A literature study to support the implementation of micro-AWM technologies in the SADC region

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Most of the photographs were taken by our many partners in the region. Diagrams were incorporated from Professor Bancy Mati's comprehensive report on micro-AWM technologies in Eastern Africa, work previously commissioned by IWMI.

The review of the key technologies borrowed heavily from the SADC country reports produced by the partners to the overall study, of which this literature review formed part. Thus, special thanks to Angel Daka, Mario Ruy Marques, Henry Mloza-Banda, Sylvester Mpanduji and Lawrence Nyagwambo. Your insights and those of your colleagues in our respective countries in the SADC region are yet going to be of immense value in the intensive period of implementation that we have to enter now to enable the poorest people in our region to achieve the Millenium Development Goals.

To MaTshepo Khumbane and the food insecure women of the Water for Food Movement, who take each other's hands to uphold and spread a message of hope and self-reliance among themselves and an ever-increasing number of poor households, villages and countries – thank you for your perseverance and your joy and laughter amid hardship. Please open our eyes, for we continue to grope in the dark. Speak to us, otherwise we the researchers, officials and politicians will continue to speak to each other, instead of to you.

I wish to thank my family for their support and tolerance of my regular absence.

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List of Abbreviations

AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
AU	African Union
CA	Conservation Agriculture
CF	Conservation Farming
DDPA	Desertification, Drought, Poverty and Agriculture Consortium
EQUINET	Regional Network for Equity in Health in Southern Africa
ESA	East and Southern Africa
EU	European Union
FAO	United Nations Food and Agriculture Organization
HIV	Human Immunity Virus
ICID	International Commission on Irrigation and Drainage
IMF	International Monetary Fund
IWMI	International Water Management Institute
MDG	Millennium Development Goals
NEPAD	New Plan for Africa's Development
NGO	Non-Governmental Organization
NIRESA	Network on Irrigation Research and Extension in South Africa
NISTADS	National Institute of Science, Technology and Development Studies
PVC	Poly-Vinyl Chloride (plastic)
RWH	Rainwater Harvesting
SADC	Southern African Development Community
SARIA	Southern African Regional Irrigation Association
SARPN	Southern African Regional Poverty Network
SMC	Smallholder Market Creation
SWC	Soil and Water Conservation
TK	Technologies and Knowledge
UK	United Kingdom
USAID	United States Agency for International Development
WfFM	Water for Food Movement
WTO	World Trade Organization

Introduction

Water for agriculture is increasingly recognized as a major constraint to improving the lives of the rural poor and is an important component of rural livelihood programs to be established in Southern Africa. The overall goal is to contribute to improving the lives of the rural poor through better and sustainable agricultural water technologies/ practices leading to increased agricultural productivity and incomes for small farmers in Southern Africa. FAO Investment Centre is designing a regional program on agricultural water management on behalf of SADC and the African Development Bank. This literature review is part of a project meant to provide inputs into this larger program.

Specifically, this project aims to identify suitable innovative agricultural water management techniques and approaches and determine the corresponding unit costs as a basis for agricultural water investment planning in the pilot SADC countries. This project is linked to a USAID-funded project, "An Inventory of Agricultural Water Technologies and Practices in Southern Africa and an Assessment of Poverty Impacts of Most Promising Technologies." The two are being implemented in a way that will ensure synergies between them.

Methodology and limitations of the study

This study does not intend to provide a comprehensive representation of all micro-AWM technologies used in SADC countries. Rather, it focuses on the most commonly promoted and/or most promising technologies.

This was a desk study, based on an internet search and literature provided by IWMI and several of its partner institutions, literature collected from contacts in the relevant countries, and country reports written by appointed consultants (partners) as a parallel activity to this study.

An internet search using as keywords the names of rainwater harvesting and conservation agriculture technologies in combination with the names of the SADC countries covered by the study, produced a surprisingly large number of documents (more than 2000 titles). Although the internet search was confined to published academic material obtained via Google Scholar and academic libraries, still much of the literature referred only anecdotally to the technologies and were thin on technical specifications, information on costs, and the details and extent of uptake of technologies.

This report is based on a selection from this large database of the most useful documents for the purposes of this study. The accompanying CD contains electronic copies of a selection of those original documents, but does not include those that are restricted by copyright. Further, an overview is provided of internet sites that contain documents on micro-AWM technologies (see section on 'Data Sources').

Important considerations in the design of support for micro-Agricultural Water Management technologies

'Micro-AWM technologies' – definition and role

Agricultural water management embraces a whole range of wider practices including *in situ* moisture conservation, water harvesting, rainwater harvesting, supplementary irrigation, irrigation, various techniques of wetland development such as treadle pumps, drip irrigation systems, sprinklers systems, etc.

In the literature, the term 'micro-irrigation' is sometimes used to refer to Agricultural Water Management (AWM) technologies. However, 'micro-irrigation' is traditionally an engineering term which referred to modern small-aperture micro sprayers and drippers used in sophisticated irrigation systems to improve application accuracy and water use efficiency. The Micro 2000 conference in Cape Town, South Africa (which also marked the 50^{th} anniversary of the International Commission on Irrigation and Drainage (ICID) and the launch of the Southern African Regional Irrigation Association (SARIA)) was significant in this regard. There was some debate on the need for a broader understanding of the term, to include all 'precision irrigation'. It was argued that the term should include methods such as short-furrow flood irrigation, where placement of the water is very accurate and water use efficiencies very high.

In recent years, the term has taken on an even broader meaning, largely as its use was adopted by a much wider range of disciplines working in the development field. It is now used regularly to refer to a wide range of production and water management approaches used on a small or micro scale by smallholder farmers and homestead food gardeners.

Even the term 'irrigation' has come to mean much more than conventional full-scale irrigation of crops to achieve top commercial yields. Instead, the focus is expanding to embrace a much broader range of production approaches and strategies for the management of water and soil fertility and even 'the animal factor', in pursuit of food security in the first place, and income generation as an important further step towards sustainable livelihoods.

> 'Newer production technologies and crop varieties, geared to suit small farmers and fit small plots, are a must for pulling the poor out of poverty through irrigation', according to Hussain et al. (2003).
>
> 'However, agricultural technology policy for the future will need to differentiate clearly between the needs of emerging commercial farmers, many of them engaged with global commodity chains and requiring support in managing information- and skill-intensive innovations, and the needs of a semi-subsistence and often part-time sector, requiring simple, often labour-saving, technology.' (Tripp, 2001)

The term '**micro-AWM technologies**' is used in this report to reflect the range of low-cost AWM technologies that are used on a micro-scale by rural households. The proper place for micro-AWM technologies is crystallizing from their potential immediate impact on rural households and specifically the target population for Millennium Development Goal 1: people living with hunger.

In SADC, micro-AWM technologies can help households to stabilize their staple production and produce the micro-nutrients (available in fresh vegetables and fruit) that are essential to turn the tide on the physical and mental underdevelopment in under-5s from malnutrition. Further, micro-AWM technologies are playing an increasingly important role in enabling households to produce for local and distant markets.

The attraction of micro-AWMs is in their potential to rapidly improve the ability of large numbers of poor people to better control their existing productive resources, thereby helping to reduce their vulnerability. This can be achieved without the need for the complex institutional arrangements without which irrigation schemes cannot function. They also do not suffer from the long lead times (often several decades) before irrigation schemes become fully productive (Chancellor, 2002) and are not associated with the major social disruptions typical of large developments.

However, despite its inherent characteristics which make micro-AWM more accessible to households living with hunger, the challenges in its adoption are not insignificant, especially in the context of the havoc being wreaked by HIV/AIDS:

> The need to develop new skills and purchase inputs if conservation agriculture is introduced reduces the possibility of its adoption by vulnerable households, whether impoverished by HIV/AIDS or for other reasons. Where communities are experiencing the impact of a mature epidemic the capacity for changing established farming systems might not equal the perceived need to do so unless a very substantial period of support is provided. Even if the challenges of investing labour, cash and other resources can be overcome, the risks are considerable. For these reasons, any attempting to introduce substantial changes to an agricultural system need to be accompanied by long-term technical support and adequate and carefully designed social safety nets. (Barnett & Grellier, 2003)

Barnett and Grellier found that the coping mechanisms employed by households trying to deal with the compounding effects of HIV/AIDS in an existing context of chronic hunger and vulnerability to climatic unpredictability, not only lead to delayed recovery times, but more and more lead irreversibly to destitution. Labour saving technologies and farm power are important components in a wider strategy needed to cope with HIV/AIDS, but need assistance to enable their adoption.

In SADC, the time has come for the mainstreaming of micro-AWM technologies, as opposed to the tendency to date to argue their validity as an 'additional strategy' and thus effectively a stepchild to what is still widely perceived as 'real development', notably irrigation schemes. For instance, in at least one case in South Africa this stepchild status has resulted in the shifting of budget allocated to micro-AWM technologies (targeted at more than 50 000 livestock, dryland and homestead producers) to enable the purchasing of more sophisticated irrigation systems on existing irrigation schemes (targeting about 12 000 irrigating households).

It is also necessary to understand how the promotion of micro-AWM technologies needs to fit into a larger array of interventions and structural changes in the fight against poverty.

> "Interventions are needed to build a multi-disciplinary and integrated response to food security and nutrition, with a focus on fair trade, gender inequalities and community control over productive resources. In other words, these interventions need to ensure food sovereignty[1]." (Chopra, 2004)

Differences between Asian and African circumstances, differences between the West, East and Southern African subregions, and differences between and within countries within the SADC subregion, became apparent from the review of literature. Among the range of 'micro-AWM technologies' some seem to sometimes 'self-select the poor', as borne out by reports on treadle pump adoption studies in Bangladesh (Shah, 2000) and Malawi (Mangisoni, 2006), whereas the International Water Management's (IWMI) review of KickStart and Enterprise Works shows the opposite (Van Koppen et al, 2005). Similarly, uptake of drip irrigation in Gujarat and Maharashtra was reported to be almost exclusively the domain of 'the rich and the very rich', but was successfully targeted to the very poor in Nepal (Namara, 2005; Shah and Keller, 2002).

These issues are critical as we pursue the MDGs. As shown below, all evidence points to the fact that it is probably impossible to halve the number of people living with hunger in SADC by 2015. However, we will be even less effective in the fight against poverty if we fail to target our interventions to truly benefit the poorest of the poor – instead of just touching the 'cream of the poor'.

The compelling need to target 'households living with hunger'

> "Poverty is complex, multidimensional, and is the result of myriad interactions between resources, technologies, institutions, strategies, and actions. The multidimensional character of poverty has been reflected in a wide array of papers, poverty reduction strategies, and policies. Although *water provides only a single element in the poverty equation, it plays a disproportionately powerful role through its wide impact* on such factors as food production, hygiene, sanitation and health, vulnerability/food security, and the environment. Indeed, development agencies, groups, and experts worldwide are increasingly recognizing the important role that water can have on poverty." (Hussein et al., 2003, our emphasis).

This literature study recognizes the multi-dimensional nature of poverty, but specifically considers the effect of absolute poverty and food insecurity in the context of countries of the Southern African Development Community (SADC).

> "Nutritional status is the best global indicator of well-being in children." (De Onis, et al. 2000)

It is no accident that 'prevalence of under 5 malnutrition' is used as a key indicator when we measure progress towards Millennium Development Goal 1: Eradicate Extreme Poverty and Hunger. (African Development Bank, 2002). It is well accepted that the well-being of children is fundamental in the fight against poverty.

> "Studies have indicated that malnutrition contributes to a significant reduction in lifetime earnings. Long-standing malnutrition, especially during the pre-school age is likely to result in irreversible damages to the child's intellectual development… Thus, the repercussions of socio-economic inequalities in child nutritional status are likely to be self-perpetuating." (Zere and McIntyre, 2003)

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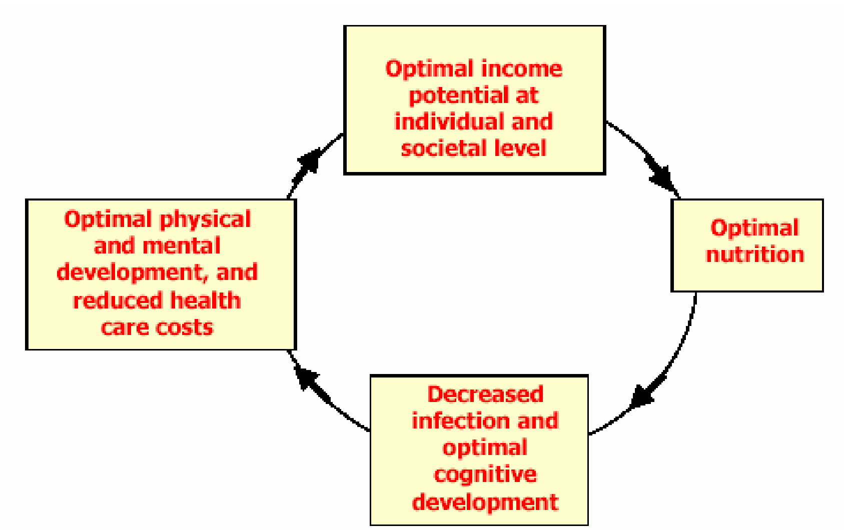
[1] Food sovereignty is emerging from the literature as a major new trend in thinking in developing countries' response to vulnerability. It is discussed in more detail in the next section because of its important implications for the role of micro-AWM technologies.

Several writers discuss the scope and depth of hunger and poverty in Sub-Saharan Africa. Disturbingly, in the midst of the world's commitment to the MDGs, in Southern Africa, the trends are in fact worsening.

> The world's most severely malnourished people are growing in number: from 826 million in 1995-97 to 852 million in 2000-02. Three-quarters of these people live in rural areas; most are farmers. Of this vast global number, 204 million live in sub-Saharan Africa, where they account for one-third of the population. Here life expectancy has been falling for 20 years; farmers make up two-thirds of the workforce. There are 110 million more of them than there were at the end of the 1960s. (Berthelot, 2005)
>
> "Levels of poverty, hunger and undernutrition are worsening in East and Southern Africa (ESA), even though they are improving in almost every other region. This undermines the achievement of UN Millennium Development Goals in this region. Instead of the potential virtuous cycle that could be created between improved nutrition and improved economic wellbeing, ESA is currently caught in a vicious cycle of worsening poverty, hunger and undernutrition. This exaggerates inequalities in income and health, and increases the vulnerability of the poor." (Chopra, 2004)

Figure 1: The virtuous cycle of improved nutrition and economic well-being (from Chopra, 2004)



In a study examining all available large-scale nutritional survey data over the last ten years in the SADC countries of Lesotho, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe, IFPRI found that the slow national trend for improvement in nutrition in the 1990s ceased by the end of that decade.

