Experiences with Micro Agricultural Water Management Technologies:

Malawi

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1. INTRODUCTION

The study was premised on the observation that water for agriculture is increasingly recognised 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 of current initiatives in this regard is to contribute to improving the lives of rural poor people through better and sustainable agricultural water technologies/practices leading to increased agricultural productivity and incomes for small farmers in Southern Africa.

Increased global concern about the ever-dwindling availability of water resources to meet the needs of increasing human population has recognized the need for improved management, identification and promotion of water augmentation technologies. Africa is desperate to eliminate poverty and develop effective water resources whose management demands a holistic approach. That was the focal point of discussions and decisions reached at the 3rd World Water Forum which was held in Kyoto, Japan, March 16-23, 2003. Earlier in 2002, one of the outcomes of the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, was the formation of a global alliances to deal with matters of providing sustainable freshwater to individuals and communities around the world that includes through rainwater harvesting.

Malawi is prone to extreme weather events such as droughts, floods, tropical cyclones, tornadoes that often have far reaching negative impacts on human health, agriculture infrastructure and many other key socio-economic sectors. Of all these extreme weather events it is drought that has a far reaching effect on the food security of the country thereby compromising on poverty reduction policy of Malawi Government. Good examples of the climate hazards have been confirmed by the impacts of the 1948/49 and 1991/92 droughts. The two eminent droughts had harsh negative impacts on agriculture, livestock, wildlife, tourism, water resources and hydroelectric generation. From these, a number of initiatives in soil and water conservation were initiated dating back to the colonial agricultural period. While the premises for their promotion and adoption may have metamorphosed overtime, the various technologies and practices remain more important to day in the face of water deprivation from climate change and ecosystem degradation.

The study specifically was aimed at filling the gaps in knowledge by completing an inventory of existing agricultural water technologies and practices in Malawi; and to identify those technologies/practices which are most promising and should be promoted.

The study consisted of a literature review to identify organisations or projects in Malawi that employ small-scale irrigation and water harvesting technologies. The study identified two female undergraduate agricultural engineering students at Bunda College of Agriculture as enumerators and who visited with several libraries and project offices for a literature search. One male enumerator, with a B. Sc. (Irrigation Engineering) was given the task of visiting with project offices of both government and non-governmental organisations in Lilongwe to collate the same data. Certain of the data collected was collated with that obtained from the field study described below.

The study in Malawi involved visiting and consultations with Irrigation Officers and Land Resources Conservation Officers at the eight (8) Agricultural Development Divisions in the three regions of the country. In turn, where necessary, the field officers proofed findings with District Agricultural Development Officers within each of the eight Divisions. Data collected for each technology from different sources was collated or pooled together for that technology.

The study also used some existing literature to document adoption issues such as adaptability, cost effectiveness or impacts. Summary of contact details of various actors has been given as an annexe.

2. OVERVIEW OF FOOD SECURITY, HUNGER, AGRICULTURE AND WATER IN MALAWI

Malawi's economy is based largely on agriculture, which accounts for more than 90 percent of its export earnings, and constitutes 45% of the gross domestic product (GDP), and supports 90 percent of the population. Malawi has some of the most fertile land in the region.[1] Almost 70 percent of agricultural produce comes from smallholder farmers, most of whom rely on a single harvest of maize for consumption, but have a chronic lack of access to seeds and fertilizer. More than 40 percent of smallholder households are cultivating less than 0.5 hectares. Pressure on the land is relatively high. It is estimated that 85% of all arable land is in use.

Apart from maize, people grow rice, sorghum, millet, cassava, sweet and Irish potato, groundnuts and other legumes during the year. The most important cash crops are tobacco and groundnuts in the North and Central regions, pulses, cotton and tea in the South, and vegetables throughout country. In some areas sugar cane and coffee are grown. Although maize production has decreased, the production of roots and tubers has increased significantly over the recent years, as has the production of groundnuts.

