is dependent upon many other factors not covered in this report, particularly the marketing environment experienced by Africa's rural farmers.

Dr Bruce Lankford
School of Development Studies
May 2005
b.lankford@uea.ac.uk

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[2] Readers of the CFA report will note that the CFA have used a band of 5-7 million hectares as target.

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Dr Bruce A. Lankford[1]
(with Thomas Beale, Research Assistant)

Overseas Development Group, University of East Anglia, Norwich, NR4 7TJ

1. Background to the Challenge

The Commission for Africa (CFA) identified agricultural development as a key part of its strategy for growth in Africa, building on the New Partnership for Africa's Development (NEPAD) Comprehensive Africa Agricultural Plan. The Commissioners have endorsed a focus on four specific areas, namely the development of irrigation and post-harvest infrastructures; research, innovation and extension; local markets and institutions; and security of land tenure. This paper addresses key issues and priorities for investment in irrigation (the section on post-harvest interventions which was sent to the CFA, has been omitted from this report).

The aim of the section on irrigation was to review the opportunities to increase the productive potential of arable land by increasing the area of irrigated cropping systems, increasing access by poor people to irrigation and/or the benefits of irrigation, and enhancing the management of existing areas under irrigation and increasing access to water for livestock. The study determines the sustainable targets for growth and productivity gains, and shows that irrigation should be encapsulated within a wider comprehensive framework for water development. In addition, a budget for the programme and initial benefit: cost analysis have been determined.

The (omitted) section on post-harvest infrastructure starts from the premise that post-harvest losses of commodities are significant, but that these have to be considered in the broadest sense covering issues of physical, quality and income losses, poor access to markets, and food insecurity. The review then considers the options for mitigating against these losses through: improvements in infrastructure, food safety management systems in national food systems; sustainable approaches to processing of commodities, linking farmers to markets through innovative support to small- and medium-scale enterprises; and use of market financing/inventory credit through using the crop in storage as collateral.

2. Irrigation infrastructure

Introduction

This paper's aim is to stimulate discussion on irrigation within and outside the Commission for Africa (and as such it should be read alongside similar analyses[3]). Its purpose is to demonstrate that there is a case for addressing irrigation in Africa via a comprehensive framework to tackle poverty and environmental issues, and to suggest how donors and governments might achieve this. A comprehensive framework of water management is recommended because lessons indicate that irrigation infrastructure should be encapsulated in this wider approach. The case here describes a 10

[3] For example, AMCOW (2003). "African Water Facility: Establishment and Implementation Plan."

year programme to 2015 to mobilise resources to set water management onto a higher level so that beneficiaries and other stakeholders can sustain the programme and related benefits in the long run.

The paper assumes that other complementarities that affect the rural economy are being addressed (e.g. credit, village governance, access to markets). The paper also assumes that since irrigation is a sub-sector of agriculture, measures will be taken to benefit the latter, particularly rainfed agriculture, which is the significant part of African agriculture. In addition, the programme here relates to irrigation and surface water resources rather than to water and sanitation, also a key issue for Africa. Lastly, watershed protection (afforestation, soil conservation, rainwater harvesting) is not within the main scope of this paper although it is part of river basin management. This paper concentrates more on the role of irrigation in affecting surface water allocation and distribution in river basins, rather than on land degradation issues.

Investing in irrigation

Irrigation plays several fundamental roles in poverty eradication, social cohesion, economic growth and environmental security:

1. Irrigation contributes to economic and entrepreneurial activity locally, regionally and nationally. Irrigation generates employment for local and migrating poor rural people on irrigated farms and creates supply chains that bring employment and businesses. Irrigation is a livelihood strategy for many thousands of Africa's farmers attracted by the ability to grow food for the household and crops for local, regional, urban and international markets. In areas with widespread irrigation, it is usually the major part of household income. Irrigation helps with poverty alleviation and is linked to Goal 1 of the Millennium Development Goals[4].
2. At the local level, irrigation improves food security during dry periods, and cumulatively adds to national food security. Food security remains a key priority for many African governments. The Forum for Agricultural Research predicts that an annual increase of 6% production is needed to meet food security by 2015, which the FAO argues must come from 75% productivity intensification and 25% expansion[5].
3. In distributing water via a canal network, irrigation systems permit other livelihoods activities such as livestock-keeping, brick-making and fish production. Canal water can help with domestic needs for water, though usually is not of a sufficient quality for drinking.
4. However, by evaporating water, irrigation affects the amount of water available downstream and interacts with other sectors including the environment. Irrigation subtracts from between 50% and 90% of water in semi-arid basins, and thus the management of irrigation is at the heart of the hydro-governance of those catchments. In this regard, irrigation relates to Goal 7 of the MDGs. By addressing water distribution, irrigation interventions can significantly benefit the environment and rural, urban and industrial development.
5. By depleting water, irrigation brings conflicts from loss of livelihood, greater incidence of disease and loss of ecology. On the other hand, co-operation over water is a sign of strengthening and flexible social and political institutions. Water distribution is usually complex and is dependent on weather, soils, crops, supply, areas and efficiency. Managing water successfully within an irrigation system and its surrounding catchment is linked with organisational development and higher levels of institutional capability.

The case, therefore, for investing in irrigation not only stems from productive and rural poverty imperatives, but because irrigation is intimately involved in some of the most critical water re-distribution challenges facing river basins today. This allocation challenge applies to both intra-sector equity issues and to the intersectoral balance of water, and from large to small volumes of water.

[4] MDG goal 1 = Eradicate extreme poverty and hunger (& MDG 7 = Ensure environmental sustainability)
[5] Dargouth, S Overview of the collaborative programme "Investing In Africa's Water Future"- presented at the "Comprehensive Assessment" seminars held during World Water Week, August 20, 2004.

From these points, it is argued that the development of irrigation in Africa requires the delivery of that technology within a comprehensive framework; a framework that places irrigation within water resources management, that relates to different organisational and scalar levels; that distinguishes appropriate interventions from those that appear suitable but are not; and that delivers institutional, economic and environmental sustainability. This framework (see Appendices A and B) fits integrated water resources management (IWRM) and rural development perspectives that are in keeping with the Commission for Africa views on promotion of infrastructure[6].

Irrigation in Africa

On the African continent, the total irrigated land is estimated to be 12-13 million hectares translating to 7.3% of total arable land for Africa and 8.6% for sub-Saharan Africa (SSA), (calculations by author from FAO statistics, which do not relate to some quotes - e.g. Tafesse (2003) - of 3.7% in SSA). In this report, a figure of 13 million hectares is used as the total area under some form of controlled water management. The importance of irrigation varies a great deal from country to country, and while Egypt has 99 % of its cultivated land under irrigation, the Democratic Republic of Congo has only 0.2 % of its arable land under irrigation. Types of irrigation in Africa also vary. Examples of drip and sprinkler irrigation are found in South African and Swaziland citrus and sugar industries as well as in Tanzanian and Kenya irrigating export flower and vegetable crops. Micro irrigation (the use of low technology header tanks and pipes, and treadle pumps) is found in parts of Tanzania and Niger. Examples of productive use of water using domestic systems are found in Northern Namibia and Zimbabwe. Hyper large-scale irrigation is found in the Sudan (the Gezira system is 0.8 million hectares). Large scale formal surface systems are found throughout Africa. Examples of formal smallholder estate type schemes are seen in Swaziland and Zimbabwe and large conglomerated areas of informal smallholder systems are found in Southern Tanzania and Nigeria. Small-scale informal systems are found throughout Africa using water from low-lying wetlands, rivers and small boreholes. In general, in Africa, the mix between areas of systems smaller than 100 ha and greater than 100 ha is 44% and 56% respectively[7]. These types are not simply diverse forms of irrigation but represent differences in organisational capacity, costs of operation and maintenance, and responses to outside environmental and economic factors. Therefore increasing the prevalence of irrigation in Africa demands an ability to understand these types so that appropriate strategies may be crafted for both area expansion and higher productivity and efficiency.

Irrigation benefits

There are three main aspects to irrigation benefits; area expansion, productivity (which includes irrigation efficiency and profitability) and access. They are interrelated but each is addressed by different means. Irrigation area can be increased by farmers themselves, or with the assistance of donor and Government projects. Estimates of growth in the last decade vary from 0.5%[8] to 0.7%[9], adding about a million hectares in 10 years (decade growth rates have varied between 0% and 2% in the last 30 years (Rosegrant and Perez, 1997)). It is worth noting that in 2002, FAO[10] gave an estimate of the likely growth achieved by 2015 without specific interventions in land and water development, of less than 2 million ha, going from 12.6 million ha to 14.4 million ha in 13 years, representing a rate of 1.1% per year. This is probably comparable to the last 10 years of 0.7% as further urbanisation, population growth and market adjustments generate economic incentives to enter into irrigation.

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6 The Commission for Africa Consultation Document on 11 November 2004: “These mechanisms should ensure that the infrastructure programmes are tailored to development needs (rural, national, and international) rather than ‘prestige projects’, and are environmentally and socially responsible”.

7 Analysis based on Irrigation in Africa, FAO, Rome, 1995

8 Foures, J-M, Demand for products of irrigated agriculture. "Investing In Africa's Water Future"- presented at the Comprehensive Assessment seminars held during World Water Week, Stockholm, 2004.