> "The latest data from Zimbabwe and Zambia show deterioration in 2001–2003. The levels of malnutrition remained shockingly high in Malawi and Mozambique with more than 30% of children exhibiting stunted growth. Overall, 2.3 million children are underweight in the six countries (Figure 2). Importantly, these national figures hide important sub-national variations with some districts showing distinct improvements whilst others have deteriorated sharply." (Chopra, 2004)

The African Union has just released its report on the status of food security in Africa (AU, 2006), which highlights the continuing vulnerability of poor households in the region.

Status of food security and prospects for agricultural development in Africa.

Extracts for Southern Africa from a report from the AU Ministerial Conference of Ministers of Agriculture, February 2006.

Malawi

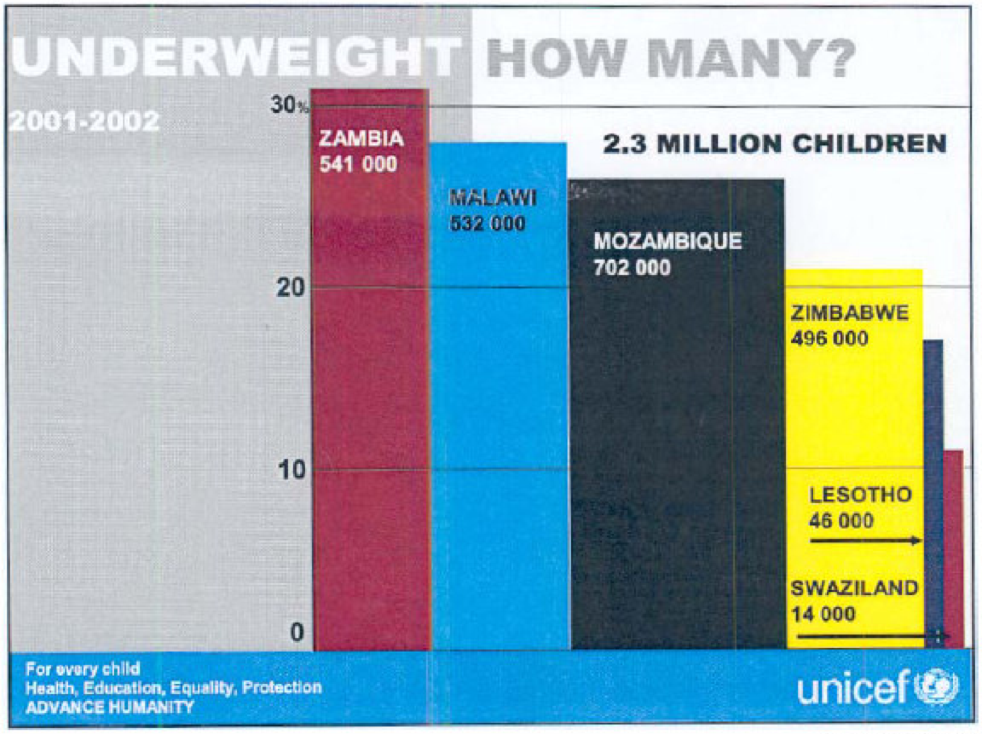
According to the Malawi Vulnerability Assessment Committee (MVAC) assessment conducted in May 2005, between 4.2 million and 4.6 million people would be food insecure between April 2005 and March 2006 and require between 272,000 MT to 423,000 MT of food aid or its cash equivalent. According to the recent MVAC revised needs estimate, the number of people at risk has risen to about 4.9 million, with missing food entitlements of 280,400 MT for the whole year (April 2005 to March 2006). The government has intervened through food aid and/or other market-based interventions and both interventions have been applied. The food aid interventions coordinated by WFP and the DFID voucher system started around June 2005. Although adequate resources have been pledged to address increased food aid needs and commercial requirements, of particular concern is the slow and intermittent rate maize inflows into the country, commodity flows have been delayed by transportation capacity limitation and logistical problems. There is need to address current bottle necks and logistical issues to avoid further deterioration of the situation.

During 25 to 31 December 2005, heavy rainfall in the southern highlands of Thyolo and Mulanje, as well as the surrounding hills overlooking Chikwawa and Nsanje districts, caused massive flooding. In Nsanje District, the Ruo River burst its banks and flooded areas around Makhanga and the outskirts of Bangula town. Roads in some areas have been washed away or are covered by water, leaving some communities only accessible by boat. Bridges and culverts have also been affected. The damage caused by the flooding has been enormous with crops, houses and livestock critically affected.

Zimbabwe

The levels of food insecurity continue to worsen for both urban and rural populations, due to the reduced availability of staple cereals and the ever rising cost of living. Household food stocks were running low during the hunger season (September- January) and more people were being forced to look for maize and maize meal on the market. While tremendous effort is being made by the government to import food into the country to cover the production gap, officially estimated at about 1.2 million MT of maize, in-country grain distribution problems arising from shortages of fuel and trucks are restricting the amount of grain available on the market, particularly in the remote parts of the country. At current importation rates, the government will manage to import about 80 percent of its targeted maize imports of 1.2 million MT (AU, 2006)

Figure 2: Underweight children in Southern Africa



(Source: UNICEF 2003a)

Even in South Africa, the economic giant of the SADC subregion, chronic hunger, malnutrition and stunting have not been beaten. Almost a quarter of all children in South Africa are stunted (low height-for-age) due to malnutrition, which has been shown conclusively to be related to poverty, which seems to be on the increase.

> "The relationship between socio-economic status and illness and death is observed to be inverse, with morbidity and mortality concentrated in those at the lowest end of the socio-economic scale." (Zere and McIntyre, 2003)

> "Analysis of the results in the 1999 October Household Survey and the 2002 Labour Force Survey suggests that the number of people in the bottom two expenditure classes increased by about 4,2 million over the period." (Meth and Dias, 2004)

International media coverage of famine and starvation in Malawi in this 2005/06 growing season is reminding the world of the unpredictability and unreliability of rainfall in this part of the world. Mid-season dry spells have again turned a promising crop and weeks of back-breaking labor into a humanitarian crisis of devastating proportions. But most often it is not only nature that is to blame for famine:

> "In 2000 the International Monetary Fund (IMF) advised the Malawian national food reserve agency to reduce its near-full capacity stocks to around 30,000–60,000 metric tonnes of maize, enough to feed the entire Malawian population for two to three months, and to use the proceeds to pay back its debts, to pay salaries to cover running costs and to replenish old maize. This proved to be very costly, as Malawi was unable to import enough grain from the international market to prevent widespread hunger the following season." (Lambrechts and Barry, 2003, quoted in Chopra, 2004).

For poor people in the SADC subregion, hunger is enemy number one. Facing famine, people over the world even tolerate hunger in an attempt to safeguard their future livelihoods:

> …"people are prepared to put up with considerable degrees of hunger, in order to preserve seed for planting, cultivate their own fields or avoid having to sell an animal" (De Waal quoted in Chopra, 2004 from Devereux and Maxwell, 2001).

The vulnerability of households to seasonal hunger has been the subject of many anthropological studies. Ellen Messer (1989) examined the literature and found that in contradiction to Miracle's (1961) denial of the existence of seasonal hunger in Africa, anthropological observations have consistently documented periodic food shortages there as well as in other parts of the world. According to Messer (1989) and Barnett & Grellier, (2003), populations attempting to subsist on the production of a single post-rainy season harvest have rarely covered their annual nutritional needs. Moreover, such populations have lacked slack-season sources of income sufficient to purchase adequate supplies of food. Note that Messer's findings were prior to the onslaught of HIV/AIDS, which has exacerbated the situation for rural families beyond anything that the world has ever experienced or has the capacity to understand as yet.

While the world is promising to commit to the achievement of the Millennium Development Goals in ten short years – including reducing by half the number of people living with hunger – the scales in the fight against this age-old foe is clearly tipping for the worse. The effects of HIV/AIDS is yet further crippling the ability of vulnerable households to win this war.

> "The insidious role that HIV and AIDS is playing in undermining development in the region is shown by comparing the recent droughts to the earlier droughts in 1991–92. The 1991–92 drought was far more severe and yet… far fewer deaths from starvation were reported. Through its devastating impact on economically active members of society the epidemic is eroding the capacity of many communities to cope with the usual challenges that poverty brings." (Chopra, 2004)

Table 1: Millenium Development Goal 1 - status in selected Sub-Saharan African countries

GOAL 1: ERADICATE EXTREME POVERTY AND HUNGER Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger					
Country	Total population in millions (2001)	Population living below US$1 a day (%) (1990-2000)	Total population living below US$1 a day in millions (2001)[a]	Undernourished people (as % of population) (1998-2000)	Total number of undernourished people in millions (2002)[b]
Angola	12.80	n/a	n/a	50.0	6.4
Botswana	1.70	23.5	0.39	25.0	0.42
DRC	49.80	n/a	n/a	73.0	36.35
Lesotho	1.80	43.1	0.78	26.0	0.47
Madagascar*	16.40	49.1	8.05	40.0	6.56
Malawi	11.60	41.7	4.83	33.0	3.82
Mauritius	1.20	n/a	n/a	5.0	0.06
Mozambique	18.20	37.9	6.89	55.0	10.01
Namibia	1.90	34.9	0.66	9.0	0.17
South Africa	44.40	<2.0	<0.88	n/a	n/a
Swaziland	1.10	n/a	n/a	12.0	0.13
Tanzania	35.60	19.9	7.08	47.0	16.73
Zambia	10.60	63.7	6.75	50.0	5.3
Zimbabwe	12.80	36.0	4.6	38.0	4.86
Developing country average	4,863.80	n/a	n/a	18.0	875.48
Sub-Saharan Africa average	626.40	n/a	n/a	33.0	206.71

[a] Calculated by using the total population in millions and the percentage of the population living below US$1 a day
[b] Calculated by using the total population in millions and the percentage of the undernourished population
n/a Not available
Source: Human Development Report, 2003
*Madagascar is not yet a member of SADC, but may be admitted in 2005.

In this context of dire need, the world has given itself an unambiguous mandate to focus attention on the poorest of the poor. Therefore, in this study we have sought to understand how the many promising micro-AWM technologies and interventions reported on in the literature might impact the most vulnerable households – those who are food insecure, living with HIV/AIDS, aged or underage, child headed households, poor men, women and children.

SADC cannot afford repetitions of discredited approaches, which gobble up large amounts of investment, but fail to impact positively on the majority of its rural population. We cannot afford to again hear that…

> "..the appointed farmers already belonged to a group of relatively wealthy peasants and …the scheme did not lead to an overall expansion among other peasants." (Green, date unknown)

Barnett & Grellier (2003) quote the following as examples of project conditions or requirements that have tended to exclude the poorest households from participating:

Example

Assets typically required for project participation in Uganda, Tanzania, Malawi and Zambia:

- ***Zero grazing:*** *access to grass and other fodder or land on which to grow elephant grass before the arrival of livestock; labour to cut grass; shelter and fencing for livestock; access to water.*
- ***Conservation agriculture:*** *access to land, access to labour, cash or credit for pesticides, equipment etc.*
- ***Irrigation****: access to land, access to water, access to irrigation equipment e.g. treadle pumps, drip irrigation system, time for management and maintenance*
- ***Micro-credit:*** *access to approx. $0.5 per week, access to savings groups*

T here are exciting stories of smallholder farmers across the region who are now achieving improved production and market access, but we have scrutinized those reports to see – *do*, and if not, then at least, *could* the hungry also benefit from this? If we don't ask this question rigorously – and act on it right now – then what hope do we have of achieving the MDGs by 2015?

Agricultural Water Management Technologies: issues arising

Who is adopting low-cost technologies?

> "There should be evidence of a process of targeting to ensure that this grant would contribute to the achievement of the MDGs." (DWAF, 2004)

This quote from the South African government's subsidy for homestead rainwater systems for productive uses by the poor, recognizes the universal challenge involved in reaching and mobilizing the most needy. Across the region and elsewhere in the world, there is agreement on the potential role of low-cost technologies for uptake by the poorest households, but is this in fact what is happening?

Literature on Asian experiences differ somewhat on this question. In Gujarat it was observed that the largest proportion of micro-irrigation adopters belongs to the relatively very rich group of farmers. This was especially so in Maharashtra. In Gujarat the situation was a bit milder, i.e., the adoption was not confined to the richest group but extended to the middle and rich farmers.

> "However, in both locations, the poor and the poorest sections of the farming population had not benefited much from innovations in micro irrigation technology." (Namara, 2005)

They also found that farmers with higher status, education and off-farm income were more likely to adopt micro irrigation technologies. However, in an earlier study covering several South Asian countries, it was found that farmers who were primarily dependent on agriculture-based occupations (and thus presumably less dependent on off-farm income) were more willing to adopt, try or improve innovations (IWMI, 2003).

> It is generally true to say that in Africa or in Asia, as in Europe and North America, it is the wealthy who innovate and adopt most rapidly and the poorest who innovate and adopt least readily.
>
> However, there is one important qualification to this statement. While the poor do not readily innovate and adopt new technologies at the cutting edge of production activities because they are

> inevitably risk averse given their limited margin for experimentation, they do in fact innovate and adopt in many other respects. The poor are *bricoleurs*: they make do and mend, they must have an eye for the opportunities offered by their material and social environment. They innovate through force of circumstances. (Barnett & Grellier, 2003)

In Malawi, a convincing case is made of the pro-poor nature of low-cost technologies. Mangisoni (2006) showed the impact of treadle pumps on households' movement in and out of poverty from 2004 to 2005 in two regions in Malawi. In Mchinji, 79.5% of the adopters were food insecure prior to their adoption of treadle pumps. Significantly, 73.5% of the adopters of treadle pumps were able to become non-poor (in terms of consumption poverty), leaving only 6% of all adopters still with food shortfalls. No non-poor adopters slipped into poverty in this period. However, among non-adopters, the story was quite different. None were able to get out of poverty, while 27% non-adopters who were previously food secure, actually dropped into consumption poverty in the same period.