Malawi's agricultural development has for a long time heavily relied on rainfed agriculture. Recent droughts have adversely affected agricultural production worsening the plight of the smallholder and affecting the economy as a whole. Rainfed agriculture is therefore unreliable if sustainable food security, poverty alleviation and rural development are to be achieved. Malawi has, therefore, to step up efforts in the promotion of irrigated agriculture, especially among its smallholder farmers. A study in Malawi by FAO/IPTRID in 1996 confirmed that smallholder irrigated agriculture can contribute significantly to food security, poverty alleviation and rural development. A Sub-Regional workshop organised by FAO/IPTRID, with financial support of the Global Water Partnership and held in Zimbabwe in 1997 further supported this finding. It is estimated that only about 28,000 ha are under irrigation in Malawi compared to an estimated potential of 100, 000 ha for formal irrigation development and 200,000 ha for small-scale irrigation in the dambo areas.

A number of constraints are responsible for the low proportion of land put to irrigation. The first constraint relates to siltation of water courses due to poor land use practices. This makes it difficult to use water for irrigation. Secondly, farmers face high interest rates for their agricultural inputs. As a result farmers grow their crops without inputs such as fertiliser. Thirdly, there are poor market linkages and lack of agroprocessing and storage facilities. These act as a deterrent to growing surplus and diversified range of crops that may not necessarily be consumed within the rural economy. Fourthly, there is inadequate sector capacity to support irrigation programs. This leads to inefficiencies in the use of the irrigation facilities with smallholder farmers earning little benefits from their irrigation activities. Fifth, there is lack of irrigation culture among farmers in Malawi. While the picture is changing, most farmers still seem not to take irrigation as an important source of food and cash income. Lastly, poor farmer organisations make smallholder farmers unable to compete with big farmers. Farmers operating on their own do not have sufficient bargaining power or position on the market.

Despite these problems, there are a number of irrigation and water harvesting technologies currently being practised by smallholder farmers in Malawi. These technologies include, but are not limited to, motorised pump based schemes, sprinkler irrigation schemes, treadle pump based schemes, river diversion schemes, and various soil and water conservation and rain water harvesting technologies.

3. DOCUMENTATION OF IDENTIFIED FIELD PRACTICES AND THE ROLE OF VARIOUS ACTORS

3.1 Identified field practices

The study identified twenty-seven (27) agricultural water technologies and practices that encompass (i) soil and water conservation measures, (ii) water harvesting and management and, (iii) irrigation practices. The detailed descriptors of these technologies are given as an annexe based on typology given to meet study objectives.

A. Soil and water conservation

A.1 Terracing

- (a) Vegetative cover
- (b) Fanya juu terraces
- (c) Stone lines
- (d) Terracing
- (e) Small earth bunds/ raised footpaths
- (f) Gully control and utilisation

A.2 Conservation farming

- (a) Minimum tillage
- (b) Contour cultivation and ridging
- (c) Tied ridges/ box ridges

B. Water harvesting and management

B.1 Pitting systems

(a) Infiltration pits/ retention ditches/ contour furrows/ swalles
(b) Planting pits

B.2 Runoff harvesting

(a) Road /footpath runoff harvesting
(b) Stream/ flood diversion

C. Irrigation and Water Storage Systems

C.1 Micro-irrigation

(a) Bucket drip irrigation system

C.2 Conventional irrigation systems

(a) Sprinkler irrigation system
(b) Treadle pump irrigation system
(c) River diversion irrigation system
(d) Residual moisture cultivation

C.3 Bag gardening

C.4 Water storage systems

(a) Roof harvesting with above ground tank
(b) Wells
(c) Under ground tanks
(d) Earth dams
(e) River impounding/weirs
(f) Underground water springs

For each of the technologies presented above, an attempt was made to present the purpose and impact of the technology. What is apparent is that every one of the initiatives has been introduced and/or developed with the aim of improved plant production (for food, cash income or both), either as an immediate, primary purpose or sometimes as a combined aim, together with the need to harness water or control soil erosion.