9 By author from FAOSTAT data, last updated 2 July 2002, http://faostat.fao.org/default.jsp?language=EN

10 FAO (2002). "World agriculture: towards 2015/2030.

However, area growth can be greater than 1-2% in specific circumstances. Research by one of the authors of this report in the Usangu basin in Tanzania points to 14% annual growth over 40 years, with area going from 3200 ha in 1960 to 21000 ha in 1999. This growth includes 6000 ha of large-scale donor funded schemes that provided a step up in area and 'seeded' an additional unforeseen informal growth of about 2000 ha. Without the 6000 ha, growth by informal smallholders is estimated to have been 3.8% per year. Kay (2001) reports growth of flood plains irrigation in Nigeria of 28% over 20 years.

Reviewing the literature, net income to farmers from irrigation in Africa is affected by a number of factors, ranging from US$300-2000/ha, while turnover ranges from US$800-4000/ha[11]. Gains in productivity (tonnage per hectare and incomes) are also happening, principally from increased land and water competition between farmers (in response higher farm densities, targeted interventions and cyclical water shortages), responses to market signals and improved crop husbandry. Research reveals that on a global level, rice productivity gains of 2.3% to 2.8% per year are feasible[12]. At a more local level, growth can be sharper: in parts of Tanzania, rice yields, crop prices and irrigated land rentals have risen, respectively, by an average of 5.0%, 7.6% and 39% per year over the last 8 years[13].

Access to the benefits of irrigation (a function of total area, labour dynamics and land distribution) is also increasing – principally due to increased area under irrigation and the range of jobs found therein. Direct access to irrigated land will arise via area expansion, but could also be targeted by specific intervention programmes that re-distribute land to the poorest households giving a foothold of about 0.3 to 0.5 ha (in Tanzanian rice growing areas, households require a minimum of 0.5 ha). Successful redistribution programmes are possible (Koopman *et al.*, 2001) and could be a part of future programmes.

In summary, irrigation production (a function of area and productivity) in Africa is currently expanding – mainly stemming from an increase in the irrigated area – mostly within the smallholder sector being developed by smallholders themselves attracted to the benefits of irrigation. This has happened despite a relative drop in funding in the last twenty years – although formal projects have provided important 'seeds' to increased expansion.

Existing and new donor approaches to water and irrigation management

Irrigation in Africa is experiencing renewed interest, although this has not always been the case. Funding decreased during the nineties[15]. More recently, water management in Africa is changing as a result of new initiatives and concerns. Recent statements from NEPAD, AMCOW and the G8 Evian Summit show a consensus that irrigation is seen in a broad 'water framework'.

A large number of donors are working on water and irrigation in Africa[14]. One of the largest donors is the World Bank with an annual budget of US$3 billion[15]. German aid (with an annual commitment to the water sector in Africa during 1990-2000 of approximately US$170Mn[16]) is pursuing a number of avenues including responsive calls to assist with water resources strategies in Namibia and Tanzania and the funding of urban wastewater irrigation more generally[17]. France provides Euro 180 million per year though the fraction for irrigation not known plus France has aims to double this effort[18]. Danish aid (DANIDA, average commitment US$50 Mn/year) has provided sector support to irrigation in a number of countries (e.g. Malawi, Tanzania). Italy has provided a similar commitment. The Netherlands and the UK have committed approximate US$35-40 Mn annually during 1990-2000 on a variety of activities particularly those involved in capacity building. DFID has recently supported the

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[11] The assumption here is that most African farmers engage in one irrigated season per year.
[12] Cai, X., and Rosegrant, M. W. (2003). World Water Productivity: Current Situation and Future Options.
[13] Lankford and Kadigi various sources from Ruaha and Kilosa fieldwork (2001-2004).
[14] See also http://www.thewaterpage.com/donor_involvementSADC.htm#The%20African%20Development%20Bank%20(ADB)
[15] 16% of Bank lending for water, with a quarter of this going to irrigation, which has decreased in 1980 2.4 billion to 0.5 billion in 2001.
[16] DANIDA (2004). Denmark's Development Cooperation in Water and Sanitation. http://www.um.dk/Publikationer/Danida
[17] http://www.gtz.de/ecosan/english/
[18] France – A Partner of NEPAD. An action Plan for Africa. Document prepared for G8 Evian Summit.

EU Water Initiative and the Nile Basin Initiative. The European Union has funded a number of hydrological assessment projects and is currently developing new African water funding opportunities (EU-ACP Water Initiative (WI) and Water Facility (WF), which will work alongside the AMCOW 'African Water Facility'). Other donors such as Sweden, USAID, the Canadian International Development Agency (CIDA), Finland and Norway have also developed a variety of water projects. There is also enhanced interest from the UN system (FAO, IFAD, UNDP, UNEP, UN Habitat, UNESCO, UNICEF, UN Water) in water and funding available from GEF to manage water resources.

New networking and research opportunities are being strengthened. Examples include WATERNET (a network for investigators funded by the Netherlands), the Water Research Fund in Southern Africa (WARFSA), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Global Water Partnership in Southern Africa, and at a higher level, support for the African Ministers Council on Water (AMCOW), and enhanced research by the International Water Management Institute (IWMI) via the Consultative Group on International Agricultural Research (CGIAR). There is greater participation by African water professionals in water events such as the World Water Forums.

New water laws and strategies are being generated by many countries (e.g. Tanzania, Kenya, South Africa). Water is being addressed by new Environmental Laws that stipulate that after domestic provision, water for the environment must be guaranteed. Combined with these legislative changes is the development of new institutional arrangements. For example river basin authorities are being funded in many countries (e.g. Tanzania, Kenya), while at a larger scale international co-ordination bodies are being strengthened – e.g. the Nile Basin Initiative and Lake Chad.

NGO programmes, normally restricted to water and sanitation, are more visible – TIIP and Pamoja in Tanzania are examples of successful organisations working on irrigation management and conflict resolution respectively in the Kilimanjaro region. At a larger scale, WWF and IUCN are successfully implementing river basin programmes in Africa.

Water is also being addressed by Poverty Reduction Strategy Programmes, although mainly as a water and sanitation issue rather than increasing access to, and efficiency of, irrigation. In some African Poverty Reduction Strategy Papers (PRSP's) (e.g. Tanzania) this is now being addressed with more urgency.

A critical look at irrigation development in Africa

Many of the above interventions represent important progress made in the last 10 years, and a basis on which to develop an enlarged programme. However many issues need to be examined prior to planning a new programme. At a continent-wide level, there is a case for investing in irrigation, but the sustainability of the programme will depend on a more detailed and accurate assessment of potential, needs and capacity so that any eventual interventions tackle real problems rather than constructed ones. The following subsections explore three issues related to the translation of high level strategic aims into effective country, basin, sub-basin and system projects.

Institutional capacity and focus

There are several concerns about higher-level institutional capacity to deliver an enlarged irrigation programme if the latter is not designed well or is overambitious. (It might be possible to argue that the per hectare costs of formal irrigation development in Sub-Saharan Africa are a proxy indicator of associated institutional demands since this is about six times that found in Asia and North Africa, and about 10 times that of informal farmer built systems in Africa).

Institutional coherence and functionality is critical to the success of water management because of scalar connectivity between crop, field, farm, canal, system, subcatchment, sub-basin, and basin. Thus, the cumulative effects of water activities at the crop scale can affect the flow and utilisation of water at the basin scale. The opposite is also true – institutions designed at the national scale may not be appropriately attuned to field and farm. Both of these effects demand a framework of interventions that can adequately address these scalar challenges. In the new programme there will be a need to deliver solutions that address *both* local and basin wide concerns. Plus, rivers in Africa also cover international boundaries, with ten major basin having more than four riparian countries. These and other similar situations point to the importance of co-ordination between institutional levels.

Externally-driven schemes often impose new institutions which can clash with local arrangements. This particularly applies to canal irrigation which requires a high level of co-ordination between users. In addition, with the exception of some North African countries and South Africa, Water User Associations are not as well developed as they are in Asia and tend not be financially sustainable. In addition there are new challenges arising from the need to co-ordinate water abstraction between irrigation systems found in the same catchment.

Structural government capacity to deliver an enlarged programme within the time frame is a concern. It is generally agreed that water (and irrigation) should be tackled via an integrated approach (IWRM) – yet this concept is new, and has yet to be fully incorporated into modalities for managing water at different scales, in different sectors and by separate Ministries. Furthermore, the presence of irrigation expertise in Ministries of Agriculture is often undermined by a lack of staff, resources and organisational rank. Examples are found in Swaziland and Tanzania[19], where staff have expressed concern over a lack of 'presence'. Similarly, river basin management programmes are often generated within Ministries of Water – even though irrigation might utilise the major proportion of freshwater resources. This is changing, but Ministerial gaps imply a need for institutional strengthening and ongoing research of the relevant issues[20].

Lastly, with relevance to capacity at all levels, the impact of HIV/AIDS may further constrain uptake and delivery of an enhanced investment programme.

Establishing targets for irrigation expansion

This section examines various cases for irrigation development under an expanded programme. The potential irrigation area in Africa from FAO AQUASTAT is 46 million hectares, which means that current area under irrigation of 13.1 million is 27% of potential (or 19% in SSA). To fully expand to this potential within 10 years would represent annual growth of 26%, which is highly unrealistic. At the lower end, as discussed above, the FAO 'business as usual' estimate is estimated to deliver 1.1% annual growth leading to a total area of about 14.5-15.0 million ha by 2015 (11% growth in 10 years). This includes both surface and groundwater development of irrigation.