The Water for Food Movement in South Africa and Lesotho argue that conventional 'trickle-down' approaches to technology transfer tend to be ineffective in reaching and mobilizing the poor, and may even create blockages to uptake by the poor. Many poor people automatically assume that the successes of 'early adopters' are achievable only by well-to-do people, whereas successes achieved by the poorest are perceived to be achievable by all. Water for Food Movement believes that technologies which are tried, tested and adopted by the poorest households first, are more likely to get adapted to work within their means and circumstances. This, together with the perception of achievability, increases their potential for rapid uptake among other poor households.

Adaptation for adoption – the critical importance of farmer creativity

Based on more than 40 years of leadership and experience in mobilizing rural households for food security, MaTshepo Khumbane, chairperson of the Water for Food Movement in Lesotho and South Africa insists on the importance of individuals' own creativity and experimentation as the very foundation of the pathway out of poverty.

Without farmers' own creativity in experimenting, adapting and making a technology their own, the entire innovation/adoption initiative is quite meaningless. The literature supports the importance of innovation and farmer engagement with technology as a basis for adoption and reduced dis-adoption:

> "The central lesson is that this cluster of actors and their mutual dependencies ***enable continuous innovation*** in pomegranate production and marketing" (Raina, date unknown).

In the stakeholder meetings of the Desertification, Drought, Poverty and Agriculture Consortium (DDPA) (see Winslow *et al*, 2004) it emerged that "an integrated ecosystem approach to building livelihoods and saving lands as needed for combating desertification and drought must be a knowledge-intensive venture. Local participation in understanding the problems related to desertification and drought and in devising solutions is essential for impact. The peoples living in desertification-prone areas hold local technology and knowledge (TK) resources that are critical in the search for solutions. Traditional TK interacting with contemporary TK can help partners think 'outside the box' to come up with new practices that are appropriate to their conditions." None of this can happen without the creativity of the farmers themselves.

Importance of *approach* to technology development and dissemination

> "One thing seems clear from the lessons of the past: the approach to technology development and

dissemination is as important, if not more so, than the technologies themselves." (Winslow *et al*, 2004)

This belief is echoed by many authors (refer to those quoted below as examples), with numerous examples of failed attempts at technology development and transfer which turned into triumph when farmers were brought into the very center of the decision-making process. It is recognized that it is not easy to place poor people in the driver's seat, but it is clear that unless we step back and let this happen, our very best efforts are doomed to fail.

> Communities must be able to exchange views with governments, and agriculturalists must listen to and learn from ecologists, for example – particularly in the course of a participatory, holistic initiative like this one. Technical factors are only one part of the challenge, of course, but revolutionary new approaches are now possible that could create breakthroughs in this area. (Winslow *et al*, 2004)

Several authors (see below) now report on innovative approaches to achieve 'bottom-up' development and adoption of technologies, such as those mentioned below:

The DDPA attempts to combine the best of earlier approaches (e.g., participatory methods, attention to indigenous knowledge, integration of the institutional and policy dimension) with a holistic integrated ecosystems approach that:

- Investigates the occurrence, causes and effects of land degradation (rather than proceeding on general assumptions that may not apply in many particular circumstances);
- Views agriculture and agricultural production within the context of total ecosystems goods and services (rather than as a separate world);
- Considers technologies and peoples' actions within an institutional and policy context (rather than solely as a technical matter);
- Looks at genetic resources within the context of their on-farm use (rather than transferring models developed under very different conditions in other areas of the world);
- Looks at agricultural solutions as just one component of livelihood diversification strategies (rather than taking a purely sectoral perspective); and
- Recognizes knowledge and knowledge exchange as central resources in finding solutions (rather than just as a way to transfer new technologies to the farm).

Delve and Roothaert (2004) have experimented with an approach they call the 'resource-to-consumption (R-to-C) concept', which extends the commodity chain to include investment in natural resource management (NRM) and links NRM to market opportunities. Their approach links farmer participatory research, market opportunity identification, and development of technologies for integrated soil and nutrient management, with a focus on women and the poor.

Bellon *et al* (1999) reports on how they have successfully engaged farmers to use their own (farmers') taxonomies as a participatory diagnostic tool to jointly develop improved soil fertility management.

Nyagumbo (1999) reports that he found that "cook-book recommendations and solutions were being resented farmers with only certain aspects of recommended technologies being taken up. Farmers were subsequently exposed to various technological options which they could experiment on and implement according to their own resource endowments and preferences. Due to the success of this approach farmers embarked on various innovations which they tried to test on their own."

Empoverished communities are getting less tolerant of being 'talked about, but not spoken to'. In a non-agricultural context, the shack dwellers' movement says this in no uncertain terms:

> I must warn those comrades, government officials, politicians and intellectuals… they are too high to really feel what we feel. They always want to talk for us and about us but they must allow us to talk about our lives and our struggles. For us the most important struggle is to be recognised as human beings. We are on our own. We are completely on our own.
>
> Most of us are not working and have to spend all day struggling for small money. Our bodies itch every day because of the insects. If it is raining everything is wet - blankets and floors. If it is hot the mosquitoes and flies are always there. There is no holiday in the shacks. When the evening comes - it is always a challenge. The night is supposed to be for relaxing and getting rest. But it doesn't happen like that in the *jondolos*. People stay awake worrying about their lives. You must see how big the rats are that will run across the small babies in the night. You must see how people have to sleep under the bridges when it rains because their floors are so wet. Some people just stand up all night.
>
> We have learnt from our experience that when you want to achieve what you want, when you want to achieve what is legitimate by peaceful negotiations, by humbleness, by respecting those in authority, your plea becomes criminal. (Zikode, 2005)

The 'staircase' approach in Uganda has been successful in counteracting the exclusion of households of the poorest households by enabling flexible entry into and movement up and down the 'staircase of activity options'. Instead of insisting on a minimum level of assets to gain entry to the support programme, people's skills or other non-material contributions could also enable them to be recognized and respected. They could maintain their participation in their choice out of a range of activities, depending on their changing circumstances. The programme started off with sufficient training and interaction to ensure that everyone had a shared understanding of the overall goals and conflict resolution strategies. (Barnett & Grellier, 2003)

The Lesotho villages engaging in Water for Food Movement activities have successfully engaged their political leadership – not to obtain funds or material support, but to gain recognition and appreciation for their own efforts towards food security.

> We are the food insecure, therefore we, not you, are the only ones who can achieve the MDGs. Do not dictate to us, and do not give us money in a way that disturbs our unity and makes us fight among each other. Just recognise what we are doing, and support our cause. (Adapted from the Water for Food Movement Charter, 2005).

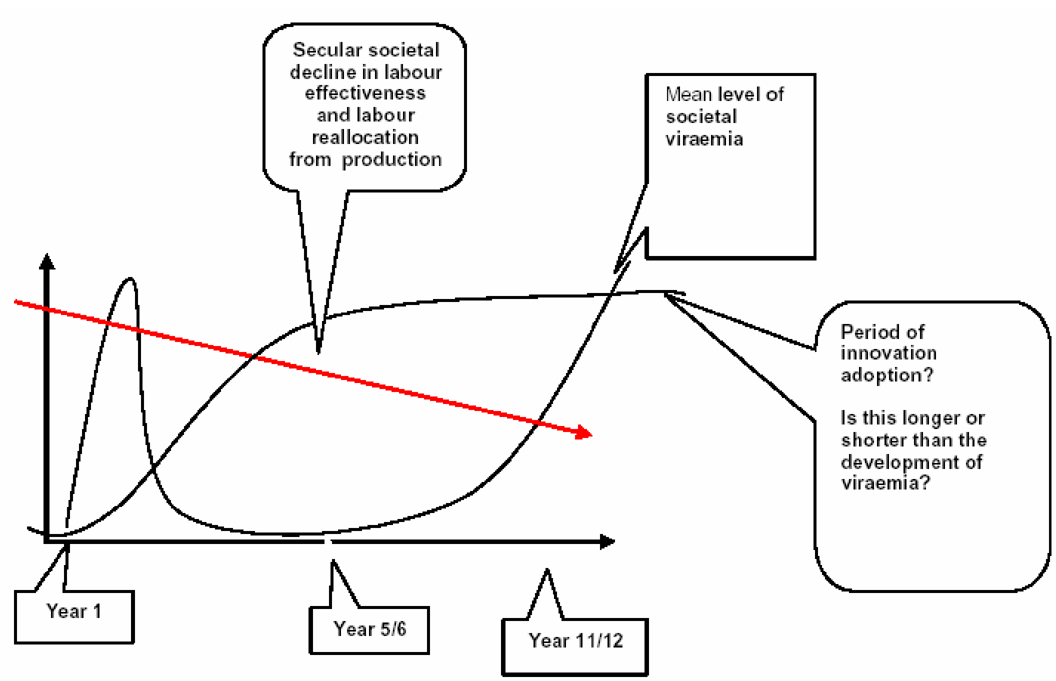
The required pace of adoption

The adoption challenge is major and complex. Participatory approaches are often viewed as being slower, but, as discussed above, essential to enable sustainable uptake. The Lesotho experience is challenging the belief that participatory processes are necessarily slow, as uptake of rainwater harvesting spread within three months across four villages when it was promoted through the social mobilization strategies of the Water for Food Movement (WfFM, 2006). Many other examples show a slow initial start and then rapid dissemination when sensible ideas take root and conditions are right. This is what Shah (2002) calls 'wildfire development', and must be what every development practitioner hopes to experience in their lifetime.

The effects of HIV/AIDS places tremendous urgency on the required pace of adoption.

> In rural communities where households have been launched into poverty or destitution by death and illness and where seasonality is a major factor, the pace of adoption is critical. It probably cannot go beyond one season; people do not have the resources to endure for longer than that. (Barnett & Grellier, 2003)

Figure 3: Adoption, disease progress and effective labour availability (Barnett & Grellier, 2003)



The required pace for adoption is influenced by the development of HIV into full-blown AIDS. Improved nutrition is essential to provide infected individuals with the necessary resilience against opportunistic diseases, but may come too late if the pace of adoption is slower than the development of the disease. Anti-Retroviral (ARV) treatment is viewed by Barnett and Grellier (2003) as an essential 'labour saving technology' in the sense that it literally enables longer retention of labour capacity of infected individuals.

Lack of proper cost and impact assessments

In her Ph.D. thesis (Taylor 1998), Jennifer Taylor studied project documentation of eleven key governmental and non-governmental international agricultural development organizations and found that very little is being documented on actual impacts, and argued that this could have very negative consequences for development agencies efforts to address poverty and food insecurity in developing countries.

> "Of the study's 51 projects, only six reported on the level of participation by small-scale, resource poor farmers. Seven projects reported numerical data on before and after rate of adoption of the technology. Sixteen of the 51 projects reported numerical data on sustainable benefits of the project to the small-scale, resource poor farmer. Only one document reported data on both the adoption of technology and

sustainable benefits to the small-scale, resource poor farmer.

> The results of this study suggested that the impending need for improved global food production as we move into the 21st century through the more than one million small-scale, resource poor farmer participants within the projects of this study may not be met due to the low amount of evidence in the implemented project reports of adoption of the technology, and the inadequate reporting of benefits essential to the small-scale, resource poor farmer" (Taylor, 1998).

This lack of proper documentation may well be hindering the dissemination of AWM technologies today. Despite much debate among researchers and development agencies about AWM technologies, their importance goes unnoticed. For example, while a large body of evidence argues the value of treadle pumps and other AWM technologies in the fight against hunger in Malawi, a January 2006 article in the SA Irrigation magazine runs an article titled 'Major boost for Malawi irrigation" (World Bank approval of a $40m grant in support of Malawi's strategy for sustainable economic growth) without a single mention of treadle pumps, drip kits, minimum tillage and other AWM technologies.

Similarly, the photograph on the World Bank's report on 'Agriculture and Achieving the MDGs' shows a large commercial grainfield with heavy equipment! (World Bank, IFPRI, date unknown)

Do we understand? Or are we repeating the mistakes of the past?

> One wonders what the chances of success will be this time... People seem to have short memories or unfounded confidence that they will succeed where others have failed. (Laker, 2006)

> "*Just because we do not always understand* the economic and social factors determining incentive effects does not mean they do not exist". (Barbier and Burgess, 1992)

Even a cursory scan of the literature on agriculture and development in Africa leaves one humbled and with a grave sense of the responsibility resting on the shoulders of decision-makers today. While the world is gearing up for the challenge of achieving the Millennium Development Goals in the next decade, the past is telling us that many of our 'new ideas' have already been discredited by earlier generations in their repeated attempts at fighting poverty and underdevelopment.

> "The Master Farmers' Scheme of 1951 was the most ambitious rural development program ever developed in colonial Malawi. …it was comprehensive, including education, subsidies, and marketing, and aimed at redirecting peasant production. The aim was to create a class of yeoman farmers who would act as role models for other farmers. It was the first experiment of working with individual farmers instead of communities. The scheme lasted for twelve years only …the structural constraints that, from the very beginning, prevented the scheme from being a success in terms of sustainability and expansion, …were not an outcome of state involvement as such but depended on the colonial *government's shallow knowledge of the logic of peasant economies*." (paraphrased from Green, date unknown)

The Millennium Development Goals are about fighting poverty, hunger and death. But are we listening to the poor, the hungry and the dying? Do we fare any better than the 1950s colonial governments in understanding the logic of what poor people are doing in their attempts to survive?

Do we know: where are the poor, how are they surviving and what are the constraints – from their perspective – to the improvement of their ability to survive? Do we understand, and are we creating opportunities in response to the differences in their aspirations, circumstances and abilities? Do our development programs recognize that some things cannot change overnight, and that in this Millennium Decade, the majority of those very people targeted by the MDGs will not become market-driven entrepreneurs? Do we take notice and understand what is happening when poor rural women walk out on an address by a leading politician urging them to 'go business'? Can these same women and others like them say to us, as politicians, government officials, development workers, researchers, bankers and donors: 'You are talking to each other, you are not talking to us'.