In terms of costs and benefits of these technologies, this evaluation is weak in terms of quantification. The reason is simply that very few of the initiatives have yet been adequately validated in numerical terms, either by the land user or by research agents. Where figures are given, they are generally our estimates in consultation with field officers and have accepted them to be credible after relating to comparable, documented technologies.

Data on economic benefits are correspondingly weak unless technical methods had been employed necessitating a different kind of study, such as an impact study. While the owners of the technologies or officers that introduced them may have a vested interest in "talking up" the benefits, even so, these benefits must be real in order to underpin the investment. Otherwise they would simply be uneconomic.

With respect to adoption, the data gathered regarding numbers or perception has variable reliability. Again, it comprises estimates confirmed by, or originating from, field officers. Adoption is in all cases without outside incentives or start-up kits or resources. It is possible that in some cases, further adaptation after/ during adoption may have occurred. In some cases, the technologies have just been introduced while in some, the technologies are site specific and have hardly spread at all.

3. 2 Examples of potential to move technologies

The key to unlocking Malawi's agricultural potential is enabling farmers of all types and non-agricultural businesses to undertake new initiatives by lessening or removing constraints to increased production. This may require that technology is appropriate for smallholder farmer needs; that dissemination mechanisms for technology are broadened through utilisation of a wide range of technology dissemination mechanisms; that technologies are realistic in terms of inputs and costs, and that access to credit is made easy at affordable rates if access to technology impinges on capital outlay. Often it is alleged that government departments, unlike NGOs, do not deliver. Two examples are given below to illustrate the contrary and other examples abound.

The Department of Irrigation while in the Ministry of Agriculture was provided with funding by the Emergency Drought Recovery Project (World Bank) to meet the task of improving access to irrigation through rehabilitation of irrigation schemes or canalisation in 2003-4. Nearly 11,900 m of canals from river diversions providing water to 66 ha and benefiting 1,026 farm families were constructed throughout the eight Agricultural Development Divisions (ADDs). About 38,610 canals serving 1,407 ha of irrigation schemes and 3,656 farm families were rehabilitated. The work showed that against constraints often cited in policy documents such as inadequate capital; lack of capacity; lack of coordination; and, fragmented development, judicious application of community mobilisation principles and sector wide approaches can deliver development.

For instance, lack of capital or inadequate funding, was circumvented by establishing self-sustaining revolving fund deposited with a commercial bank and that is owned and governed by farmers themselves. Lack of capacity was met by forming scheme management committees through which members were trained in administration and management of people and resources. And development of projects in isolation was circumvented by integrating canalisation projects with improvement of road network or aquaculture development through linkages with other donor or NGO development projects. It is noted however, that irrigation farming is expensive either in time or money. In this respect, while ensuring food security, farmers needed to move from subsistence to commercial agriculture.

Another illustration is the Department of Land Resources Conservation in the Ministry of Agriculture which was responsible for establishment of rainwater harvesting interventions to combat water deprivation during the same period with funding from the same source. Across the eight ADDs, 50 tanks of 2,500 to 10,000 litres capacity were constructed. Each tank constructed was targeted for farm families of about 15-20 people. In Karonga ADD, 28 road runoff harvesting structures and 54 hill-side runoff trenches were constructed. The Department committed itself to the AIDS Action Group in Lilongwe, to use rooftop rainwater harvesting as an intervention in HIV/AIDS affected households. Thus, the potential of rainwater harvesting to mitigate water deprivation in disadvantaged households is immense. This evaluation observed that rainwater harvesting structures were built for farmers with external funds. There will be need to emphasise the principle of demand driven adoption and least of all, cost sharing as the technology gets widely adopted.

This study proposes interventions in the following areas: (i) environmental protection, (ii) water to augment rainfed agriculture, (iii) water to augment irrigated agriculture, and, (iv) water for domestic use to free women and the girl child labour for other productive purposes.