The NEPAD[21] targets for 2015 add up to an expansion vision from 12.6 million ha to 20 million ha and a total budget of US$ 36.9 billion, to which are added US$3.8 billion for O&M giving a total budget of US$42 billion by 2015. This represents an annual budget of US$4.2 billion providing for annual increments of 0.74 million ha, and 5.9% average annual growth. (C.f. "develop small-scale water control 14.2 million ha at US$ 14.4 billion; rehabilitate large-scale irrigation systems 3.6 million ha at US$ 8.9 billion; develop large-scale schemes of 1.9 million ha at US$13.6 billion")[22].

It is useful to consider a more disaggregated view to establish a target for the Commission for Africa initiative. Of main interest are the North, Sudano-Sahelian, East and Southern Africa regions, which each have limited total water resources – which includes internally produced surface water and groundwater and accounts for external flows[23]. Northern Africa has only 3.6% of Africa's water resources, while the other have 9.9%, 6.9% and 1% respectively, combined with irregular rainfall regimes (see Table 1 and FAO, 2003). These compare with Central Africa and the Gulf of Guinea

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[19] Irrigation in the Government of Tanzania's Ministry of Agriculture has recently been upgraded from a unit to a Department.

[20] The Commission for Africa Consultation Document 2004: Support NEPAD's agriculture programmes and rebuilding of Africa's agricultural research, development and extension services, including capacity of universities

[21] CAADP- Comprehensive Africa Agriculture Development Programme (http://www.fao.org/documents/)

[22] Note also, AMCOW in 2003 argued for $615 Mn in 2004-2008, and budget of $123 Mn/yr.

[23] Water that exits or enters a country via an international river or groundwater movement.

region with 78% of total water resources, which occurs in a humid belt where rainfed agriculture is most likely to be the cropping system of choice. Hence it is difficult to generalise across the continent about use of available water resources. (Plus, the potential irrigation figures of Northern and Southern Africa are suspect in that they lead to total utilisation of water resources to 75% and 135% respectively – both of which are highly unsustainable given increasing climate variability and rising demands from other sectors).

With respect to irrigation expansion, it is also important to consider, apart from suitable sub-basins in which population growth has lead to increased irrigation, why potential has not been tapped to-date. Low demand for products, remote markets, the surrounding farming system, higher institutional transaction costs associated with water distribution and maintenance, and environmental constraints all combine to reduce the attractiveness for irrigation to farmers whose own livelihood perspectives determine the choices they make (rather than specialists' viewpoints on the 'potential for irrigation'). In particular, climatic seasonality and variability are pronounced in Sub-Saharan Africa, which makes it difficult for farmers manage and distribute water for irrigation. In a wet year, farmers don't necessarily need irrigation, but in a dry year when irrigation is necessary, not only does rainfall diminish, but so do surface water sources. In the larger rivers, a lack of command makes it difficult to tap water. The savannah plains of Africa have different groundwater dynamics than the floodplains of Asia, with water being generally less available, deeper and more mixed in quality.

Thus, a target for the Commission for Africa analysis has taken into account the constraints discussed above, past expansion rates, and the existing and potential irrigation areas for the different regions. Substantial expansion in the Northern and Southern regions which are water stressed, and expansion in the Central region which is humid, is not envisaged. Growth here will mostly depend on efficiency gains and some new area development combined with greater supply development.

Commission for Africa growth targets for each area have been estimated (Table 1), with Sudano-Sahelian, Eastern and the Gulf of Guinea being set at 6% annual growth, and Northern and Southern regions set at 2.5% and 2.7% respectively. These targets establish a total growth over 10 years of 5 million hectares to a cumulative total of 18 million ha. This gives an 'Africa' average annual growth of 3.8% which appears a realistic yet high-investment strategy that lies below the NEPAD '5.9%' vision but above the 'high irrigation investment' scenario defined by Rosegrant and Perez (1997; page 15) as 3.0% annual growth. The target of 5 million hectares includes both surface and groundwater supplied irrigation.

Table 1. Commission for Africa targets envisaged for infrastructure development of irrigation

Region in Africa	Total and % of water resources actual (km^3/year)	Current area of managed water (000 ha)	Potential area (000 ha)	% Total water use if potential utilised	Annual irrigation expansion (%)	Target of annual expansion by 2015 (000 ha)	New total area by 2015 (000 ha)
Northern	134.5 (3.6%)	5915	8131	75%	2.50%	1478.8	7393.7
Sudano-Sahelian	374.1 (9.9%)	2861	5578	12%	6.00%	1716.6	4577.6
Gulf of Guinea	1024.0 (27.1%)	1408	8280	2%	6.00%	844.8	2252.8
Central	1950.0 (51.6%)	466	13320	1%	1.50%	69.9	535.9
Eastern	262.0 (6.9%)	656	5364	17%	6.00%	393.6	1049.6
Southern	37.4 (1.0%)	1835	5980	136%	2.70%	495.5	2330.4
Total	3782	13141	46653		Wgt ave = 3.80%	5000 approx	18000 approx

Source: FAO Aquastat and author's calculations. Notes: Data not calculated for Islands.

Technological choice, irrigation efficiency and productivity

The programme will also target increased productivity of irrigated agriculture from both existing and newly developed lands. Irrigation productivity and efficiency can be improved, but it is of concern that irrigation is frequently labelled as 'inefficient', especially since its detailed measurement using appropriate whole system methodologies at the catchment level has been so very rare. On the improvement of water efficiency, there is little consensus on how best to achieve progress here and it is difficult to see from current strategic approaches how farmers will achieve significant gains in water efficiency as a result of intervention programmes. A gap has formed between different viewpoints – some consider that efficiency does not matter, and that wastage is picked up within the catchment, others believe the solution lies in micro-irrigation, while others propose conventional technologically-expensive solutions such as drip irrigation, canal lining and upgrading intakes. In many circumstances these are untenable and have little impact on efficiency. None of these tackle water management on surface irrigation systems bigger than 50 hectares, where water can be depleted by water management activities[24] that could be improved to achieve gains for other farmers. In addition, it is not easy to foresee how water released from improved irrigation productivity will be shared between different goals of irrigation expansion or of meeting other sector's needs. In other words, the benefits of saving water need to be planned. There is a real need here to develop effective methodologies that raise efficiency in cost-effective and realistic ways, and that share the benefits of those gains according to stated aims.

Related to this, it is worth commenting on 'irrigation improvement programmes' that have engaged with smallholders in the belief that formal donor programmes can improve smallholder management. Research conducted by the Netherlands Agricultural Support Programme in Tanzania showed that improvement and rehabilitation costs were on average US$2,400-US$12,000/hectare, but ranging far higher than this[25]. It is not clear how these costly programmes genuinely increased production except where they developed new lands not previously irrigated. On the contrary, some of these programmes further stressed the basin environment and added to levels of conflict (Lankford 2004).

For this report, US$600/ha is estimated to the current 'global' African figure for net profitability from irrigated cropping, which will be applied to new area development to determine the net benefit of the expanded area. In addition, the programme will generate over 10 years an assumed 34% combined gain in yield and price productivity above that generated in the 'without project' scenario, leading to an annual gain of 3.4%, which translates into an average real increase of U$20/ha each year. (Figures regarding access to irrigation have not been generated, but it can be assumed that a good proportion of new areas developed under formal projects could be distributed at 0.5 to 1 ha per household).

When planning, different kinds of technologies should be pursued with caution. There has been an emphasis on small-scale irrigation since the early eighties, largely because of a collective analysis that large-scale irrigation systems were costly to establish and manage, and that smallholders were informally developing their own systems outside of formal assistance packages (World Bank 1981). However, transforming the view that 'small-scale systems are appropriate for Africa' into actual projects has been problematic when on a per hectare basis these have been expensive and can cumulatively add to widespread water depletion within river basins. Likewise, Kay (2001) raises concerns about low-cost technologies being a "euphemism for poor engineering design and construction". In a new programme, careful audits and cross-checking mechanisms to determine how to proceed are advised.

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[24] For example canal maintenance, co-ordinated planting schedules; improving the placement of water via higher ratio of field canals; infield water control, and introducing deficit irrigation and rotational cycling where appropriate; ensuring an optimal ratio of flow to area supplied.

[25] Appendix B of this report calculates the cost of the CFA irrigation expansion project to be 3864 US$/ha if total budget is divided by the added area achieved under the project.

Conclusions – A Comprehensive Framework for Irrigation

At a supra-regional level there is a strong case for irrigation investment (greater food production, reduced environmental stress, pro-poor livelihood benefits, enhanced protection from climate change), and there are many opportunities for rehabilitating, regenerating, expanding and improving irrigation in Africa. Access to irrigated lands for many thousands of households could be generated by doubling the area under irrigation in certain areas, pursuing ownership transfer programmes from the state to smallholders and deploying micro-irrigation projects. In particular, opportunities exist with area and productivity gains on smallholder systems by improving the economic environment in which farmers invest privately in irrigation technologies such as intakes and boreholes.