Do we recognize that more than 90% of the hungry households in SADC will still be without access to a plot on an irrigation scheme by 2015, no matter how hard we work on the development of irrigation schemes in the next ten years? Do we face the fact that our very best efforts cannot provide enough people with access to markets, credit and business skills in the next ten years to turn the tide on hunger? Are we honest enough to admit that current trends in unemployment are not pointing to broad-based escape from poverty in SADC?

There seem to be two major lines of thought in the thinking on how to approach agricultural development in SADC:

- On the one hand, there are the proponents of modern market-based development and economic growth from which spin-off effects are hoped to bring relief to the poor majority; and
- On the other hand, those who believe that these spin-offs and trickle-down effects can never hope to reach a significant number of people to achieve the MDGs by 2015. Those who believe that alternative and parallel strategies are necessary to address the plight of the poorest sectors of society more directly.

In both Lesotho and South Africa's irrigation policies, a combination of the market-based and poverty-focused approaches are advocated (Lesotho country report, 2006; Government of South Africa, 2003). In practice, however, the bulk of both governments' spending is on irrigation schemes aimed at market-based production. There is much less spending in support of improved dryland production (which is practiced by the majority of smallholder farmers) and on the promotion of small micro-AWM technologies.

The course of events in wider processes warrants examination. In the early drafts of the planning documents for NEPAD implementation, almost the entire proposed budget for agricultural development was earmarked for the development of irrigation schemes (unpublished). A regional workshop in Lilongwe, Malawi, organized by AU and EU and attended by most SSA countries, used Malawi's and other countries' experiences to argue strongly in favor of smaller micro-AWM technologies. Although the bulk of the CAADP budget is still aimed at irrigation scheme development, there was indeed some shift towards micro-AWM technologies targeted at independent smallholder farming households. However, when it comes to practical implementation, will we see the same thing happen as in Lesotho and South Africa, with cases of expenditure shifting from micro-AWM to irrigation schemes?

It is a harsh reality that when the pressure is on, politicians and development agencies revert to familiar spending patterns. For instance, in South Africa's major programme on the Revitalisation of Smallholder Irrigation Schemes (RESIS), the R1.08bn ($181m) included R344m ($57m) for micro-AWM technologies in support of the large majority of farmers surrounding, but without access to a plot on the formal irrigation schemes[2]. Further, R224m ($37m) was earmarked for farmer capacity building and training (IPSP, 2004). However, when the pressure increased on politicians and bureaucrats to spend large budgets in short timeframes, the following happened (derived from RESIS project documents, 2005):

- Funds earmarked for micro-AWM were reallocated to scheme infrastructure, particularly highly sophisticated modern in-field irrigation equipment;
- Farmer capacity building and training efforts were abandoned;
- Institutional development, namely the establishment and capacity building of farmer organizations for participatory irrigation management on the schemes were abandoned; and
- Expenditure focused exclusively on large-scale infrastructure development (bulk water supply and in-field irrigation systems) through commercial contractors, with minimal opportunity for effective participation and decision-making by farmers.

Table 2: RESIS budget prior to abandonment of micro-AWM components

RESIS Financial Summary of Activities

Activity	**Description**	**Total (R)**
Facilitation	Scheme revitalization facilitation	80,016,000
Training	Scheme & water management, crop and entrepreneurship training	41,022,000
Aftercare	Aftercare on training	61,533,000
WUAs/institutions	Facilitation and legal establishment of WUAs	41,022,000
Water supply	Bulk water infrastructure	236,760,000
Infield irrigation	Infield irrigation equipment	98,650,000
Access roads	4 km road per village	184,250,000
Rainwater harvesting	100 tanks per village	92,125,000
Stock dam & watering system	1 dam or system per village	36,850,000
Dip tanks	1 tank per village	4,606,000
Dryland	Support for 100 hectare per village	210,045,000
	Total for Planning Budget	**1,086,880,000**

From: IPSP, 2005. Micro-AWM technologies are highlighted.

In a context where rapid expenditure is required to retain political and donor support for initiatives, while procurement and implementation capacities remain cumbersome and ineffective, attempts to promote micro-AWM are indeed vulnerable.

[2] Less than 5% of the rural population in the former homelands have access to a plot on an irrigation scheme, while 70% have access to dryland fields, and all residents can produce on their homestead yards (LDA, 2002).

Positive lessons can be drawn from successes with major implementation of sanitation programs in South Africa's KwaZulu-Natal province from 2002. With a novel approach to streamline the delivery of large numbers of small infrastructure units (VIP toilets) to remote rural households, Makhetha Development Consultants were able to achieve 60% of South Africa's total sanitation achievement for that year, even though they were only one of many implementers nationally, and working in only one province (Makhetha, 2002). These lessons are drawn on now in the pilot implementation of underground rainwater harvesting tanks for food insecure households in South Africa (DWAF, 2005).

There remains a grave danger that political pressure to accelerate implementation, even of highly appropriate micro-AWM technologies, will fail to allow enough time for adopters to experiment with technologies[3] sufficiently to successfully incorporate them into their production and daily household processes.

There are many indications that the current generation of development leaders may repeat the mistakes of the past. This is discussed in more detail in the next section, but it is clear that we need to be much more diligent about getting in touch with the realities faced by people living with hunger:

> …pathways through which HIV/AIDS may affect entire farming systems and human nutrition... may go unnoticed and unreported. Those whom these affect have little influence; and government and agencies lack the perspective to track events of this sort.
>
> It is of greatest importance that governments, multilateral and bilateral agencies take seriously the need to monitor farming system changes as a result of HIV/AIDS. This is necessary if one of the long-term effects of the epidemic is not to be a steady reduction of rural communities' ability to provision themselves – a process already far advanced in parts of Southern Africa. (adapted from Barnett & Grellier, 2003)

Markets, credit, exports and the hungry: The need for food sovereignty

The exemplary work done by various governments and NGOs in opening up markets for smallholder farmers, particularly coupled to treadle pumps and bucket and drum drip kits, should be expanded rapidly. Further attention is necessary in creating marketing networks and reducing farmers' vulnerability to market fluctuations. But markets, credit and exports cannot be seen as the 'answer for Africa'.

> Replacing cash- or food-crops with high labour requirements by starchy root crops is a widely reported survival strategy (of poor households) in the face of labour and time constraints (which are exacerbated by the effects of HIV/AIDS). (Barnett & Grellier, 2003)

There is no doubt that Africa desperately needs better markets and credit systems, and that these need to be pursued with vigor. But, we need to understand that the bulk of the MDG target population simply do not have the frame of mind or physical strength to grab such opportunities as described by Hatibu *et al.* (2004):

> "…high returns of 10 - 200 US$ per person day were obtained when rainwater harvesting was applied to vegetable enterprises. It is concluded that for RWH to contribute to improved incomes and food security,

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[3] The critical role of experimentation and creativity as a pre-condition to successful adoption is argued elsewhere in this document.

> smallholder farmers should be assisted to change from subsistent to commercial objectives with marketing-oriented production of high value crops combined with processing into value-added products. This will require farmers to participate in food markets and thus increasingly depend on the market for food security as opposed to emphasizing self-sufficiency at household level".

When we are targeting the hungry and the destitute to help them arrive at the MDGs, we have already seen that it is fundamentally important that we know who we are working with. Do we understand the mind processes of a person chronically concerned about food security and physically weakened by the lack of it?

> …it is likely that uncertainties about the rains *and the functioning of markets* are more prominent disincentives (for agricultural effort).
>
> Other interference with production for home consumption includes commercial crops and low prices of food crops. Again, the shift of land and labor in all parts of the world from subsistence to cash crops has been mentioned as further reducing home food production. In some African examples, *cash crops are specifically implicated in shortages of food for home consumption and seasonal hunger*. These studies suggest that food purchased with cotton or groundnut earnings does not compensate for food forgone in the shift away from home staples. (Messer, 1989)

Haswell (quoted in Messer 1989) observed how the rich were further impoverishing the poor by selling them food at high prices and lending them money at high interest rates. She saw no solution, since technological gains such as improved roads and agricultural intensification appeared destined to benefit the rich, not the poor. She doubted

> "whether there are reserves of human energy either for more intensive physical activity or to summon the will to organize, plan, adapt, or innovate."

Chopra (2004) reminds us of the harsh realities that come with our growing HIV/AIDS problem:

> "Young people are inheriting debts and, at the same time, having to grow more food to feed more dependents without the luxury of having gone through an apprenticeship in agricultural techniques and with *less opportunity for accessing credit and knowledge* through community and state institutions."

The blind belief in 'market forces' to bring about development have often been to the detriment of the poor.

> In an attempt to stimulate greater involvement by the private sector, the World Bank, through its structural adjustment reforms, replaced the Zambian grain marketing authority with the much smaller Food Reserve Agency.
>
> However, a lack of infrastructure has made it uneconomical for private traders to do business in remote areas and *people have been left with no access to markets on which to sell their produce or buy inputs*. An independent IMF evaluation found that the liberalisation of the state marketing board contributed to a 30% increase in rural poverty between 1991 and 1994 (Lambrechts and Barry, 2003, quoted in Chopra, 2004, our emphasis).

The warning lights are also flashing at much higher levels. Chopra (2004) tells us that the latest evidence seems to indicate that the strategy of relying upon food exports is actually worsening the balance of payments for countries in East and Southern Africa. Our pre-occupation with markets and exports gets a reality check when we examine the 'opportunities' from the viewpoint of a resource-poor person:

> The higher quality control and infrastructure requirements for the international market mean that high levels of capital investment and economies of scale are needed.
>
> Increased growing of food crops for export is redirecting the already small investments in rural areas towards expensive infrastructure projects designed to provide rapid road connection between the commercial farms and the airports, ports and other points from which produce can be distributed to international markets. It is also undermining other support mechanisms for small farmers such as agricultural research.
>
> Increasing reliance upon exports makes countries in the region especially vulnerable to changes in agricultural policies in OECD countries, especially to those from the EU, which account for 50% of agricultural exports from the ESA region.

The following is an extensive quote from Chopra (2004), which shows us some of the imbalances which has lead to the growing acceptance of developing countries' need for 'Food Sovereignty'[4]:

> Development is now defined as a necessary global project in which international institutions and firms are increasingly responsible for managing economic growth, including managing food security as a global problem with global solutions via biotechnologies (McMichael, 2004:124).
>
> More specifically the idea of food security has been reconstructed as a global market function that is based upon the presence of a free market and governed by corporate rather than social criteria. This position was boldly stated by a senior US official to the WTO, when he said that the
>
>> "idea that developing countries should feed themselves is an anachronism from a bygone era. They could better ensure their food security by relying on US agricultural products, which are available, in most cases, at much lower cost" (quoted in McMichael, 2004:127)
>
> This is the fundamental policy position that is driving many of the changes in agriculture and food security in developing countries.
>
> Naturally, the national food security of developed countries is a different matter altogether. In his address to the Future Farmers of America in Washington on 27 July 2001, President George W. Bush clearly recognized the fundamental role that agriculture plays when he stated:
>
>> "It's important for our nation to build – to grow foodstuffs, to feed our people. Can you imagine a country that was unable to grow enough food to feed the people? It would be a nation subject to international pressure. It would be a nation at risk. And so when we're talking about American agriculture, we're really talking about a national security issue." (Bello 2000:12)

Berthelot (2005) has further arguments on the need for food sovereignty:

> Sub-Saharan Africa's share in global trade fell from 2% to 1.6% between 1990 and 2004. A standard reading of this is that Africa is not integrating well enough with the world market. This is a gross misconception: in 2003 foreign trade accounted for 52.7% of gross domestic product (GDP) in sub-

[4] "Food sovereignty" is a term popularized by the international peasants' movement, Via Campesina, which first used it on a pamphlet at the 2002 World Food Summit in Rome. The Peoples Food Sovereignty Network defines food sovereignty as: "The right of peoples to define their own food and agriculture; to protect and regulate domestic agricultural production and trade in order to achieve sustainable development objectives; to determine the extent to which they want to be self-reliant; to restrict the dumping of products in their markets." (Berthelot, 2005)

> Saharan Africa. That compares with a global average of 41.5% - and just 19% in the United States, 19.9% in Japan and 16% in the Eurozone (not including trade between Eurozone countries) (World Bank Country Data Profiles: www.worldbank.org/data/country data/...).
>
> Setting aside the East Asian average of 70% (driven by China), the figures support a very different conclusion - but you never hear economists publicly declaring that countries' wealth is inversely proportional to their integration in world trade.
>
> The greater the share of agricultural produce in a developing country's total exports, the greater that country's malnutrition rate is likely to be (UN Food and Agriculture Organization, Review of the State of Food and Agriculture, November 2005. www.fao.org/unfao/bodies/conf/ c2005...). Except in the tropical/exotic products sector, the shortfall between agricultural production and consumption has increased considerably. From 1995 to 2003 West Africa's food exports grew by 50% - from $4bn to $6.1bn. But the trade deficit for the agricultural sector grew even faster: it went up by 55%, from $2.9bn to $4.3bn.
>
> The best solution for all parties is food sovereignty. This means a return to effective protection against imports. It should also include a ban on all exports at prices lower than what the average production cost would be without subsidies, direct or indirect. Paradoxically, this is ultimately the least protectionist way for countries to support their farming sectors, since it employs a tool that is available to all. (Berthelot, 2005)

Mousseau (2005) aims to "break through the rhetoric, debunk the myths of world hunger and ensure that it shifts the terms of the debate on hunger from a politics of despair to a politics of hope." He also recommends using the framework of food sovereignty in aid programs, arguing that

> "examples from hunger crises around the world have proven that policies that emphasize helping affected countries develop their own agricultural sectors actually help feed more people and decrease developing countries' dependence on aid programs in the long run."

He advocates the need for supporting small farmers through strong agricultural polices, support for the production of staple food rather than cash crops, protection of prices and markets, and the management of national food stocks. Further, he points out that procurement procedures with high-standards used by WFP, NGOs and donor countries tend to exclude small-scale farmers from providing produce for Food Aid in their own countries.

This then brings us back to the household level and one of the most pervasive myths needing to be debunked.

The myth that: **"If it is not profitable, it is a non-starter."**

Clearly, if the majority of the MDG target population in SADC cannot hope to derive their livelihood from market-based production in the next ten years, as conclusively shown above, then they cannot be expected to depend on technology that requires profitability to function – at least not in the sense of having to produce a cash return.