3.3 Technologies for Environmental protection

Rationale. In general, soil erosion by rainwater arising from reduced vegetative protection, tends to deteriorate the ecological balance of the catchments. The shortage of water due to decrease in the discharge of springs and wells can be expected. Since this phenomena is due to improper land and water uses, particularly inability in optimizing the use of available rainwater at early stage in the hydrological cycle, it is the management of rainfall and resultant runoff which seems to be a key to many aspects of ecological control, as well as supplying water, raising production, and increasing incomes of rural or watershed dwellers. It is therefore critical to identify those technologies that have an immediate bearing on harnessing and managing rainfall and runoff with visible impact.

Contour ridging. Conventional land preparation practices in Malawi are those where ridges are remade on 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. 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, overtime, 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 a s 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) in at the soil surface or in the upper layer of the sol profile if ridges are tied or pits are made.

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

Minimum tillage. In a similar manner, conservation farming, which has been promoted by the Sasakawa Global 2000 program and widely adopted by farmers, is based on the premises for multiple economic and technical benefits. The aim of using conservation agriculture technology, minimum tillage in Malawi, is to maintain the field weed free, increase retention of moisture in the soil and reduce erosion by maintaining the residue of maize on the surface and reduced cost of production to farmers. In Malawi 48 % of the total labour cost is used in weeding but with minimum tillage, farmers do not need to till the soil since the technology advocate the use of herbicides and accompanying package comprising of hybrid seed and fertiliser. The build-up of organic matter, the disappearance of weeds over years and the improvement of soil physical characteristics that is expected from the conservation agriculture is a medium to long-term phenomenon that will probably start showing up several cropping season latter.

The technologies being proposed for amplification are thus as follows:

(a) Contour ridging
(b) Gully erosion control
(c) Minimum tillage

3.4 Technologies for rainfed agriculture

Rationale. Most of Malawi receives annual rainfall ranging from 600 mm in the Lower Shire Valley in the south; to 1225 mm in the higher plateau areas (some get 3000 mm). Customarily, there is enough rainfall for at least one main crop in the year. But sometimes there is crop failure due to poor distribution pattern in the season. The rain intensity is often greater than soil infiltration rate causing runoff and erosion. The rain season lasts between late October and April and may be interspaced with one to two weeks dry spell, when some farmers lose their crop or sustain drastic reduction in crop yields. Rainwater harvesting water activities, that include for instance *in situ* practices such as conservation tillage, may be cheap and appropriate antidote to this phenomenon in that they aim at conserving or storing the runoff from catchments for subsequent use. Small-scale water harvesting systems, which encompass a broad set of technologies from soil and water conservation systems for infiltration enhancement to small earth dams for supplemental irrigation, have an important and untapped potential of contributing to improved soil and water management and thereby increased crop yields.

Planting pits. These are adaptable to wide range of crops that include sugarcane and fruit trees. In this study, the observation is made that this technology can be adapted for banana cultivation in the Shire Highlands where successive years of low rainfall has reduced productivity of the banana. In East Africa, banana is an important economic crop as is the case with farmers in the Shire Highlands. However, the crop is often planted on the flat, in furrows or in pits unlike in Malawi where the crop is often planted on the ridge or contour. The technology comprises a combined structural/agronomic measure and its impact in soil and water conservation is achieved through improving ground cover and harvesting both runoff and sediment.

Road runoff harvesting/ infiltration ditches. There are no precise technical guidelines for this type of water harvesting in Malawi. However, farmers in rice growing flood plains have perfected road runoff capture, a technology which can be easily emulated elsewhere using conventional land husbandry principles for design and layout. In soil conservation terms, it reduces land degradation and soil erosion by water. Its primary aim however is to increase soil moisture for crop production and achieves this impact through water harvesting. Infiltration pits/ retention ditches are one way of harvesting water from roads or other sources of runoff but they are distinct technologies in their own right.