An improved knowledge base and better market conditions surround these opportunities, which mean new projects are likely to be more sustainable. Farmers are more motivated to engage with the market given a benign macro-economy and higher farm gate prices. Processes of project design and delivery based on participation with beneficiaries have changed for the better. A variety of robust irrigation technologies are available which fit individual needs and capacities.

However, this review also cautions that irrigation in Africa is complex and manifold. While some general figures point to low uptake of irrigation in Africa, suggesting high potential for further expansion, a disaggregated view gives a more complicated picture; and certainly a view that further irrigation expansion should be circumspectly and accurately addressed. Irrigation expansion can bring conflicts during the dry season even where the full utilisation of water in the wet season has not occurred. Variation between dry years and wet years also suggests that irrigation interventions might have to first examine improved management, equity and access rather than seek further expansion. Thus although benefits will come from a new enlarged programme of irrigation support, there are four main risks; poorly targeted projects; expensive costs; low project sustainability; and depletion of water for other sectors, particularly the environment. It is these problematic dimensions of irrigation that need managing within a comprehensive governance framework of water and irrigation. This framework is given in Appendix A. Described here are some key features of this approach:

Focussed and sustainable delivery

At the basin scale, water development tends to undergo an S-shaped curve of slow growth initially followed by a momentum phase, and then a plateau phase as demand meets supply. This curve signals different approaches within each part. If, for example, irrigation is in a growth or plateau phase, governments and donors need not fund programmes that target irrigation *expansion*, but instead target a) *equity* - the re-distribution of water and land to improve security and access by poor people to the benefits of irrigation, and b) *productivity* – the enhancement of specific productivity of a given hectare of land, and of an increase in land arising from any redistribution of water.

The comprehensive framework tackles broad strategies as well as selective interventions that in turn are appropriately identified by conducting detailed multi-disciplinary audits of individual sub-basins and irrigation systems. Targeting is important because a successful technology in one locality may not translate well to others, even close by, because of changing livelihood, market, geo-hydrological, knowledge and production systems.

The target is for an additional 5 million ha of irrigated land in Africa, representing an average increase of 3.8% each year, with different regions receiving different rates of growth (from about 2% to 6%). This is argued to be an acceptable goal for irrigation expansion and is comparable with the higher NEPAD target of an additional 7 million hectares. The Commission for Africa irrigation infrastructure programme is estimated to cost US$1.93 billion/year (refer Appendix B) compared to US$4.2 billion/yr for NEPAD.

Innovation and convention

It is important to design projects that suit the river basin and local context rather than apply a dogmatic approach that might stipulate for example an over-emphasis on small-scale solutions. This will require a judicious mixture of both innovative and conventional technologies. Examples of the ‘innovation’ are for example the ‘seed’ smallholder schemes whereby only headworks are constructed to divide a larger river into manageable streams for smallholders to develop their own systems. Examples of conventional systems are the dam and smallholder schemes widely tried during the latter half of the 20th Century which have had a mixed track record. Similarly, innovative ‘collector well’ designs for productive purposes will improve yields from dryland areas underlain by crystalline basement rocks (Lovell 2000).

With respect to innovation, it is worth explaining here the ‘irrigation and sub-basin transition programmes’ (see component number 12 in Appendix A). The emphasis is on a mixture of approaches designed to solve identified problems with productivity, expansion and access rather than to utilise an ‘irrigation improvement’ methodology based on ‘normative’ irrigation engineering. The transition programmes are based on a multi-disciplinary and stakeholder identification of the issues.

Knowledge and institutional reform and linkages
The approach relies on problem-solving by improved client-orientated services combined with knowledge cross-checking with an advisory panel and other expert inputs. Improved services to solve problems and remove constraints are best delivered at the local level, but this requires improved co-ordination and meaningful responses from support organisations delivered in a satisfactory timeframe. An ability to respond to real problems in turn calls for institutional reform of service providers (extension services, etc). Furthermore, effective partnerships will influence how countries in Africa will sustain and manage existing and new infrastructure.

Return on investment
With respect to the justification of the project, a benefit : cost ratio analysis has been conducted, which shows a conservative ratio of 1.58 over 10 years (see Appendix B). While some of the assumptions are sound, this is somewhat conjectural, and would need further modelling before proceeding. The ‘with project’ scenario brings an additional 3 million ha over a ‘without project’ scenario, and higher productivity and increased agriculture-based economic activity across the whole continent. In many ways, other outcomes not included in the analysis will be significant, stemming from improved water management, reduced food imports, and better allocation in different river basins.

Cost recovery
Pursuing a total or partial cost recovery of such a large programme is problematic, except for some technologies, e.g. treadle pumps, that can be sold to farmers. From the evidence, farmers rarely cover the running costs of medium to large scale surface irrigation systems let alone sunk costs or capital depreciation and replacement costs (although in theory this should be possible). Policy makers may have to recover costs via cross subsidisation from wealthier water users and from a general growth in economic activity and taxation rather than by directly burdening poor rural populations for water and infrastructure that generates further administrative costs. In addition, enhancing ownership and responsibility for projects at the user level will also assist in the long-term sustainability and benefits of this programme.

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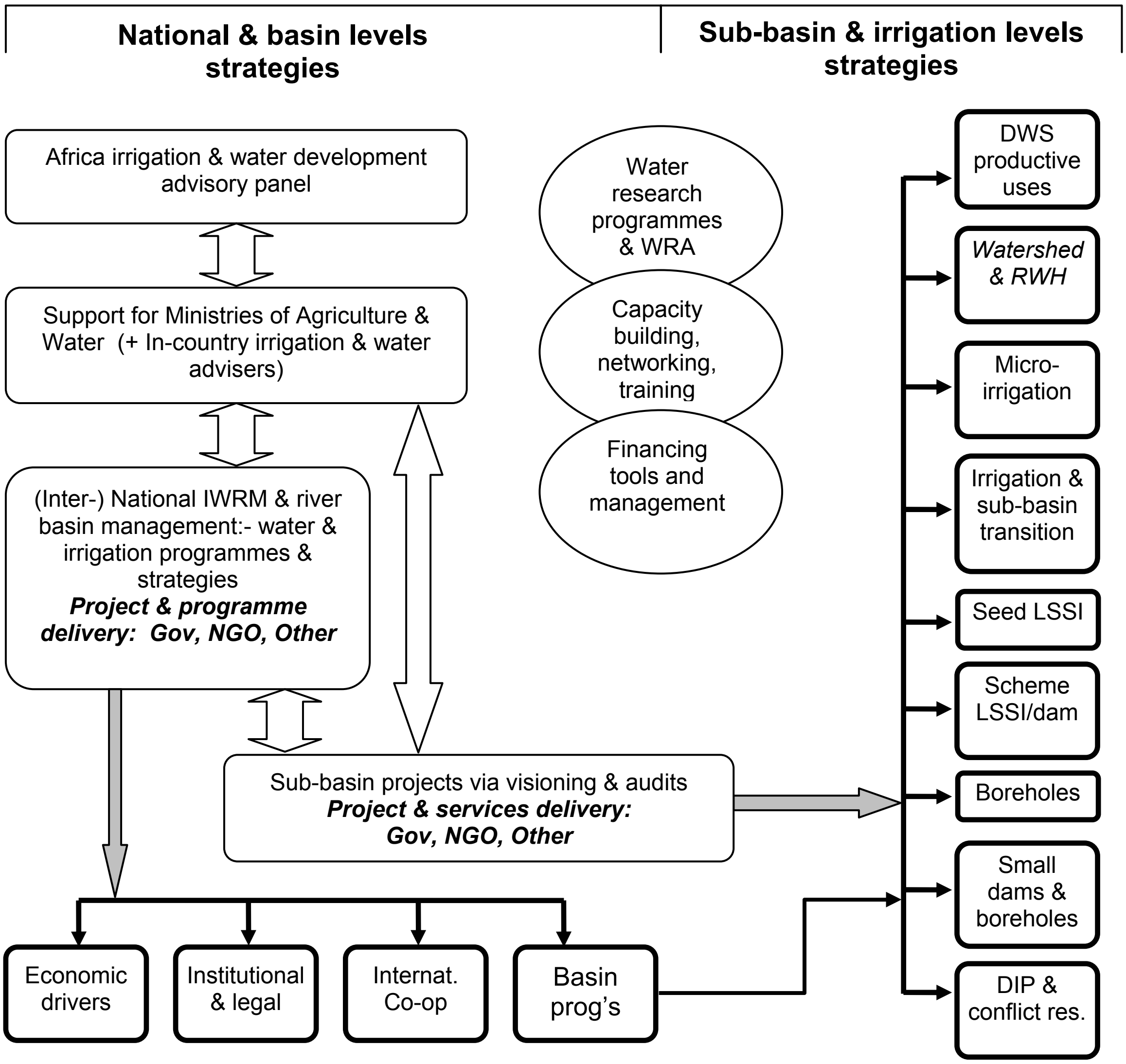
Appendix A. Comprehensive Framework for Irrigation and Water Development

The question of how to develop Africa's water resources for irrigation in ways that meet complex criteria and risks is best answered via a comprehensive framework (Figure 1). The framework combines different strategies related to scalar and organisational levels, beginning with a continent-wide plan to oversee national and international programmes that translate into basin and sub-basin programmes delivered by government or non-governmental organisations. The programmes (left of diagram) identify projects at the national, basin, sub-basin or irrigation system levels, given on the bottom and right hand side of the diagram. At the centre of the figure are three circles – research, human resources and finance – which relate to all components. The approach is marked by a high degree of inter-relationship and cross-checking. The framework presents conventional ideas (although placed in a modernised setting) as well as more novel ones. The framework combines problem-solving at the irrigation and sub-basin system level with measures that address broader underlying factors. Each of the components is discussed below in more detail, while Appendix B provides an overview of the costs and projected benefits.