Box 5: Requirements for food sovereignty

Food sovereignty requires:

- *Prioritising* food production for domestic and local markets, based on peasant and family farmer diversified and agro-ecologically based production systems;
- *Ensuring fair prices* for farmers, which means the power to protect internal markets from low-priced, dumped imports;
- *Access to land, water, forests, fishing areas and other productive resources* through genuine redistribution;
- *Recognition and promotion of women's role* in food production and equitable
- access and control over productive resources combined with decision making powers;
- *Community control over productive resources*, as opposed to corporate ownership of land, water, and genetic and other resources;
- *Protecting seeds*, the basis of food and life itself, for the free exchange and use of farmers, which means no patents on life and a moratorium on genetically modified crops; and
- *Public investment* in support of the productive activities of families, and communities, geared toward empowerment, local control and production of food for people and local markets.

(Source: Food First 2003)

While it is true that very few households are completely divorced from the cash-based economy, it is equally true if they had sufficient cash they would not be hungry. Thus, we should instead emphasize the need for technologies that do not require cash, or need very little and only occasional cash, to sustain livelihoods.

Many of the micro-AWM technologies lend themselves very well to this need. It is important to distinguish between their role in the cash-economy and their economic efficiency. A technology which enables a household to be substantially more productive by increasing their agricultural output, is economically efficient even if it does not generate a cash return. At the same time, every one of these micro-AWM technologies can indeed generate cash profits, given the right circumstances. As IDE concluded in their Smallholder Marketing Creation:

> "The thrust has largely remained on crop production and marketing while rural livelihoods could be enhanced further by combining incomes from crops, livestock and perennial tree crops. As such, *the treadle pump ought to be seen as a smallholder farm asset for water management* rather than a mere tool for irrigating vegetables and other market garden crops." (IDE, 2005)

Initial labour constraints to the adoption of some micro-AWMs

Labour emerges as a major item in the literature relating to the transition to Conservation Agriculture from conventional approaches. Therefore this issue is dealt with in detail as part of the discussion on Conservation Agriculture in the section on Key Technologies below.

Key Technologies

Overview of the Key Agricultural Water Technologies used in SADC countries

The following table was developed from the country reports done by various consultants as part of this study during November 2005 - January 2006.

Table 3: Overview of the Key Agricultural Water Technologies used in SADC countries

Technology	**Angola**	**Botswana**	**Lesotho**	**Malawi**	**Mozam-bique**	**Namibia**	**South Africa**	**Swazi-land**	**Tanzania**	**Zambia**	**Zim-babwe**
Lifting (pumping) Treadle pump			X	X				X	X	X	X
Rope and washer pump											X
Elephant pump											X
Hand pump						X					
Small power pumps							X				
Application to crops Bucket and drum drip			X				X		X	X	X
Direct applicator hose (low pressure gravity)								X			
Bucket irrigation							X	X			X
Clay pot (sub-surface irrig)										X	
In-situ SWC/ Conservation Agriculture Flood recession					X					X	
Planting pits/ beds/ ngoro, chololo,				X		X			X		
Infiltration ditches/ fannya juu/ micro basins/ micro catchments				X	X				X	X	X
Minimum tillage (conservation farming)				X			X		X	X	X
Contour ridges				X			X		X		
Gully erosion control				X			X				
Paddy bunds									X		
Mulch									X		
Dambos/ valley bottoms					X	X			X	X	
Strip farming		X									
Ex-situ RWH/storage *Charco* dam									X		
Small earth dams		X		X			X	X	X		X
Hand dug shallow wells						X					
Boreholes		X				X	X				
Hill & underground spring-gravity				X						X	
Underground tanks				X							X
Above ground tanks				X						X	
Road etc run-off harvesting			X	X							
Roof top harvesting				X							
River diversion/weirs				X			X		X		X

Technology Descriptions and Application

In this section, the most promising and/or most commonly used technologies from the table above are described and some information given on their current use in the SADC countries. Where possible, this information was augmented from the literature.

The technology descriptions are mostly from a comprehensive report by Professor Bancy Mati (Mati 2006), while the information on their application in SADC countries is from the reports by the partners who worked on this study.

As in the table above, the technologies are divided into four categories, namely:

- water lifting (pumping) technologies;
- technologies for water application to plants;
- *in-situ* soil and water conservation (SWC) technologies, or Conservation Agriculture; and
- *ex-situ* rainwater harvesting and water storage technologies.

From these, we selected a few technologies for further discussion based on a combination of factors, namely the number of countries practicing them, their popularity and the recommendations of the country partners' reports. For instance, one technology, clay pot irrigation, is not very well known, but was so strongly recommended by the Zambian country partner for its accessibility to the very poorest households, that we included it. And indeed, some very interesting literature from across the world echoed the enthusiasm.

In addition, a questionnaire was circulated to country representatives at the January 2006 meeting of the Southern African Regional Irrigation Association (SARIA), a regional association established in 2000 under the auspices of the ICID. Ten SADC countries were represented in the January 2006 meeting. Delegates were asked to select the five priority technologies in three categories, namely the currently most widely used low-cost AWM technologies, most promising low-cost AWM technologies for household food security, and most promising low-cost AWM technologies for market production. The results from this questionnaire were used to further refine the selection of technologies emphasized in this report.

The technologies selected for further discussion includes the following:

- water lifting (pumping) technologies: treadle pump and small motorized pump;
- technologies for water application to plants: bucket & drum drip, clay pot irrigation, direct applicator hose, and bucket irrigation;
- *in-situ* soil and water conservation (SWC) technologies, or Conservation Agriculture: planting pits and infiltration ditches, minimum tillage and mulch; and
- *ex-situ* rainwater harvesting and water storage technologies: small earth dams, boreholes and river diversions.

Water lifting (pumping) technologies

Treadle pump

The treadle pump is a low-lift, high-capacity, human-powered pump designed to overcome common obstacles of the resource-poor farmers to irrigation. The treadle pump can lift five to seven cubic meters of water per hour from wells and boreholes, up to seven meters deep as well as from surface water sources such as lakes and rivers. There are two types: those that lift water from a lower level to the height of the pump commonly called suction pumps, and those that lift water both from a lower level and lift it to a height greater than the height of the pump known as pressure pumps. In all forms, water is pumped by two direct-displacement pistons, which are operated alternately by the stepping motion of the user.

It has two significant advantages over motorized pumps for irrigation of agricultural land of less than one hectare. It is considerably less expensive than motorized pumps and also it costs much less to operate, having no fuel and only limited repair and maintenance costs.

The treadle pump also possesses a number of features which sets it apart from other non-motorized irrigation pumps.

- First, its water lifting capacity of five to seven cubic meters per hour meets the irrigation requirements of most African farmers, the majority of whom cultivate less than one hectare of land.

- Second, because the treadle pump employs the user's body weight and leg muscles in a comfortable walking motion, use of the pump can be sustained for extended periods of time without excessive fatigue. The treadle pump is much less tiring than other manual pumps that utilize the upper body and relatively weak arm muscles.

- Third, the treadle pump can be fabricated entirely from locally-available materials and by using welding equipment and simple hand tools in the metal workshops commonly found in Africa.

Are kids staying out of school because of treadle pumps?

It was initially feared that introduction of treadle pumps would increase households' use of child labor, making the children tired before going to school and consequently negatively affect their performance in school. Field experience during the evaluation of the USAID-funded Smallholder Market Creation project, however, showed that school going children worked on treadle pumps after returning from school and actually this made their irrigation activities easier and less strenuous as they were previously involved in bucket irrigation. One farmer in Chibombo likened the way children like treadling to the way they like playing. Of course this may not preclude the possibility of households overusing some children in operating treadle pumps. This calls for sensitization of communities in appropriate household division of labor (IDE, 2005).

A Google Scholar internet search using '[treadle pump] AND [children] AND [school]' as keywords yielded 125 titles, but none of these referred to problems with children staying out of school as a result of treadle pumps. On the contrary, many referred to improved school attendance due to improved livelihood circumstances thanks to the treadle pump.

Technologies for water application to crops

This section particularly is not an exhaustive account of the irrigation technologies used in commercial agriculture, namely all the different versions of drip, micro, sprinkler, mechanized (centre pivots, irrigation booms, side-rolls, etc) and non-mechanized irrigation systems available on the market. Instead, the systems described here can be used by independent small-scale producers without having to become part of a group of farmers or a formal irrigation scheme. However, these technologies are also suitable for use by farmers in irrigation schemes.

Bucket and drum drip

Conventional drip irrigation systems typically cost US$ 5,000–10,000 per hectare, or much more, installed in East and Southern Africa. However, recent advances have introduced some adaptations in the systems that are making them accessible to small-scale farmers. Simple drip irrigation systems are now available which would cost a farmer US$ 15 to cover 15 m2, or US$ 200–400 for a bigger system covering 500 m2. (Sijali, 2001).

The reader is referred to Sijali's excellent handbook, with diagrams of layouts and functions of virtually every bucket and drum drip kits available in East and Southern Africa.

Drip irrigation enables the farmer to make use of limited amounts of water and fertilizer which can be applied together with the irrigation water to grow high value crops (e.g., watermelon, tomato, onions).

In Tanzania this technology has been promoted since 2003. The importation, promotion, selling, and distribution are done by a private company, namely Balton Tanzania Ltd with its office in Arusha. The promotion is done through different mechanisms, including agricultural shows, TV, radio, and newspapers. The system and components are imported from Israel and Germany. Balton (T) Ltd assists farmers who purchase the system with installation.

Since the promotion of the technology started in 2003, more than fifteen farmers have installed the system, in Arusha, Kilimanjaro, Manyara, Coastal and Ruvuma regions on the mainland. The farmers have installed different family drip system sizes ranging from system covering 500 m2 to 2000 m2. (Tanzania country report)

The families that have installed the drip system can be regarded as relatively rich families because the systems are relative expensive for a poor farmer to afford. For example a system covering 500 m2 costs Tshs 292,000.00 (US$265). However it needs minimal labor and maintenance, which mainly involves replacement of filters. Despite its cost, it seems to be gaining popularity, because of its low water use and minimal labor requirements because farmers buying the system are located near town and city centers where labor is expensive, and ground water abstraction is becoming popular.

The cost-benefit analysis for the drip irrigation system show that a farmer can earn about the same amount of income when he/she owns a treadle pump together with the drip system or when he /she owns the pump only from an acre (0.4 ha) of onions. Given the small amount of water used, its convenience of operation, and the minimal labor required the drip system is very attractive.

The drip kits in Lesotho are supplied for 10m x 10m or 20m x 20m plots. The kits are low-cost, easy to assemble and operate. Water is supplied from a tank connected to a roof catchment and placed with its bottom at least a meter above ground to provide sufficient elevation head to drive the drip system. The homeowner's roof is used to capture rainfall and direct it to the irrigation tank through gutters.

(Lesotho country report)

In Zambia, the drip kit is viewed as a simple system operating on the same principle as the clay pot drip system. The bucket, which is a low volume (5 liters – 10 liters) reservoir as compared to the drum (200 liters), is installed at an elevation of 2m – 3m above ground to provide a low pressure head -- enough to operate micro-tube drippers installed on the laterals that are connected to the main line from the reservoir. Water is pumped from the source to the reservoir by using a treadle pump. The micro-tubes emit water drop by drop on the root zone surrounding the irrigated crops and thus wet the surrounding soil. Water is taken up by the plant and some water evaporates due to heat and wind. Fertilizer is supplied along with the irrigation water from the reservoir (Zambia country report).

This system has been known to optimize yields per unit volume of water and land. Yield increases up to threefold have been registered in piloted trials by IDE and the Ministry of Agriculture and co-operatives. (Zambia country report).

In Zambia to date, only about 10 ha of land are irrigated by this system countrywide. The major drawback to accelerated uptake is lack of manufacturing capacity in the country leading to sporadic supply of drip kits by IDE. World Vision once supplied some bucket kits as a one-off program to its recipients.

The system greatly reduces labor of irrigating and weeding the crops. This is meritorious to the disadvantaged vulnerable populations that are aged, disabled and weak from HIV-AIDS pandemic.

In Zimbabwe, the kits are also viewed as low-cost, easy to assemble and manage. They do not need high quality water, providing the water is filtered. A 20 liter bucket with 30 meters (100 feet) of hose or drip tape connected to the bottom. The bucket is placed at least 1 meter (3 feet) above the ground so that gravity provides sufficient water pressure to ensure even watering for the entire crop. Water is poured into the bucket twice daily and passes through a filter, fills the drip tape and is evenly distributed to 100 watering points. The multi-chambered plastic drip tape is engineered to dispense water through openings spaced at 30cm (12 inches). Two bucket kits costing around $20 will produce enough vegetables for a family of seven and can last over five years. The system is most suited to kitchen gardens. As well as the bucket, a grower would need several strong poles, tools, manure, water and vegetable seedlings. The poles are used to make a support structure. (Zambia country report)

Low cost drip kits have been provided through various initiatives. The kits range in size from small gardens of 10m x 10m and 30m x 30m to small plots of up to 4,000 m2. The water source for the drip kits in Zimbabwe has been groundwater, particularly family wells and boreholes. The drip system requires water of low turbidity to avoid blockages and needs a small head for flow. For these reasons, coupled with the costs incurred in treating surface water and the energy to raise the head, surface water has been excluded in the promotion of the drip kits.

Clay pot (sub-surface irrigation)

> "The buried clay pot or pitcher method is one of the most efficient traditional systems of irrigation known and is well suited for small farmers in many areas of the world." (Qassam, 2003).