The technologies being proposed for amplification are thus as follows:

(a) Minimum tillage
(b) Infiltration /retention ditches
(c) Planting pits
(d) Road /footpath runoff harvesting

3.5 Technologies for irrigated agriculture

Rationale. Since there are limited opportunities under rainfed agriculture to produce sufficient food both at household and national levels, crop production has been intensified through a number of interventions including small scale irrigation using treadle or motorized pumps, or self help irrigation schemes in flood plains. It is estimated that only about 28,000 ha are under irrigation in Malawi compared to an estimated potential of 100, 000 ha for formal irrigation development and 200,000 ha for small-scale irrigation in the dambo areas. Irrigation development in Malawi began as far back as 1949 at Limphasa in the Northern Region. In the mid 1950s two more schemes were added on the Chilwa/Phalombe plain. Since then a number of schemes have been developed and a variety of technologies introduced and/or tried for use by smallholder farmers. Some of these have been adopted by farmers and enjoying relative success while others have failed to impress. This study proposes the following technologies for amplification.

River diversion/ canalisation. In Malawi, about 10 years ago, almost invariably the river diversion/surface technology was used for production of rice. The technology was most commonly used in Shire Valley, Machinga, Salima and Karonga ADDs. Karonga, Salima and Machinga ADD accounted for 81% of the flood plain area in Malawi and this could well explain this. The presence of perennial rivers is another probable explanation. However, this is not the case now. The Department of Irrigation, then in the Ministry of Agriculture was charged with the task of improving access to irrigation through rehabilitation of irrigation schemes or canalisation in 2003/4. In terms of the latter, nearly 11,900 m of canals from river diversions providing water to 66 ha and benefiting 1,026 farm families were constructed throughout the eight Agricultural Development Divisions (ADDs). About 38,610 m of canals serving 1,407 ha of irrigation schemes and 3,656 farm families have been rehabilitated. Study visists made to Ntcheu learnt that the concept of canalisation dates back to 1989-90 when Mozambican refugees were in Ntcheu and introduced the technology. However, since then, there were only two canals and water management and farming was disorganised, being done ad hoc by the farmers themselves.

Increased area of cultivation and increased yield per unit input were some of the expected outcomes from the projects. There was however, slow integration between water utilisation and identification of yield and income enhancing crop enterprises particularly in Salima RDP than Ntcheu RDP. Farmers in Nkhotakota RDP in Salima ADD are said to have performed relatively better using canalisation. Farmers had the know-how to maintain the physical integrity of the canals, manage the water in the canals and its application for irrigation. In Ntcheu RDP, farmers learnt new production technologies through the canalisation schemes, such as Sasakawa methods, Mleranthaka methods (conservation farming). They learnt organisational management (clubs and schemes) and financial management through establishment of revolving fund which they were managing independent of agricultural staff.

Treadle pump irrigation. In Malawi although the treadle pumps were introduced in 1996 exclusively for irrigation purposes, they are now also being used for household water supply as well as brick making. The system operates on the principle of pumping water manually from a low to a high point from which it flows by gravity through a system of channels to irrigate crops. The treadle pump was currently ranked third among existing technologies in terms of number of farmers served and this it has managed to achieve within three years of its introduction. Among the major contributors to its relative success in such a short time is that it is simple to operate and robust with few breakdowns. A number of studies have shown that treadle pump irrigation has offered tremendous opportunities to farmers who have in varying ways dramatically increased agricultural production while enriching their livelihoods. Properly managed, treadle pump irrigation can greatly improve household food security, incomes, nutrition and health on a sustainable basis without detrimental effects to the environment. The logic behind this potential lies in the ready access to technical knowledge and support for under-utilized land, water and labor resources during the long dry season.

It has often been argued that it is not socially acceptable to women and that it is energy demanding robbing men and women of their energy. However, its thorough testing and adaptation in many parts of Malawi demonstrates many features ideally suited to smallholders that have shown an improvement in income and livelihoods. The Total Land Care, an NGO, has developed a successful model, with farmers, to address farmers' lack the skills, knowledge and resources in taking advantage of the demonstrated potential and availability of the treadle pump technology.