Figure 1. Comprehensive Framework of Irrigation and Water Development for Africa



Source: ODG, UEA

Description and explanation of the components of the Comprehensive Framework

1. A Comprehensive Framework for Irrigation and Water Development in Africa

Explanation: A comprehensive approach is necessary because the costs, risks and externalities associated with irrigation can outweigh the benefits. Irrigation, as a major consumer of water in Africa, should not be tackled as an engineering intervention but as a water governance challenge. There is a need for all stakeholders to commit to this perspective and associated components and activities.

Components: See Figure 1 and sub-sections below. In addition; mainstreaming the framework, co-ordination with AMCOW and NEPAD water initiatives; delivering African water networks and professionals; ensuring long-term political will and partnerships to sustain the benefits of the work.

Costs: Total costs are estimated at 1.93 US$ billion/year or US$19.3 billion over 10 years.

Benefits: Benefits are difficult to estimate (see Appendix B), but relate to reduced capitals costs, improved management, enhanced rural productivity, employment and business; reduced local, regional and international conflict; greater food security; and enhanced environmental protection. On average, an additional 0.5 million ha/year can be developed and net income productivity gains of 3.4% per year, giving total projected benefits of US$35.2 billion after 10 years.

Risks: As well as the risks mentioned with each component below, there is a risk that the framework may suffer from a lack of co-ordination.

Conclusions: If a new departure for irrigation is envisaged, the lessons of the past indicate that the technology should be wrapped within a comprehensive framework that addresses institutional, economic, social and environmental sustainability.

2. Africa irrigation & water advisory panel

Explanation: The framework first suggests that an advisory panel for Africa (or regions thereof) be established to oversee the process internationally and in each country, and to co-ordinate research, capacity building and financing programmes that will feed into different components. Although actual projects would be developed at the national and local scale, cross-checking donor and government activities would generate important functional benefits for longer term sustainability.

Components: International co-ordination, planning of training/research, overall strategic directions, financing tools, audits of national plans and budgets, ensuring best practice, visions of water development.

Costs: Costs would be associated with salaries, overheads and expenses – estimated at US$250,000/year per person. If ten people were attached to this body total cost would be US$2.5 million/year.

Benefits: It is possible to think of several major donor projects that would have benefited from peer review and improved co-ordination between donors. There remains a concern that future irrigation projects will be too orientated towards irrigation rather than the whole catchment. Such a body would ensure a more balanced approach.

Risks: There is a risk that the panel might itself not have sufficient and rigorous technical knowledge regarding water management.

Conclusions: A good case can be made for a technical panel to oversee the development of Africa's water resources – too often professionals in the water sector work without sufficient reference to wider or local expertise and knowledge.

3. Programme support for Ministries of Agriculture and Water

Explanation: The next component is the establishment of support to Ministries of Agriculture and Water, which could also take the form of the in-country TA officers being embedded in the Ministry, training, or specific projects (see below). Working with existing, or developing new, programmes of irrigation development, the Ministry staff and the Africa advisory panel would generate focussed plans at the basin and sub-basin levels, with coherence at the national level. Donors have commonly provided support either on long-term or short-term basis. Examples of the former include DANIDA's Agricultural Support programme, and an example of the latter is JICA's funding of the Irrigation Master Plan in Tanzania. Funding can also be used to strengthen Irrigation Sections within the MoAg. Programmes can also address 'change management' within institutions (see Human resources development), particularly those that enhance service delivery.

Components: Increase support for African Ministries of Agriculture and Water to spend on irrigation and irrigation extension, co-ordination, identification of training, strategic planning (water strategies), audits of river basin and project plans and budgets. Change management programmes.

Costs: Costs would relate to the nature of the support and specific projects that would be tied to the aid. Suggested annual budget is set at US$ 0.5 million per country for twenty countries each year (which could revolve).

Benefits: Relate to enhanced planning for irrigation at central levels.

Risks: That despite supporting irrigation and water resources development, irrigation remains a blind spot within the Ministries of Water and Agriculture.

Conclusions: Institutionally, it is necessary and sensible to go through central Ministries in establishing projects at the national, regional and local scale.

4. In-Country irrigation advisers & programmes

Explanation: One approach (used for example by DANIDA) has been to fund irrigation programmes that then disburse funds for projects at the system or basin scale. This can be steered by a generalist (who might be performing other project cycle functions) or an irrigation specialist who can steer enhanced irrigation spending programmes more carefully.

Components: Provide TA support for African Ministries of Agriculture and Water for above programme support. Co-ordinating with other advisers and with the Africa-wide body panel.

Costs: Programmes, related to salaries and logistical costs, generally run to about US$200,000/year/per adviser. (Fifteen countries suggested).

Benefits: Difficult to quantify, but providing valuable backstopping at the national level.

Risks: Few risks perceived provided appointments were technically sound and linkages were made to the Africa Advisory Panel.

Conclusions: This is an optional post to run alongside the Ministry support, but one that would form a useful input to programmes and projects develop at that level.

BROAD NATIONAL AND BASIN WATER AND IRRIGATION PROJECTS

Referring to the bottom of Figure 1, programmes would then be expressed at the national and basin level to improve general conditions for irrigation uptake, allocate water and both conserve and develop the resource.

Management and service delivery of national and basin projects

These national and basin programmes would be delivered by NGO's, Government staff or consultancies. For example, policy analysis, legal reviews and project design for river basin offices would be conducted by specific consultancies consisting of national and international experts.

5. Examine economic drivers

Explanation: Research in the last 15 years has pointed to the significant role that wider economic and livelihood drivers play in affecting the success of individual infrastructural projects. The challenge here is for central policy-makers to create benign conditions for farmers to enter into irrigation perceiving it to be from an economic sense profitable, predictable and secure. One example from India is the uptake of groundwater development on the basis of subsidised electricity prices.

Components: Various issues are at play here; land tenure and distribution (security of tenure), access to credit; penalties from local taxes; subsidies and costs of fuel and electricity for water pumps.

Costs: Research and policy analysis consultancy projects (set here at eight per year at a cost of US$200,000/per project).

Benefits: Benefits are widespread, encouraging more farmers to develop their own irrigation.

Risks: Poor research and lack of policy uptake from consultancy findings and recommendations.

Conclusions: Ensuring beneficial economic signals is vital part of the promoting irrigation uptake.

6. Review irrigation and water institutional and legal framework

Explanation: Equally important are the institutional and legal conditions that influence how farmers enter into and negotiate over water resources for irrigation. Examples include the design of formal and customary water rights.

Components: Reviews of water strategies, legal frameworks, amendments to water/environmental laws.

Costs: Research and policy analysis consultancy projects (set here at eight per year at a cost of US$200,000 per project).

Benefits: Benefits are widespread, encouraging more farmers to develop their own irrigation.

Risks: Lack of policy uptake from findings, failure to seek input from all stakeholders.

Conclusions: Appropriate institutional agreements smooth conflict and promote sustainable uptake.

7. Strengthen international riparian cooperation

Explanation: Since ten river basins in Africa over 350,000 km^2 are considered major international basins and approximately 45 rivers cross international boundaries, co-ordination at the international level in Africa is vitally important.

Components: Water co-ordination, meetings, water treaties, monitoring – additional work covered in other components.

Costs: Costs of this programme (discounting other projects covered below) are associated with consultancy and staff costs, estimated at US$0.5 Mn/year per basin (10 basins over 10 years – this includes the Nile Basin).

Benefits: Benefits relate to reduced conflict and improved transfer of water between countries leading to some productivity and expansion gains.

Risks: Other conflicts (e.g. trade, transport) undermining water agreements; failure to implement agreements.

Conclusions: As water scarcity becomes more of an issue, international agreements over the resource will proportionally grow in importance.

8. Fund river basin management (RBM) offices and programmes

Explanation: River basin management programmes are required to co-ordinate sub-basin and irrigation system interventions. Delivery of these programmes can be by via governmental, NGO or other mechanisms (i.e. long-term TA consultancies).

Components: Water resources assessment and monitoring; sub-catchment/irrigation project definition, planning and administration; national co-ordination; audits of sub-basin projects; transboundary basins.

Costs: Costs are associated with running of an authority, its offices, sub-offices and equipment. Costs are highly variable. On an annual basis for a large African river basin covering 60,000 km^2, one can assume for an effective programme US$ 1.5 million per year, excluding costs associated with other irrigation interventions. (Here, 60 basins in total are identified).

Benefits: Benefits are related to co-ordinated water management and resolution of conflicts arising. Water programmes are targeted at reaching the poorest, and environmental issues related from over-abstraction mitigated.

Risks: Without sufficient critical analysis, RBM may address incorrect or non-priority issues, or tackle key problems in ways that do not solve them.

Conclusions: It is difficult to conceive of irrigation and water development proceeding without co-ordination at the river basin level – though concerns remain about the direction, scope and efficacy of such programmes, especially if replicating existing administrative systems. The presence of a higher-level advisory panel may address these issues and advise accordingly.