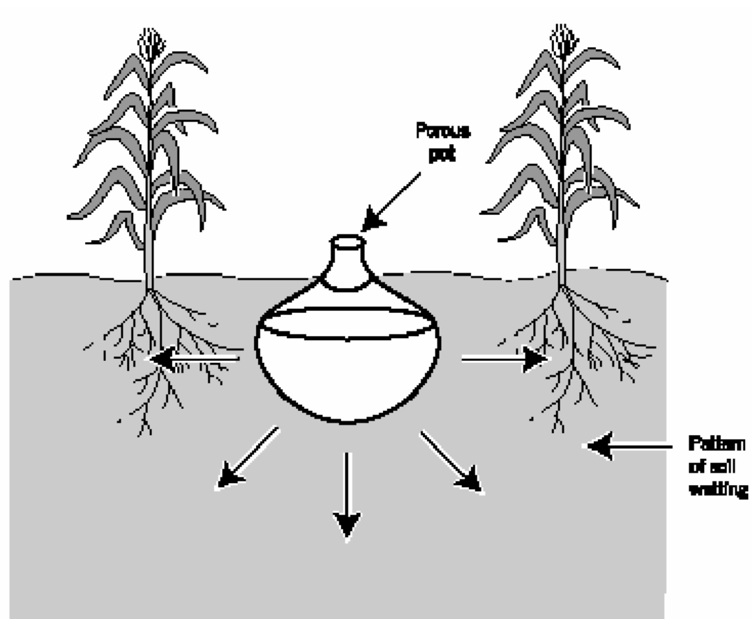
This is a low-cost indigenous sub-surface drip system achieved by use of unglazed fired clay pots that remain micro-porous and are molded by hand by women at rural level. There however exist molding machines that can mass produce clay pots with specifications of porosity and firing temperature to eliminate possibility of shrinking and swelling of clay which may lead to cracking. The clay pots are buried in the ground with their necks appearing above ground in a row at specific plant intervals. Plants are planted adjacent to the pot on either side and the pots filled with water and covered with a clay lid to avoid direct evaporation of water and rodents drinking the water.

According to RELMA (Sijali, 2001), this is a method of irrigation in which water is stored in clay pots buried in the ground, from where it is slowly released to the plants. This method is particularly good for fruit trees, but also used for vegetable crops in homestead gardens. Such use of soil-embedded porous jars is one of the oldest continuous irrigation methods that probably originated in the Far East and North Africa. The method consists of:

- Clay pots that are placed in shallow pits dug for this purpose;
- Soil is then packed around the neck of the pots so that the necks protrude a few centimeters above the ground surface;
- Water is poured into the pots, either by hand or by means of a flexible hose connected to a water source.

Using the principle of moisture potential, water begins to ooze out of the pot from its high water potential to wet the surrounding soil outside the pot where the soil water potential is low. The water is instantaneously taken up by the crop from its root zone around the clay pot. It has been well established that irrigation intervals between 7 -14 days are achievable and that water saving between 50% and 70% are obtained resulting in yield increases between 30% and 45% over conventional flood furrow and basin irrigation systems (Daka & Bosma, 1999). This indicates a high potential for labor saving while irrigating. Crops that prosper under this system include tomatoes, rape leaf vegetable, cauliflower, maize and beans which yielded 42, 33, 22, 13 and 5 ton/ha respectively under clay pot system as compared to 40, 27, 16, 9.3 and 4.7 ton/ha under conventional irrigation systems. This was achieved at higher water productivity than conventional irrigation.

Figure 4: The pattern of soil wetting around a porous clay pot (Sijali, 2001)



The clay pots have been made at village level and used for storage of seed, as flower pots and as water storage containers at household. Water stored in clay pots becomes cooler than room temperature, thus simulating a refrigeration system, because some water that oozes out is evaporated from the clay pot surface by heat.

The pots are made of locally available clay with optimum properties of strength (to resist crushing), permeability (to exude water into the soil at an approximately steady rate), and size (to hold enough water for at least one day's supply). The potential of clay-pot irrigation has not been fully exploited by farmers in the eastern and southern Africa region, even though the technology is suitable for small-scale farmers. There have not been many reports of previous experience in the region. (Sijali, 2001)

The value of the clay pot or pitcher irrigation is confirmed by several authors from across the globe. Bainbridge (2002) explains the advantages as follows:

There are numerous advantages to using buried clay pot irrigation. First, pots are not as sensitive to clogging as drip emitters, although they may clog over time (after 3-4 seasons) and require renewal by reheating the pots. Second, the system does not require a pressurized water system, which is difficult to establish and maintain at remote sites. Third, animals are less likely to damage or clog buried pots than aboveground drip systems. Fourth, by selecting lids that collect rainfall, any precipitation that does fall can be conserved and used. Finally, buried pots are more robust than drip systems because they do not rely on continuous supplies of power or water to operate.

The controlled water delivery from buried clay pots provides both young seedlings and planted seeds with a steady supply of water under typical desert conditions, and in soils that drain quickly. Researchers in Pakistan used buried clay pot irrigation to establish acacia (Acacia spp.) and eucalyptus (Eucalyptus spp.) trees in an area with 8 inches (200 mm) of annual precipitation (Shiek'h and Shah 1983). The trees irrigated with clay pots grew 20 percent taller than trees that were hand-watered at the same rate. The clay pot irrigation increased survival from 65 percent to 96.5 percent. Kurian and his colleagues (1983) also used buried clay pot irrigation to grow mesquite (Prosopis spp.) seedlings. In that case, trees irrigated with clay pots were more than three times taller than rainwater-fed trees and 70 percent taller than surface-irrigated trees.

Stein (1990) developed design criteria for clay pot or pitcher irrigation.

The following table gives a cost comparison of various alternative irrigation methods for very dry and remote conditions (from Bainbridge, 2002).

Table 4: Estimated costs for a remote site, one growing season (800 plants)

Irrigation Method	Materials and Labor	Water Demand	Survival
Porous hose	$3	low	high
Deep pipe	$3.25	low	high
Clay pot, lid	$4.50	moderate	high
Porous capsule*	$6	low	high
Perforated drain pipe	$3	moderate	moderate
Microcatchment	$15	moderate	moderate
Drip**	$2.50	moderate	moderate
Wick	$3	very low	moderate
Basin	$3	high	very low

*requires water tank, gravity pressure
**requires water tank, filters, pressure (tower or pump), risky without regular maintenance

From: Bainbridge, 2002

In-situ Soil Water and Nutrient Conservation/ Conservation Agriculture

The Green Revolution transformed millions of livelihoods across Asia, until rising input costs, faltering produce prices and ailing resources triggered a reversal of the gains. It is now recognized even in mainstream commercial agriculture circles that

> "an unintended outcome of the intensification of agriculture is global degradation of soil and water resources, air quality, and the loss of biodiversity. Thus, the earth's agro-ecosystems have become increasingly stressed by economic/profit activities." (Clayton *et al*, in the 2004 proceedings of Canada's FarmTech conference)

According to several authors, the livelihood and economic well being and nutritional status of over 1 billion people worldwide are already adversely affected due to land degradation (FAO, 2003; Pinstrup-Andersen, 1999; Scherr, 1999).

Now indeed, as Conservation Agriculture enters the commercial farming mainstream, one observes a shift in thinking towards the integrative principles of Old World farming practices. For instance:

> "A knowledge gap exists on the interactive impact of crop management practices and weed, disease and insect pests… Blackshaw et al. (2000a) published an extremely important concept when they considered integrating cropping practices for weed management in a dry bean crop. Knowledge about cropping systems that encourage diversity of crops and pests is required…" (Clayton *et al.*, 2004)

According to the African Conservation Tillage Network, the rapid spread of conservation tillage in Brazil and the neighboring countries was mainly caused by the fact that this production system reduces the production costs significantly. But even though African farmers face a similar scenario to their Latin American counterparts in terms of rising costs and diminishing returns,

> "dissemination of conservation tillage practices (in Africa) is rather slow. Reasons are, amongst others, an underdeveloped rural infrastructure and the dominance of very small farms, using manual labour and being reluctant towards any changes of farming systems because of risk avoidance. (Steiner, 2002)

This statement raises several questions. First, what is the score? Just how slow, or fast, is the uptake of Conservation Agriculture in "Africa", or rather, in the highly diverse range of situations found on this complex continent? Second, what are the factors of adoption? Are the small size of farms and manual labor practices indeed a stumbling block for the adoption of Conservation Agriculture, or are there other factors at play that we need to understand in our design of support programs? And third, a very pertinent question to ask while we are designing programs to achieve the MDGs, just what are the components of rural infrastructure that needs addressing in order to enable adoption of Conservation Agriculture by African farmers?

Before we explore what the literature has to say on some of these questions, let us pay attention to the current situation and the terminology.

> In Africa, over 30 countries face dryland degradation or desertification (FAO, 2003). Annual use of nutrients in Africa averages only about 10 kg of NPK ha- (Henao and Baanante, 1999). Under these circumstances, it is important to investigate cropping and nutrient management systems to optimise the integrated use of all nutrient sources (e.g., fertilizers, organic manures, waste materials) suitable for recycling nutrients and bio-fertilizers for the maintenance of soil fertility and crop productivity. (Keerthisinghe *et al.*, 2003)
>
> Crop rotations to optimize nitrogen fixation, efficient management of crop residues and exploration of the soil by developing rooting systems and management methods that limit nutrient losses are some of the approaches that are being used to increase crop production in integrated plant nutrient management

> systems. The challenges would be then to: a) identify best crop combinations suited to the agroecological zone and socio-economic conditions, and b) develop and pilot-test improved technologies for the efficient management of the available resources within each cropping system.
>
> Water is the single most important factor limiting crop production in large areas of the world. If insufficient water is available, fertilizer and crop varieties with high yield potential are useless. Thus in identifying promising plant nutrition management systems, it is important to focus on efficient water management practices to sustain crop production in both irrigated and rainfed conditions.
>
> In rainfed farming systems, which cover about 80% of arable land used worldwide, optimizing water use efficiency is one of the main factors influencing crop production (FAO/IAEA, 2001). Selection of crops to optimize the use of residual moisture after harvesting the main crop, use of local practices to increase the storage of rain water, addition of manure and crop residues to improve soil structure and thereby increase infiltration of rainfall into the rooting zone of crops and minimize evaporation losses, and improved rate and timing of N fertilizers, all showed promising results in increasing crop productivity in semi-arid and arid regions (FAO/IAEA 2001, quoted in Keerthisinghe, 2003).

According to Clayton (2004), the FAO has proposed the use of the term "Conservation Agriculture" as a generic terminology to replace the widespread use of "conservation tillage" to describe farmer's adoption of new tillage/seeding systems. The FAO rationale is that agricultural production technologies that are geared towards resource conservation involve more than tillage as seems to be implied by the use of "conservation tillage". FAO suggest a definition for conservation agriculture as:

> "Involving a process to maximize ground cover by retention of crop residues and to reduce tillage to the absolute minimum while exploiting the use of proper crop rotations and rational application of inputs (fertilizers and pesticides) to achieve a sustainable and profitable production strategy for a defined production system."

This is a very rich definition, which, when translated into simple language bears strong resemblance to traditional African agricultural principles, approaches and practices:

- Mulch
- Avoid disturbing the soil
- Rotate crops (towards biodiversity, but not quite saying 'intercropping')
- Rational (no longer maximum or even 'optimal') use of inputs
- Sustainable
- Profitable (but does this have to mean money?)
- A defined production system (recognizing that everything does not work everywhere).

The Green Revolution never happened in Africa. There has been endless speculation and analysis as to the reasons for its failure on this continent, but could it perhaps be that finally, our research and support focus is turning towards an agricultural production system which is in nature more aligned to African tradition and belief systems? With this in mind, let us examine the evidence from the literature.

Potential uptake of Conservation Agriculture in Africa

The literature provides us with estimates of potential adoption in a paper discussing carbon sequestration (Niles, 2002). According to Niles (2002), zero tillage, cover crops, green manures, mixed rotations and agroforestry can lead to significant annual improvements in soil organic carbon. Especially arable agriculture has good potential for carbon sequestration (see table below).

Table 5: Definition of conservation tillage and examples of methods (Steiner & Bwalya, 2001)

All soil and water management practices, which reduce soil tillage (soil disturbance), maintain at least a minimum soil cover from crop residues or green manures/cover crops, and involving rotations. Planting is done through the mulch and whiles chemical may be necessary for weed control in the first few years, this thins out as the system begin to manage a low level of weed infestation.

Principle practices applied in Southern and Eastern Africa are:

- Ripping → ripping only the planting line with help of a tractor or animal drawn rippertine, attached to the ripper can be planters and/or fertiliser hoppers
- Tied ridges → mainly for holding water and facilitating infiltration in low rainfall areas. The tied ridges are also used in high rainfall areas to control and manage excess water and possible runoff. Often done on permanent ridges; the tying ridges are lower than planted ridges.
- Mulch placing → mulch material taken from non-cultivated surfaces; these materials would often last no longer than that particular season
- Direct planting 1 → used mainly in commercial farming under irrigation, i.e. where two crops per year are produced and a good ground cover maintained
- Direct planting 2 → in hand hoe systems were planting holes are made just before the start of rains and planting done with the rains. This goes with a heavy weeding requirement. It is also common to find kraal manure applied in the planting hole prior to planting.
- Pot holing → hand-hoe made planting stations designed for harvesting and consentrating water in the planted stations. Fertilizer is also appied in the same station. Planting will always be done in the same stations to allow newer crops to benefits from the fertilizer residue effects.
- Winter ploughing → tillage done soon after harvest. The soil is relatively dry, so the ploughing leaves large clods on the surface. The rough surface is desired to minimise wind erosion and, mostly importantly, collect within the field the first rains and prevent runoff.
- Surface physical measures: Especially in the control and management of erosion, a variety of physical measures have been employed. These include contour ridges, storm drains, grass strips and level bunds. These are normally runoff barriers (controlling runoff velocity and quantity) aligned across the slope.
- Agroforestry: the growing of crops and trees together on the same field in some form of spatial arrangement or temporal sequence and improved overall yields. Common practices include the planting of *Sebania sesban*, *Tephrosia vogelii*, in crop fields. This is also sometimes used in what is referred to as improved fallows; tree or shrub plants are planted and left to grow for 2-3 seasons. There are then cut leaving the stamp in the ground. The trees would have also littered the ground surface with leaf material. The plant fixes nitrogen and the roots help break hard pan, while the leaf materials provide soil cover and organic matter
- Green manure/cover crops: planting of especially leguminous plants, which are later, ploughed under as green manure has been promoted in the region. This includes plants such as sunhemp (*Crotalaria juncea*) and mucuna (*Mucuna pruriens*). However, adoption of such practices is low, as farmers appear to have other priorities other than planting a crop only to be ploughed under. In southern parts of the region with one 4-5 months rain season, possibilities are also considered difficult. In the northern areas one close alternative is they let natural grass grow under fallow and later buried into mounds on which crop is then planted.

This implies that micro-AWM has a major potential role in carbon sequestration initiatives, both in terms of potential per hectare per year, and by virtue of the large areas currently under arable agriculture by smallholder farmers.

Table 6: Carbon-sequestration rates (tC ha-1 yr-1) according to four scenarios for sustainable agricultural management

Agricultural System	low	medium	high	very high
arable	0.3	0.65	1.3	3.1
rice paddy	0.1	0.1	0.1	0.1
permanent crops /agroforestry	0.4	0.6	0.6	0.8
permanent pasture	0.3	0.5	0.7	0.9

Source: adapted from Watson et al . (2000) and Pretty & Ball (2001), in Niles, 2002.

The table below presents a 2002 estimate of the potential adoption rate of Sustainable Agriculture approaches in selected African countries, totaling some 15.9 million hectares by 2012. This is but 12% of the global potential. At medium carbon sequestration rates, this would translate to a monetary value of US$482m, or about half of the current annual US international aid, stretched over a ten year period. At these 2002 net present values, the potential income from carbon sequestration does not seem like a meaningful source of funding for the promotion of Conservation Agriculture.

Information on the actual adoption of micro-AWM that could be garnered from the country reports and literature are reflected in the section on 'Key Technologies' below.

What are the factors of adoption of Conservation Agriculture?

> "By far the most important constraint (to Southern African farmers' adoption of Conservation Agriculture) is the harsh environment the majority of smallholder farmers face. Low soil fertility combined with unreliable rainfall, a high risk of crop failure due to drought and limited access of agricultural markets make farming an unprofitable and risky enterprise. An Africa specific constraint to conservation tillage is the traditional communal land tenure system, which limits the land use right to the growing period. Fields in the savannah regions turn into communal grazing grounds during the dry season, leaving them completely bare at the beginning of the season. Because of this hardly any farmer is ready to grow green manures or cover crops." (Steiner & Bwalya, 2001)

We would do well to recognize the diversity and complexity of both the situations and the technologies to understand the challenges involved in promoting uptake of Conservation Agriculture technologies globally:

> There is no single set of recommendations for improved management of plant nutrients applicable for the diverse agricultural environments and economic conditions, therefore it is important to select and transfer the most appropriate and cost effective technologies to farmers. (Keerthisinghe, 2003)

In developing countries these difficulties are further exacerbated:

> The major constraints to adoption of technologies by the farmers such as lack of resources, farmer's perceptions and attitudes towards new technologies, local and macro-economic considerations and policy support for adoption of technologies are some of the major factors that need to be examined.

Table 7: Annual carbon mitigation and associated incomes via sustainable agriculture for the years 2003 - 2012

countries	sustainable agriculture adoption rate (Mha yr^{-1})	carbon over 2003–2012 (MtC)	net present value 2003–2012 (US$ million)
Africa			
Angola	1.2	2.2	15.1
Benin	0.0	1.1	7.4
Botswana	0.5	0.7	4.6
Burkina Faso	0.2	1.1	7.8
Cameroon	0.2	5.2	35.7
Central African Rep.	0.1	1.6	11.1
Chad	1.0	2.0	13.9
Cote d'Ivoire	0.4	4.6	31.7
Dem. Rep. Congo	0.5	6.4	44.2
Ethiopia	0.6	3.5	23.9
Kenya	0.5	1.8	12.1
Madagascar	0.6	1.7	11.7
Mali	0.7	2.0	14.0
Mozambique	0.9	2.0	13.5
Niger	0.3	1.7	11.8
Nigeria	1.4	9.7	66.8
Senegal	0.2	1.0	6.8
South Africa	2.0	6.3	43.8
Sudan	2.5	7.3	50.2
Tanzania	0.8	2.1	14.7
Uganda	0.2	2.4	16.9
Zambia	0.7	2.2	15.0
Zimbabwe	0.4	1.3	9.2
subtotal	**15.9**	**69.7**	**482.1**

Moreover, policies supporting more resources for research and development of new technologies should be provided, as future food needs cannot be met using existing institutional frameworks. Although agriculture plays a vital role in the economy of developing countries, their public sector expenditures on agricultural research are typically less than 0.5% of the value of agricultural production[5], compared with 2-5% in industrialized countries. (Keerthisinghe, 2003)

Steiner (2002) states that the adoption of CT at farm level is associated with lower labor and farm-power inputs, more stable yields and improved soil quality. According to his findings, the principal reasons for non-adoption in Africa are the following:

- Lack of information on CT
- No farms around practicing CT could serve as demonstration/example
- Extensionists know very little or nothing about the system
- Costs implied in changing the tillage systems
- Lack of access to inputs and credits (for purchase of CT implements)
- Risk avoidance (fear of failure or wrong application of new technique in the absence of guidance phase)

[5] African governments have in the meantime committed to allocate 10% of their national budgets to agriculture, although it is not yet clear how much of this will be dedicated to agricultural research and extension.

- No direct returns from green manures/cover crops
- Opportunity costs of crop residues.

The increased investment requirements to switch over are pertinent for the majority of African smallholder farmers, who do not dispose of enough cash to purchase even relatively cheap implements like the jab planter (matraca) or animal drawn rippers or planter. Steiner (2002) summarizes as follows:

Additional costs of inputs in the transition phase (year 1 - 3)

- Purchase of new implements (e.g. ripper, direct planter)
- Seeds of green manure/cover crops
- Increased fertilizer rates when crop residues are left in the field, till a new equilibrium is obtained (less crucial when leguminous cover crops are produced)
- Liming to adjust soil acidity
- Subsoiling to remove hardpans caused by years of ploughing or hoeing
- Herbicides for the control of noxious weeds or
- Increased labor input for weeding.

Reduction of inputs after transition phase

- Herbicides: with good management (ground cover) only one application of a pre-emergence herbicide per season
- Fertilizers: rates can be reduced due to improved soil fertility status (organic manures, soil life)

Yet, the one dominating factor which emerges from both literature and farmers' responses that seems to be discouraging uptake and may even result in dis-adoption, is the increased labor requirement. In the SADC context, where HIV/AIDS is seriously eroding the manual labor capacity of individuals, households and villages as a whole, this is indeed a serious constraint.

Many researchers maintain that increased labor is required only in the transitional stage, which is reported to be anywhere between 1 - 5 years. Indeed, in the table below, lower labor requirements are shown for Conservation Tillage as compared to conventional tillage in Paraguay smallholdings. The reduced labor requirements in the Ghana example are even more pronounced.

Table 8: Comparison of conventional and CT production costs in smallholdings at two locations in Paraguay

Crop cost item (US$ 1998)	Conven-tional	CT	Ratio
Edeliria			
Farm area (ha)	15,6	15,6	-
Labour (pers. days)	287	240	1,20
Net farm income (US$/year)	2570	4272	0,60
Return to labour (US$/day)	8,95	8,95	0,50
San Pedro			
Farm area (ha)	6,8	6,8	-
Labour (person/d)	164	163	1,01
Net farm income (US$/year)	1010	2229	0,45
Return to labour (US$/day)	6,16	13,67	0,45

SORRENSEN *et al.*, 1998

Table 9: Man-days, maximum number of cultivated ha and yields associated with tillage systems in Ghana

Tillage system	Working days for 1 ha maize[2]	Max. n° of ha under good cultivation (ha)	Yields associated with soil preparation (t/ha)
Handhoe	100-120	1-2	1-2
Animal traction + hand weeding	50-60	4-6	3-4
Animal traction + hand weeding	25-30	8-12	4-5
No-tillage + herbicide	15-20	Up to 20	5-6

SOZA et.al. 1998

But now let us turn to literature on Southern African countries.

> From Malawi: "From the 1930s and onwards there are reasons to believe that the supply of labour was limited. The increased share of labour needed for the making of ridges, contour ridges and bunding have been documented before and is one important factor in the peasants' opposition to such methods since they were depending on the family as the main source of labour." (Green, date unknown)
>
> From Zambia: "Farmers, when asked for their qualitative assessment of CF, likewise complained of higher labor requirements in both weeding and field preparation. One farmer complained that labor demands under CF basins caused him to "lose a lot of energy and grow thin." Another suggested that the hard labor of digging basins, "reduces the lifespan of an individual." Many noted that basins proved, "hard to dig unless done right after harvest." More experienced farmers qualified these observations by noting that both digging basins and weeding were, "very demanding laborwise in the early years." (Haggblade and Tembo, 2003)

The time dimension mentioned earlier reappears here. Conservation farming, whether with basins or rippers, represents a long-term investment in improved soil fertility and soil structure. Both farmers and promoters need to look at the system over a period of years. Clearly, farmers find digging basins difficult in the first year.

But empirical measurement bears out the observation of the old timers that land preparation labor declines substantially in later years. While first year farmers require an average of slightly over 70 person-days to prepare a hectare of basins, a fifth-year farmer requires about half that amount. By maintaining permanent planting basins, farmers not only concentrate soil fertility but also reduce land preparation labor in subsequent years.

Table 10: Comparison of labor use for Conservation Agriculture and Conventional Agriculture in Zambia* (person days/ha)

	Cotton				Maize			
	Basins	Hoe	Ripper	Plow	Basins	Hoe	Ripper	Plow
Land preparation	66	59	7	7	70	50	10	8
planting	11	8	4	4	16	39	5	4
fertilizer application	1	0	0	0	18	8	8	2
liming	1	0	0	0	9	0	3	0
hand weeding	79	68	51	45	81	58	35	27
mechanical weeding	3	0	4	9	1	0	2	2
spraying	10	7	22	5	0	0	0	0
harvesting	47	22	35	26	16	21	14	6
Subtotal labor	219	164	124	96	211	176	77	48

* Hand hoe basins are compared to conventional hand hoe, and ripper against conventional plow

A sobering thought is that the labor demands on smallholder farmers are on the increase anyway, even if they don't adopt Conservation Agriculture.

> "In sub-humid and humid areas increasing demand for arable land from a rapidly growing population has led to ever-shorter fallow periods, which no longer enable the restoration of soil fertility. *Declining soil fertility and increasing weed pressure increase the workload of farmers, mainly women farmers*, while yields persistently decline. (Steiner & Bwalya, 2001, our emphasis)

This implies that urgent ways need to be found anyway to compensate for the ravages of HIV/AIDS. This becomes an energy question which may require innovative approaches to overcome. It begs some consideration that one person day of manual labor is the energy equivalent of 40g of cooking oil, a few dessert-spoonfulls. Likewise, a 40 liter fill-up at the petrol station contains the same energy as 4 person-years of hard manual labor (Sugrue, 2005). It is thus makes sense that both labour-saving technologies and farm power interventions are viewed as important components in an overall strategy in response to the effects of HIV/AIDS.

It could well make sense to find ways to provide support for households during the transitional years to shift from conventional to Conservation Agriculture. These support mechanisms should be designed carefully so as not to create negative incentives, dependency and 'disturbance and fighting', as described by Water for Food Movement women in Lesotho (see above).

Again we may do well to look to rural communities and their responses to these crises. Barnett & Grellier (2003) report as follows on changes in the social organisation of labour which is highly relevant to the planning of implementation of Conservation Agriculture:

> Formation of formed formal and informal labour sharing groups to facilitate land preparation, weeding or harvesting may not reduce total cultivation time, but it enables a greater number of households to

overcome problems of timeliness associated with land preparation, planting and harvesting. It also reduces the need to hire labour or engage in wage labour on other people's fields.

One project representative felt strongly that organisation of working groups was more appropriate and sustainable for very impoverished and subsistence farmers than any other intervention. (Another) respondent described how women in particular 'get incredible strength from each other' as sharing work provided emotional support and increased social cohesion. (Barnett & Grellier, 2003)

Regional application of Conservation Agriculture

In Tanzania, Conservation Agriculture makes use of tools and implements such as the jab planter and the animal drawn ripper or no-tillage planter, in combination with agronomic practices that have the potential to suppress weeds through soil cover and introduction of cover crops form a set of possibilities. (Tanzania country report)

The interest of fostering the adoption of conservation agriculture in Tanzania is its potential to address three areas of crucial importance to smallholder farmers, i.e., demand on household labor, food security, and household income.

HIV/AIDS and other diseases, such as malaria as well as urban migration and education are reducing the labor availability in rural households and increasing the burden of labor-intensive activities on women and children. Conservation agriculture technologies, specifically minimum tillage, reduce labor requirements especially in peak seasons for land preparation and weeding.

Conservation agriculture potentially contributes to household food security by making more efficient use of rainwater and by increasing soil fertility through the introduction of nitrogen fixing cover crops. Minimum tillage reduces expenditure on hiring farm power services and purchase of fertilizers, whilst generating additional revenue through the production of fodder and cash cover crops. Minimum tillage substantially reduces the production costs by reduced use of fuel whose cost is continuously increasing

Conventional land preparation practices in Malawi are those where ridges are remade on the contour every season, and where plant residues are covered, removed, or burnt and in which growth of all vegetation is prevented, except for the desired crop. Elsewhere, this has been termed clean tillage. (Malawi country study)

The effect of this tillage systems on crop yield is not uniform with all crop species, in the same manner as various soils may react differently to the same tillage practice. Invariably however, it is argued that, over time, the practice of ridge tillage, which moves soil from the old ridge to the furrow and back, seasonally, may have led to the development of a soil pan that effectively prevents infiltration and encourages runoff.

Various modifications of surface land configuration have been attempted for rainwater management in different rainfall regions of the country. These include *chololo* pits and tied ridges. The aim has been to increase storage of water in the soil profile and to increase runoff collection, storage, and use to offset water deficit periods such as at the onset of rains or seasonal dry spells. Ridges are constructed across the slope with the aim to contain surface runoff and ward off excess at non-erosive velocities. It is this impact that ridges achieve for which their continued use is advocated in Malawi where most of the country lies on moderate to steep slopes.

Research has shown that contour farming alone can reduce erosion by as much as 50% on moderate slopes. However, on slopes steeper than 10%, other measures should be combined with contour farming to enhance its effectiveness. In some agroecological areas, soils are predominantly clay having very low infiltration rates. In such cases the depth of water infiltration is very small and water may remain (ponding) at the soil surface or in the upper layer of the sol profile if ridges are tied or pits are made.

In Malawi, soil and water conservation technologies such as those for gully erosion control, have invariably been based on the use of vetiver grass. This has received wide scale extension effort and farmer adoption.