FOCUSSED SUB-BASIN WATER AND IRRIGATION PROJECTS

Referring to the right hand side of Figure 1, national water and irrigation priorities are expressed at the sub-basin, sub-catchment and system level in order to arrive at bespoke projects to widen access to irrigation, improve productivity and safeguard against environmental impacts.

Management and service delivery of sub-basin projects

These sub-basin projects would be managed by NGO's, Government staff or by other means. Different kinds of institutions are often best placed to deliver projects. For example, NGO's can target specific problems well and make strong linkages with farmers over longer periods of time, while Government extension officers can deliver other resources necessary for raising the productivity of water. Consultancy-led projects likewise have a different set of advantages and disadvantages. A critical aspect of the work envisaged here will be problem-solving and responding to issues articulated by local users. This responsive mode places new challenges on organisations that might be otherwise designed along thematic modes. For each technology a situational diagnostic audit and survey is required to assess the level of local demand, appropriateness of fit and identify factors that might affect longer-term sustainability.

9. Boost DWS to address productive uses of water

Explanation: Currently favoured by a number of research institutions[26]; piggyback larger amounts of water onto domestic water supply (DWS) networks to encourage households (women in particular) to irrigate garden vegetables, water livestock and undertake micro-enterprises.

Components: Reticulated pipe infrastructure, improved source supply, extension and promotion, training.

Costs: Per household costs are quite small, but ensuring this technology works on a per hectare basis is more expensive than surface gravity fed systems. The unit cost of water via a piped network is approximately 1.0 to 2.0 US$/$m^3$ which is prohibitive although marginal costs for existing systems are more favourable. Estimate 10 projects per year at US$2.5 million.

Benefits: Exposing households to some secure home food production and other livelihoods is a benefit.

Risks: As a counter-argument, research by the University of Newcastle[27] shows that this may place undue stress on the water supply network and source if not adequately catered for, and lead to continuing differentiation between users with enhanced supplies and those without. In addition, the research found that local users valued upgrading the system for convenience of domestic provision rather than for production. Total areas developed tend to be small.

Conclusions: Successful responses could be developed in specific areas, subject to detailed audit and assessment, provided a local demand could also be demonstrated.

10. Watershed protection and rainwater harvesting

Explanation: Although watershed protection and rainwater harvesting are not technically irrigation, a transition exists here, and a growing interest in the benefits of rainwater harvesting. In addition, there are cases where upstream watershed protection is an intimate part of whole basin management in order to protect water supplies for irrigation. One example is an IUCN project in the Pangani, Tanzania designed to combine catchment protection and irrigation management.

Components: Extension & promotion, some small-scale infrastructure, tree planting and afforestation.

Costs: Costs are small if in-situ rainwater is harvested. Watershed protection programmes with tree planting and other activities are more expensive. *Not costed here.*

Benefits: The benefits tend to be mixed, if rain is short then harvesting will have minimal effect, if rain is abundant the same applies.

Risks: Problems can stem from land tenure issues, lack of water and the sharing of available water. In addition, rainwater harvesting can subtract water from downstream users and should not always be perceived as being ‘free’.

Conclusions: This kind of intervention should be supported but in a catchment context using a water audit style.

11. Micro-irrigation and waste-water peri-urban irrigation

Explanation: This type includes treadle, bucket, low-cost drip and other small-scale low cost technologies that irrigate individually small areas of about 0.5 hectare. The standard format for promoting adoption includes a NGO selling kits to early leaders who are then copied by other farmers. These kinds of technologies are often used to irrigate lands with wastewater near urban environments also known as ecological sanitation (ECOSAN) projects. Critical to the success of these types of projects is the source of water (i.e. location, quantity, quality, variability, head-difference). This component also combines with component 16 to promote the uptake of small-capacity diesel-driven wells.

Components: Sourcing of water well-digging, extension & promotion, small-scale equipment and infrastructure.

Costs: Costs are normally in the region of US$100-200 per unit, paid for by beneficiaries, with donor-funded project costs added onto that. Past projects have been in the order of US$2.5 million for 5000 treadle pumps. (60 projects envisaged, one per major basin).

Benefits: The benefits come from area irrigated and crops grown. One[28] study reported an annual net benefit of US$340 per 0.3 ha, which calculates for a project of 5000 units with 6 year life to provide a benefit: cost ratio of 3.29 including both beneficiary (US$0.6 million) and donor investments (US$2.5 million).

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[26] PRODWAT thematic group (www.irc.nl/prodwat).

[27] CAMP Policy Brief No. 2 “Poverty reduction in a water stressed rural catchment, Feb 2004. CLUWRR, University of Newcastle, UK

[28] Email to “e-Conference on Irrigation in Sub-Saharan Africa” sent by Naugle, J. 21 Feb 2003:

Risks: Problems can stem from excessive uptake of the technology, and contamination and disease problems associated with waste-water use.

Conclusions: This kind of intervention is successful when supported but in a catchment context using a water audit style.

12. Irrigation & subcatchment transition programmes

Explanation: Irrigation and sub-catchment scales have been grouped here because it is no longer advisable to manage and rehabilitate irrigation without a whole-catchment and integrated viewpoint. The objective here is not 'improve' irrigation systems in the conventional sense but to address problems that are carefully identified by both experts and farmers.

Components: Surveys of issues and constraints: Irrigation management transfer of government schemes to farmers: Increase access of irrigated land and newly irrigated land to poor people, women and younger farmers (this might entail some land tenure revisions): Infrastructure rehabilitation is required but relate to ensuring improved control of water delivery within and surrounding irrigation systems. In addition, there is a need for re-tuning of existing infrastructure where the latter is proving to be out-dated or adding to conflict within the sub-catchment: Strengthening of Water User Associations may also be necessary: Conflict resolution efforts via public participation and other deliberative tools are likely (see below): Addressing parallel issues such as fisheries, drinking water, diseases, erosion, siltation, etc. Examining and addressing market drivers (such as roads) within each sub-basin. Addressing waterlogging, drainage and salinisation where occurring. Transboundary issues examined and addressed.

Costs: Despite different attempts by donors, costs for new and rehabilitated schemes remain in the region of US$5000 to US$10,000/ha. NGO's have achieved irrigation improvements for less money. Non-structural components are financially less burdensome. Total costs here are estimated at four sub-basins to be tackled in each of the 60 basins identified at a cost of US$3 Mn each/year.

Benefits: Benefits can stem from improved access to land for poor people, reduced conflict over water and enhancements to productivity (estimated at 3% per year where operating).

Risks: The great risk here is that irrigation transition programmes will be delivered using engineering-centred viewpoints – that concentrate too much on inappropriate infrastructure to the detriment of environmental, social and institutional issues.

Conclusions: These types of programmes are one of the biggest challenges facing donors and governments – how to improve surface irrigation productivity, increase area, enhance access, reduce conflict and to sustain these gains in the face of population growth, climate variability and increased competition for water from other demands including the irrigation sector. Such programmes are urgently needed throughout Africa.

13. 'Seed' new large scale irrigation scheme

Explanation: A novel and untried approach to irrigation development would attempt to bring together the advantages of large and small-scale systems; asking the question "Can the larger under-used rivers in Africa be tapped by smallholders in ways which retain the positive elements of indigenous smallholder systems?" The answer might be to construct only 'run-of-river' headworks that meet hydraulic standards, and one or two main canals, but then leave the distribution and field system to be developed by the farmers themselves. This solution would only apply to larger rivers where size and lack of command make it difficult for smallholders to tap.

Components: Intake and major canals are the only infrastructure provided. The aim is to tap larger rivers so that the water can be sub-divided into smaller flows that then can be developed by smallholders.

Costs: Costs are restricted to the main system only, leaving the remainder of the system to be organised by farmers. Costs might be as low as US$1000/ha. Total cost per project US$10 Mn with five started each year across Africa.

Benefits: Benefits are related to an immediate step up in irrigated area accessible to farmers. Areas that could range from a 1000 to 5000 ha, giving 2000 to 10,000 farmers access to water.

Risks: The main risk is the longer-term sustainability of such programmes arising from a lack of on-going project or government support.

Conclusions: There is a strong case for revisiting the concept of the larger-scale irrigation scheme in certain river basins where water quantities can be found.

14. New reservoir & large scale irrigation schemes

Explanation: Large dams have a mixed history in Africa, and there is now a renewed interest in supply solutions being promulgated by various organisations (IWMI, WB). Although not in vogue, some new large systems have been constructed in the last 10 years. However, they have their place in the right environment. One example is LUSIP in Swaziland[29].

Components: Complete system is provided usually including a reservoir, and a project management unit for long-term management. Site investigations, detailed surveys, construction, materials, recurrent management and maintenance costs, distribution of water and other benefits. (N.B. Other supply solutions also envisaged here such as large 'water carriers' that transfer water over distances of 100 km and above).

Costs: Costs are approximately US$10-20,000/ha. Total cost is estimated at US$150 Mn per 5000-6000 ha. Assumed one major project every year, leading to 10 in total over 10 years – though this could be downgraded to 5 in 10 years.

Benefits: Benefits are related to an immediate gain in area accessible to farmers. The system may seed peripheral and neighbouring systems developed by farmers themselves. If cash crops such as sugarcane are grown alongside food crops, the project can give a satisfactory return on investment over 10 years or more.