The Malawi country study proposes that soil and water conservation should combine soil conservation with water harvesting as has been attempted elsewhere in the region. For example, a stabilized gully is prevented from advancing further by use of constructed barriers (check dams, stone checks) combined with vegetative materials of economic importance such as fruit trees, banana establishment or fodder grass for structure rehabilitation. Its impact is achieved through control of concentrated runoff, by retention/ trapping of sediment, and by reduction of slope.

In Tanzania, paddy field bunding is practiced mainly in Mwanza, Shinyanga, and Tabora regions. However it is used in other semi-rid areas as rice is increasingly becoming one of the staple foods for different communities in Tanzania. The technology involves harvesting rainwater by making bunds around paddy fields located in the valley bottoms with clayey soils. The fields are of various sizes, ranging from 0.2 ha to 0.5 ha. It is a traditional method (technology) that was started in the 1950s, but it has gained popularity in recent years when cotton prices started going down. Tanzania country study)

The local communities have developed an efficient way of land resource utilization, such that in the upland catchment areas livestock are grazed. Due to livestock tramping, infiltration rates of upland soil are reduced, thus, generating more runoff to be used in lowland fields. Crop production in the semi-arid areas of Tanzania is unreliable due to un-reliability rains in terms on onset time, duration and annual amounts. This rainwater harvesting technique has therefore removed a major constraint to crop production, and as a result farmers are now producing surplus for their own consumption.

Rice production in the region has become a good additional cash crop, as the crop has a readily available market in Zanzibar Island and Middle East countries.

In Zambia, about 100,000 ha of non-equipped lowland areas are cultivated particularly in the rainy season in the interfluves. These interfluves are known as *dambos* in Zambia. Dambos cover about 3.6 million hectares countrywide and smallholder farmers have free access to them. (Zambia country study)

Dambos possess seepage zones from which capillary rise moisture is exploited to grow crops without much water control. In the flood central zones of dambos, rice cultivation is common but techniques like construction of raised beds and/or ridges makes it possible to grow other crops in this zone.

Some areas in the dambo fringes, commonly known as upper grasslands, require that supplementary irrigation water is supplied to crops. The sources of such water would be hand-dug shallow wells or outlet streams from dambos. Water can be drawn by using a bucket tied to a rope or a suction treadle pump. Shallow wells often do not exceed a depth of 1.5 m, which is a reason for their drying even when the water table is resident at 3 m – 5 m in the dry season.

Permanent Strip farming is practiced in Gaborone, Botswana at Sanitas Farm. Very promising yields are achieved at very low plant populations (up to 5t/ha at 10 000 plants/ha). This is ascribed to deep ripping in permanent strips, adequate oxygen to the roots and water harvesting by permanent profiling of the fallow strips between the Permanent Strips or ripped planting areas. (Botswana country report)

Ex-situ RWH/storage

Small dams and Charco dams

The *charco* dam technology is used to impound runoff water by digging and constructing an earth embankment. The technology is used to supply domestic water to villages and small towns. The technology can serve up to 500 households and more than 4,000 livestock units. It is commonly used to provide water for livestock in semi-arid areas of Tanzania covering about 50 % of the country and having the largest population of livestock in the country. The technology was first introduced in the semi-arid areas in the 1930s by the British colonial government. It is being promoted by the government for improved livestock production. The government consulting agency (Drilling and Dam Construction Agency) or private consultancy firms design and supervise the construction of the charco dams depending on whether the project is funded directly by the central government or local governments. But in some instances where communities get assistance from external donors (government agents or NGO), private consulting firms design and supervise the construction as directed by the financiers. Generally where the dam construction is for a village community, the community contributes about 20 % of the capital cost plus other labor inputs which may be needed during the survey and planning phases. Because of the high capital costs (20 - 50 million Tanzania shillings, US$18,000-45,500), charco dams are generally community property or properties of estate farms (e.g., sugar plantations and modern large livestock ranches).

Local communities are responsible for the management of village dams. For the dams to be successful, the village communities participate in the planning and construction of the dams and are responsible for their operation and management. Normally the village governments form dam management committees with responsibilities of operation and maintenance of the dams. Additionally the committees are expected to come up with by-laws and measures that are acceptable and implementable by the local communities within the catchment areas of the dams.

Given the fact that dams provide water throughout the year in areas having about 5 months duration of dry season, they enable construction of permanent settlements, and other social economic activities, e.g.. education to school age children, good health care services, intensive and improved agriculture, and etc. All of these can contribute to sustainable development. Thus, although it is not possible to carry out an economic analysis for the dam technology, it is one of the best practices in the semi – arid areas of Tanzania.

Hand dug shallow wells

In Botswana, traditional wood-lined wells with wooden windlasses, are improved through installation of concrete rings, backfilling to ground level on the outside of the rings and installation of a hand pump on the improved well. During installation of the improved well, the original vertical wooden supports for the old windlass are left intact. Thus, in the event of a pump breakdown, farmers are able to revert to the traditional technology while the hand pump is being repaired. This is done by reinstalling the wooden windlass and removing a loose concrete slab on the well opening to gain access to the water.

Boreholes

In most SADC countries small-bore wells (boreholes) are mostly drilled and equipped to supply community water for domestic use and animal watering. However, in dry areas of South Africa, the development of community food gardens have been based almost exclusively on borehole water. Boreholes for food production are mostly equipped with diesel or electric-powered pumps. Electric pumps are preferred, because both the operation costs and the maintenance requirements and costs are less than those for diesel motors.

In both Botswana and Namibia, livestock farmers and remote rural communities are highly dependent on borehole water, which is often their only water source. Both countries have developed effective programmes for the provision of water supply based on boreholes. In Namibia, a comprehensive capacity building process engenders community organization to ensure user responsibility for operation and maintenance of their own water points.

In the questionnaire on micro-AWM technologies filled by country representatives at the SARIA workshop in January 2006, most countries indicated the importance of boreholes.

Rooftop rainwater harvesting and above ground tanks

Despite relatively high rainfall, the level of activity in rainwater harvesting in Zambia is very low and isolated. The most common type of rainwater harvesting is the traditional one, where families draw water falling from rooftops in drums of 200-210 liters capacity for short term use. This is usually done without their realizing that they are even practicing rainwater harvesting. The technology is quite novel in its formal state but it has existed for a long time. A similar type system involves the use of gutters on buildings like schools and hospitals. Though with limited application, the system referred to as ‘institutional rainwater harvesting’ is quite effective and uses ferrocement tanks, sized between 10 to $20m^3$, which collect rainwater from roof tops via gutters. The collected water is used by the concerned communal institutions. Such interventions are currently pilot projects by the Zambia Rain Water Harvesting Association.

While the collection of rainwater by a single household may not be significant, the impact of thousand or even millions of household rainwater storage tanks can be enormous. The main components in a simple roof water collection system are the cistern itself, the materials and the degree of sophistication of the whole system largely depends on the initial capital investment. Some cost effective systems involve cisterns made with ferrocement, etc. In some cases, the harvested rainwater may be filtered. In other cases, the rainwater may be disinfected. Storage structures for roof catchments include surface tanks like ferrocement tanks.

Underground tanks to catch surface run-off

In recent years, underground rainwater tanks have been aggressively promoted as a drought-mitigating strategy in Ethiopia and have also been supported by many other governments in East and Southern Africa. A wide range of material on this is available from the Southern and East Africa Rainwater Network (SEARNET) and organizations such as Kenya Rainwater Association (KRA). The Government of Botswana has recently ‘frozen’ their ALDEP programme which supports the creation of rainwater tanks, because they were unable to cope with the demand from rural households. It was decided to put the programme on hold until the backlog of applications had been completed. (Matoto, 2006)

The Government of South Africa has launched a pilot programme for the implementation of underground rainwater tanks to enable food insecure households to become more resilient against hunger. With an average rainfall of 450mm/a (roughly half the world average), the increased run-off available from the homestead yard, adjacent roads and fields (as compared to rooftops), is an important potential water source in this country. In hilly areas it is sometimes possible to channel surface run-off into above-ground tanks, but otherwise, underground tanks (cisterns) are preferred. Cisterns also tend to be less expensive in cases where the stabilizing effect provided by the surrounding soil reduces structural costs.

Table 11: Rainfall harvesting for homestead gardening: collection areas and storage requirements

Rainfall harvesting for homestead gardening:

Estimates of rainfall collection areas and water storage required
(for a trench garden with a gross area of 100 m²)

		Limpopo		North-West	Freestate		Eastern Cape		KwaZulu-Natal
		Polokwane	Hoedspruit	Madibogo	Bloemfontein	Tweespruit	Alice	Umtata	Dundee
Summer – supplementary irrigation through 'run-on'									
Summer rainfall	(mm)	395	444	371	430	483	416	490	640
Run-on irrigation required for 100 m²	(m³)	34	26	43	27	26	26	17	17
Rainfall collection area required (impermeable)	(m²)	**126**	**86**	**172**	**93**	**79**	**90**	**52**	**39**
Winter – full irrigation from storage									
Winter rainfall	(mm)	62	70	58	122	152	153	164	118
Winter irrigation requirement- 100 m²	(m³)	34	34	43	26	17	26	17	34
Rainfall collection area (impermeable) required to catch rain for storage	(m²)	**97**	**87**	**130**	**62**	**35**	**60**	**34**	**59**
Water storage volume required for winter irrigation	(m³)	**27**	**29**	**37**	**20**	**13**	**19**	**13**	**29**
With domestic water recycling (2 m³/month)									
Reduced water storage volume required	(m³)	***17***	***19***	***27***	***11***	***4***	***10***	***4***	***19***
Run-off collection from permeable surfaces									
Run-off coefficient	(%)	**9**	**8**	**4**	**7**	**11**	**9**	**18**	**12**

Earlier work by IWMI and the Water for Food Movement has produced the table above, showing crop water requirements, run-off potential and required tank volumes to support a 100m² homestead food garden with year-round full irrigation.

The significance of even such small, but intensively cultivated gardens for food security and occasionally even some cash earnings, are evident from the following table, which shows the 'food value' of MaTshepo Khumbane's winter (dry season) production on 220m² in 2002.

Table 12: 'Food value' of vegetable crops grown in a homestead yard in the dry season (220m^2 cultivated area)

Food grown for family of 6
- Khumbane, Winter 2002

	land (sq.m)	*food (kg)*	*months of food*
Beetroot	30	126	*7*
Broccolli	23	57	*2*
Cabbage	12	96	*8*
Carrots	12	50	*4*
Cauliflower	10	69	*4*
Lettuce	20	64	*2*
Onion	50	350	*65*
Peas	43	65	*5*
Spinash	14	42	*2*
Other	8	34	
TOTAL	*222*	*953*	

This evidence has been instrumental in South Africa's Minister of Water Affairs and Forestry, Mrs Buyelwa Sonjica's decision to provide a grant to households to enable them to create homestead rainwater storage tanks of 30m^3.

A wide range of building materials are being tested during the pilot phase, with the most popular currently being self-made cement-blocks and ferrocement. Rammed earth is being investigated as an affordable alternative, while geofabric with a bitumen coating have also been tried. A variety of plastic linings are being investigated for their durability and ease of installation and maintenance by households.

> In South Africa the migrant labour system during apartheid degenerated the rural family's traditional livelihoods. People became dependent on wage labour as their only survival strategy and this left them vulnerable when unemployment hit hard. (Khumbane *et al*, 2006)

This legacy adds to the challenge of overcoming apathy and hopelessness of the food insecure in South Africa. Therefore, the implementation of the DWAF subsidy for rainwater harvesting tanks is attempting to transfer the 'mind mobilisation' technique of the Water for Food Movement to implementing agents in the DWAF pro-poor RWH programme (DWAF, 2005).

Full-scale implementation of the DWAF pro-poor RWH programme is planned to commence in April 2007, based on the lessons learnt from the current Pilot Programme.

Conclusions and Recommendations

The following conclusions and recommendations are drawn from this study of literature on low-cost micro-AWM technologies and their potential role in addressing poverty and hunger in the countries of the Southern African Development Community.

- The SADC region is highly diverse – in agro-ecological characteristics (ranging from 20-1000mm of rainfall, very poor to very good soils, and length of growing period from less than

60 to over 300 days), in population densities and cultures, and in governance histories and systems.

- There are a large number of low-cost micro AWM technologies and approaches being used in the region (approximately 70)

- No blanket recommendations on micro AWM technologies are possible. Even within a single country, the suitable application of even a single type of micro-AWM technology may differ. (Refer to Daka 2001 experience with the initial rejection and later large-scale adoption of treadle pump technology after adaptation through farmer participation in one region of Zambia.)

- From the literature the conclusion is drawn hat the adoption of technology, including AWM, is not possible without at least some measure of creativity on the part of the adopter. As such, we need to recognize creativity as a cornerstone of food security and a stepping stone out of poverty. This implies that improved approaches and mechanisms for the stimulation of creativity are essential.

- An analysis of the data on poverty and food insecurity, especially as reflected in the nutrition-related measurements in the under-5 population, reflects a deepening household food crisis in the region.

- It is argued in this paper that the Millennium Development Goals cannot be met unless the hungry themselves are specifically targeted and mobilized. There is thus a need to analyze the scope and impact of existing programmes on hungry households and to design specific programmes (or where relevant adapt existing programs) to enable improved productivity and stabilization of the MDG target households. Water control is an essential element to such strategies.

- Market-oriented strategies, while important for regional agricultural growth, are in themselves insufficient to enable food security of discouraged households in the ten years leading up to 2015.

- This paper further argues that insufficient attention is being paid to compensating for the dwindling human energy resources in households due to the ravages of HIV/AIDS. Those micro-AWM technologies which reduce the labor requirement for food production can play a significant role in helping mitigating the effects of HIV/AIDS, also through the associated improved access to good nutrition. However, not all AWMs are labor-saving.

- While large-scale infrastructural development is critical for the long-term economic growth of the SADC countries, micro-AWM technologies offer a more cost-effective and faster way to significantly reduce rural poverty and improve nutrition while also supporting local-level commercialization. Programs promoting micro-AWM need to take an integrated approach and include training and capacity building for farmers as well as for those who are providing support services. Pressure to spend large budgets quickly must not be allowed to undermine such programs: useful experience is available in the region on implementing large numbers of small infrastructural units for remote households.

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