Risks: The main risk is the longer-term sustainability of such programmes arising from a lack of on-going project, conflict amongst farmers and failure to pay fees. Other risks relate to siltation, cost over-runs, maintenance of power equipment & management of water releases during dry spells.

Conclusions: There is a strong case for revisiting the concept of the larger-scale irrigation scheme in certain river basins where water quantities can be found. This kind of intervention is likely to be rare, but there are situations where further large dams are the appropriate solution to increasing water scarcity. Longer-term management issues would need to be addressed.

15. Programme for large boreholes and/either innovative borehole technology

Explanation: Large borehole (deep tubewells) development has a mixed history in Africa (including expansion of livestock into arid areas), but there is now a renewed interest in supply solutions being promulgated by various organisations (IWMI, WB). In addition, there is interest in collector well technology for water extraction from crystalline basement geology where single boreholes would not provide sufficient water.

Components: Complete system is provided usually major borehole development, and a supported project management unit for long-term management.

Costs: Costs are approximately US$10-20,000/ha. Total cost is estimated at US$25 Mn per 300 ha for field development consisting of a number of deep tubewells (each having a command area of about 10-20 ha). The same budget is assumed to cover collector well development in a given region. Assumed 10 major project every year, leading to 100 in total over 10 years. The scale of investment also suggests monitoring of impacts, water levels, salinity etc.

Benefits: Benefits are related to an immediate gain in area accessible to farmers. The system may seed peripheral and neighbouring systems developed by farmers themselves. If cash crops such as sugarcane are grown alongside food crops, the project can give a satisfactory return on investment over 10 years or more. Collector well areas are not large, but provide critical watering for humans and livestock. Deep well technology has also enabled increased livestock numbers in arid regions such as Botswana though this has in turn impacted on fragile ecology around the watering points[30].

Risks: The main risk is the longer-term sustainability of such programmes arising from a lack of on-going project, conflict amongst farmers and failure to pay fees for maintenance of power and pumping equipment.

Conclusions: There is a strong case for revisiting the concept of the larger-scale borehole schemes in certain areas where water quantities can be found.

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[29] The components of LUSIP (first phase approx 5000 ha) are: upstream works Eu48mn; downstream works Eu18mn; land development, field irrigation Eu13mn; agro-processing Eu8mn; project management 14mn; resettlement Eu2mn; total Eu103mn. For sustainability the project needs professional management and an organisation to co-operate with traditional authority. Central Government lack experience of large project implementation. Therefore the Project Management Unit will leave behind an institution to manage irrigation after implementation. Farmers will own and manage the system which must be self financing through the Lower Usuthu Irrigation Management Association, with voting majority by elections from water user groups. LUIMA will be financed by metered water charges.

[30] See for example research by ILRI http://www.ilri.org/ and by PANRUSA "Poverty, Policies, and Natural Resource Use in Southern Africa" http://www.shef.ac.uk/panrusa/

16. Programme for small dams and shallow boreholes

Explanation: This component promotes the development of small dams, village level boreholes, dug wells, shallow tubewells and other small-scale water supply solutions developed in parallel to irrigation investments. Here the argument is that water supply for households and livestock remains a critical issue in parts of Africa and is often a question of poor local access and timeliness either not benefited or affected negatively by neighbouring irrigation development. Therefore, this programme is affiliated to the irrigation and water programme and is separate to the considerable water and sanitation needs arising in Africa in the next 10 years. The boreholes here envisaged are different to the deep or collector wells discussed in component 16, and cover handpumps for domestic use and diesel pumps extracting 10-15 l/sec irrigation water from less than 10 metres.

Components: Site investigations, detailed surveys, construction, materials, recurrent management and maintenance costs, distribution of water and other benefits.

Costs: Small reservoirs cost US$0.2-2.0 Mn. Village level and multiple shallow boreholes cost US$5000-50,000 depending on project management. Total project costs US$1.0 Mn per sub-basin with 4 sub-basins identified per 60 of the main basins funded (240 in total each year). Project costs also cover promotion of purchasing of pumps by farmers.

Benefits: The benefits can be mixed, but can generate very real but small productive outcomes mitigating negative affects of upstream irrigation development. In general small supply solutions suit better domestic water security and water for livestock[31] rather than meeting the kinds of large volumes necessary for agricultural production, although cumulatively, given appropriate conditions these can mount up (shallow diesel or electricity pumps extract 10-15 l/sec supplying command areas of about 4-10 ha, and are for example popular in parts of Sudan and Egypt along the Nile).

Risks: Risks involve sedimentation, increased incidence of water born diseases, failure of the system to obtain water, poor operation and maintenance (O&M) and conflict over distribution.

Conclusions: This kind of intervention should be supported in a catchment context using a water audit approach.

17. Deliberative inclusionary processes (DIP) and conflict resolution programmes

Explanation: Water has to be discussed by all stakeholders if appropriate patterns of water allocation are to be selected. Deliberative inclusionary processes collate a number of mechanisms designed to ensure effective public participation in water management. These, and conflict resolution programmes, are part of sub-catchment transition and management programmes described above. In addition conflict might be international, suggesting the need for particular programmes to deal with this.

Components: Meetings, facilitation, follow-up, publications.

Costs: Costs estimated at US$5000-US$10000 for individual DIP activities. Total costs here are estimated at US$1 million/year for four sub-basins to be tackled in each of the 60 basins identified at a cost of US$40000 each/year.

Benefits: Benefits relate to reduced conflict, improved subsidiarity of water management.

Risks: Risks relate to lack of follow up on resolutions leading to further frustration and conflict.

Conclusions: These are important parallel activities within river basin management.

RESEARCH, MONITORING, TRAINING AND FINANCING TOOLS

18. Water research, monitoring and water resources assessment programmes

Explanation: Research of irrigation and river basin management has increased in recent times, though much more could be done here (the funding of irrigation management research is a fraction of agricultural research funding. The Economist magazine commented on this about 10 years ago). Research can be applied to all parts of the comprehensive framework for water management, but there are urgent priorities; to correctly identify real problems at the catchment and irrigation system level rather than 'normal' problems commonly perceived. This also applies to the potentially costly solution of large-scale infrastructure (storage and irrigation schemes). Research

[31] One diesel powered shallow borehole providing 10 l/sec for 3 hours can provide 2160 cattle with 50 litres per day. In arid areas with a single tube the constraint here might be excessive drawdown and slow recovery times of the water table. Deeper water might be better in this regard, but require a change in technology.

of institutional and legal frameworks is also a priority. Data for hydrological and water resources assessment is frequently missing; upgrading of the hydro- network is an important priority. Monitoring of supply and demand, and of groundwater status in key areas is required.

Components: Research commission, management, programme monitoring, benchmarking and baseline studies, hydrological assessment and data collection networks

Costs: Costs estimated at US$300,000 per programme per year, with 60 programmes tailored to meet the 60 basins targeted (though of course different basins may be selected): total is US$18 Mn.

Benefits: Benefits relate to improved knowledge, fact-finding, programme analysis and policy-responses.

Risks: Risks relate to inappropriate or inadequate research and failure of policy uptake. Water research sometimes risks being too 'basic', concentrating on the hydrology of catchments rather than on the management of water – although all are needed.

Conclusions: As with many parts of the framework, it is difficult to defend the omission of research and data collection for water and irrigation management. Ensuring that partners continue to maintain newly established infrastructure for hydrological data collection is key.

19. Human resource development programmes

Explanation: A large range of skills requirements face water professionals; from updating conventional skills such as engineering, to acquiring new skills such as facilitating participation in decision-making. New challenges not only apply to individuals but to organisations as they respond to change within river basins. Responding to public facilitation exercises places new demands on organisations. Maintaining and managing new and existing stocks of infrastructure places responsibilities on all levels of society. Another critical capacity relates to farmers and other water users – although they hold considerable 'local knowledge' this is often constrained by the context in which they live. Water users need to be presented with alternative viewpoints on the management of water.

Components: Training, meetings, networking organisations, tertiary education, postgraduate research, change management, website development; professional accreditation. Needs assessment; using and transforming local perceptions. Web-based solutions.

Costs: Costs are as follows: approximately US$750,000 pa to support three networks with associated activities; six training programmes can be run annually at a cost of approximately US$175,000 per programme; six change management programmes can be run annually at US$100,000 per programme. Tertiary education for Masters and PhD's can be provided for 50 individuals per year at US$25,000 per individual.

Benefits: Benefits relate to improved knowledge, programme design and management.

Risks: Risks relate to structural problems found in hierarchical organisations that constrain the application of new skills and thinking; e.g. low salaries, delegation of both tasks and decision-making.

Conclusions: Alongside the comprehensive approach, a human resource development programme is critical.

20. Financing tools and management

Explanation: Separate to the budgets suggested for the programme is a budget to cover a finance-working group addressing financial research, innovation, mechanisms and management (c.f. Aeschliman, 2001).

Components: Management, research, co-ordination, monitoring of PRSP's, budgets and MTEF; private equity investment, loan and grants management, auditing accounts and revenues; compliance.

Costs: Costs estimated at approximately US$0.8 Mn per year for one overarching programme.

Benefits: Enhanced financial sustainability, co-funding from private and beneficiary sources.

Risks: Lack of uptake of findings to adjust financing mechanisms.

Conclusions: Appropriate financing and monitoring systems will be an important part of the approach.

Appendix B. Calculation of benefit:cost ratio

Costs

Table 1 shows that the total cost is estimated to be 1.93 US$ billion/year (19.3 billion US$ over 10 years). This is based on the figures utilised in the components described in Appendix A, and includes a contingency fund (which also covers unforeseen recurrent and administrative costs) of US$0.2 billion per year. Divided by a total area of 5 million ha added by 2015, generates per hectare costs of 3864 US$/ha, although the 1.93 billion is also spent on existing irrigated areas, and so after 10 years the total area of 18 million ha can be divided by 19 billion, which is a cost of 1067 US$/ha.

Table 1. Costs of the Comprehensive Framework for Water and Irrigation Development

Component	Number of units each year	Annual Unit costs 000 US$	Total Costs 000 US$
Broad and Ministerial support			
Advisory panel (no. experts)	10	250	2500
Min. Water & Agric co-ord (Countries)	20	500	10000
Irrigation advisers	15	200	3000
		Total	15,500
National & basin level programmes			
Economic drivers (no. studies/yr)	8	200	1,600
Legal and institutional framework	8	200	1,600
International co-operation	10	500	5,000
Basin offices & programmes	60	1500	90,000
		Total	98,200
Sub-basin & irrigation level projects			
DWS productive uses	10	2500	25,000
Watershed P & RWH	*Not priced here*		
Micro- & wastewater irrigation	60	2500	150,000
Irrigation & sub-basin transition	240	3000	720,000
Seed SSI	5	10000	50,000
Scheme SSI (with dam)	1	150000	150,000
Large boreholes & SSI	10	25000	250,000
Small storage and boreholes	240	1000	240,000
DIP & conflict resolution	240	40	9,600
		Total	1,594,600
Human resource dev., research and financial issues			
Research & monitoring programmes	60	300	18,000
Network programmes	3	750	2,250
Training programmes	6	175	1,050
Change management programmes	6	100	600
Tertiary education (experts)	50	25	1,250
Financing mgt programmes	1	800	800
		Total	23,950
Contingency, admin and other			200,000
Total cost (000 US$)			1,932,250
Life of investments (years)			10
Total cost (000 US$)			19,322,500
Total cost (billion US$)			19.3
Per hectare costs (total investment/new added area)			3864 US$/ha
Per hectare costs (total investment/new cumulative area)			1067 US$/ha

Source: ODG, UEA

Benefits and benefit :cost ratios

Table 2 presents a simplified calculation of the benefit: cost ratio on the basis of some conservative estimates for growth. The top half of the table calculates the benefits from an expansion of area by 5 million ha in 10 years (3.8% per year for all Africa to 18 million ha). To arrive at this, new area is added by either specific area development projects (e.g. smallholder schemes) or by informal growth of existing irrigation areas. To calculate this latter type of growth, it is assumed that 7 million hectares provides a basis for forward momentum in providing attractive conditions for more farmers to enter into irrigation. This is on the assumption that irrigating areas generate their own farming, marketing and livelihood systems, that in turn generate increased competition for water with further efficiencies leading to areal expansion. Then the figure of 7 million is multiplied by a percentage growth figure for each intervention programme that promotes productivity and smallholder growth without necessarily building new schemes. A good example of this is the estimated 2.0% growth in area that will come from improved economic conditions. Cumulatively, the comprehensive framework programme generates approximately 500,000 ha per year growth. (Note that other components in the programme such as capacity building and research are not assumed to generate their own specific growth in irrigation, but rather support those components that are more targeted on growth).

As well as area growth, profitability gains from improvements to productivity and crop prices are important achievements of the programme. Here it is assumed that both productivity (tonnage per hectare) and price combine to provide a single productivity/profitability rate. These gains apply to both the existing area (assumed here to be the whole 13.1 million ha) and to new areas generated (which is 0.5 million each year). Here it is assumed that real (accounting for inflation) annual productivity/profitability gains of 3.4% are achieved taking net benefits up by US$20 each year to US$200 after 10 years from a global figure of US$800/ha (up from US$600/ha).

A separate calculation then combines the two types of gain (expansion and increased profitability) to determine the annual cumulative benefits, which are US$35.2 billion after 10 years and US$87.4 billion after 20 years which when compared to the project cost of US$19.3 billion generates a benefit:cost ratio of 1.82 and 4.52 (note – no discounting is applied here).

It is likely these are conservative estimates of the benefits given that turnover generated by irrigation is perhaps 2 to 3 times that of profit. In other words, new area expansion and higher productivity will result in significant new economic activity not captured by this simple model. In addition, it does do not calculate benefits from food imports saved, reduced conflict, improved allocation of water, associated domestic provision and other livelihood gains – all of which are likely to be substantial. It is worth remembering though that these costs will not be compatible with other figures on water management in Africa that might include other sectors (urban, industrial use), health, water quality and clean-up issues, land restoration and catchment protection.

Table 2. Benefits of the Comprehensive Framework for Water and Irrigation Development

Existing area in Africa under irrigation (ha)				13,100,000
Base area for productivity gains & momentum (ha)				7,000,000
Target for further expansion by 2015 (ha)				5,000,000
New cumulative target area in Africa end of 2015 (ha)				18,100,000
Expansion growth target over 10 years (%)				38%
Period (years)				10
Annual growth expansion target				3.8%
Calculation of new area expansion from interventions	No. of project/year	Area added per project ha	Area added growth ha	New area added ha
National & basin level programmes				
Economic drivers (no. studies/yr)	8		2.00%	140,000
Legal and institutional framework	8		0.50%	35,000
International co-operation	10		0.10%	7,000
Basin offices & programmes	60		0.30%	21,000
Sub-basin & irrigation level projects				
Garden irrigation	10	30		300
Watershed P & RWH – not costed				
Micro- & wastewater irrigation	60	800		48,000
Irrigation & sub-basin transition	240		3.0%	210,000
Seed SSI	5	3000		15,000
Scheme SSI (with dam)	1	5000		5,000
Large boreholes & SSI	10	300		3,000
Small storage and boreholes	240		0.05%	3,500
DIP & conflict resolution	240		0.20%	14,000
Economic benefits from new area expansion				
Total new area (ha/yr)				501,800
New area year 1 net benefit (000US$/ha/yr)				0.6
Economic benefits from gains in productivity in existing & new areas				
Gain each year in real productivity/profitability				3.40%
Net benefit gained after 10 years (000US$/ha)				0.20
Final productivity after 10 years (000US$/ha)				0.80
Assumed increment in net benefit in income (000US$/ha/yr)				0.015
Cumulative benefit after 10 years (000 US$)				35,198,737
Cumulative benefit after 20 years (000US$)				87,397,116
Benefit:cost ratio (10 years)				1.82
Benefit:cost ratio (20 years)				4.52

Source: ODG, UEA

Appendix C. Acronyms

ACP – African Caribbean Pacific
AMCOW – African Ministers Council on Water
ASARECA – Association for Strengthening Agricultural Research in Eastern and Central Africa
CAADP- Comprehensive Africa Agriculture Development Programme
CGIAR - Consultative Group on International Agricultural Research
CIDA - Canadian International Development Agency
CLUWRR - Centre for Land Use and Water Resources Research
DANIDA Denmark International Development Agency
DFID – Department for International Development
DGIS - Netherlands International Development Agency
Sida - Swedish International Development Agency
UNDP - United Nations Development Program
WMO - World Meteorological Organization
DIP - Deliberative inclusionary processes
DWS - domestic water supply
ECOSAN - ecological sanitation
EU - European Union
EU-ACP WI/WF, Water initiative and Water Facility
FANNIDA Finland
FAO - Food and Agricultural Organization
GCDS – Global Cassava Development Strategy
GEF - Global Environment Facility
GTZ Deutsche Gessellschaft fur Technische Zusammenarbeit
GWP Global Water Partnership
IFAD – International Fund for Agricultural Development
IUCN - World Conservation Union
IWMI - International Water Management Institute
IWRM – Integrated water resources management
JICA- Japanese International Cooperation Agency
LUSIP - Lower Usuthu Smallholder Irrigation Project
MDGs - Millennium Development Goals
Mn – Milliion
Mt – Metric ton
MTEF – Mid-term expenditure review
NEPAD - New Partnership for Africa's Development
NGO- Non Governmental Organization
NRI – Natural Resources Institute
O&M – Operation and management
ODG, UEA – Overseas Development Group, University of East Anglia
PRSP - Poverty Reduction Strategy Paper
SBS/TBT - Sanitary and Phytosanitary Measures and Technical Barriers
SSI - Small-scale irrigation
SSA- Sub-Saharan Africa
TIP – Traditional Irrigation (Improvement) Project
UN - United Nations
UNCCD - United Nations Convention on Combating Desertification
UNDP - United Nations Development Programme
UNEP - United Nations Environment Fund
UNESCO – United Nations Educational Scientific and Cultural Organisation.
UNICEF – United Nations Children's Fund
UNIDO – United National Industrial Development Organisation
USAID – United States Aid
WARFSA – Water Research Fund in Southern Africa.
WB - World Bank
WI/WF - Water initiative and Water Facility
WWF - World Wildlife Fund for Nature

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