Water storage systems (river impounding/weirs; small earth dams). It is recognized that in the flood plains, water recedes with the advent of the dry season and water extraction for irrigation using pumps is largely dependent on underground aquifers and intermittent rivers/streams. Ground water has been developed mainly for drinking water supply of rural and per-urban areas dating back to the 1930s. In 1997, there were over 11,000 boreholes and over 5,000 protected shallow wells and the number of boreholes has increased to over 50,000 by 2003. Invariably, whether ground water is used for irrigation or as potable water, there are limited deliberate or conscious efforts aimed at recharging groundwater tables. This study proposes that water storage systems are technologies that enhance availability of surface water for irrigation.

Residual moisture cultivation. Government statistics show that only 14% of suitable land is presently under irrigation, and that this land has ready access to reliable water from lakes, rivers, streams, dams and underground sources. These areas are typically fertile, enabling farm households to intensively manage small plots of land with high returns to their labour and investment. Often, in these areas, farmers are growing crops based on residual moisture and only where there is external intervention through provision of watering cans, treadle pumps or canalisation is recourse made to irrigate crops. This study proposes that water storage systems are technologies that enhance residual moisture cultivation through ground water recharge in addition to making surface water available for irrigation.

The technologies being proposed for amplification are thus as follows:

(a) Treadle pump irrigation system
(b) River diversion irrigation system (canalisation)
(c) Residual moisture cultivation
(d) Small earth dams
(e) River impounding/weirs

3.6 Technologies for domestic water to free labour to productive uses

Water deprivation and poverty. Water deprivation is part and parcel of poverty, which is living below the standards that society judges as minimally required for human well-being. Water deprivation jeopardizes health, income, and free from drudgery. Carrying buckets, drinking unsafe water, and also lacking the access to water to improve sub-minimal incomes are increasingly seen as important aspects of integrated water management. The findings of the Malawi Social Indicators survey reveal that only one third (37%) of the Malawian population has access to safe water for drinking that is located within a distance of less than one-half kilometre. This figure increases to 48% when the distance is increased to one kilometre. Only 2.1% and 16.4% of the Malawian population have access to piped water in dwelling houses and a public tap, respectively. The most common type of water facility used in Malawi is an unprotected well or spring while the most popular safe source of water is a borehole. It has been observed that in rural areas, families tend to rely on traditional water sources which often get polluted in the rainy season.

Labour from women and the girl child. Apart from contributing time and energy to agricultural production tasks, women also manage household activities including the care of family members. Malawi Government (1994) reported studies which showed that women in Malawi spent almost as much time in farm work (20%) as in domestic activities (23%). Yet, domestic responsibilities are often viewed as deterrent for women in increasing agricultural production. In a study conducted in two villages in Lilongwe, Central Malawi, a man's work day lasted 4-6 hours while a woman's work day lasted 12 hours with household tasks taking 4-6 hours where gathering firewood and collecting water were the two major time consuming activities carried out by women. It was further reported that women spend 39 days in a year caring for the sick or being sick themselves (Malawi Government, 1994). Perhaps what is further critical to note is that most of the woman's tasks include odious physical work and distance, which must be performed daily with the crudest tools, under the toughest conditions. There is thus a limit to how far women's time and energies can be stretched. When the limit is reached, agricultural production or household needs suffer. In view of the fact that not much has been achieved in the area of work load reduction, the Land Resources Conservation Department and other stakeholders in Malawi are quite right in supporting rainwater harvesting for domestic use in water deficit locations across the country through their resident officers in the eight ADDs to ease the pressure of work on women.

Vulnerable populations. Third, if there are water sources to tap from, poor people are often disproportionately affected. They are the least to be provided directly or indirectly with physical infrastructure for obtaining water while their means to tap water are weaker, if they have the means at all. Of critical concern is the realisation that there are vulnerable groups in the rural and peri-urban areas that comprises of the disabled, female-headed households and the orphaned. The latter, principally arising out of the AIDs pandemic. Over and above their pursuit of daily sustenance, they have to contend with purchasing or abstracting water, whose availability is erratic and if available either at the wrong time of their daily calendar or they have to physically struggle to access it. The Land Resources Conservation Department graciously committed itself to the AIDS Action Group in Lilongwe, presently working in Chabwe Village, to use rooftop rainwater harvesting as an intervention in HIV/AIDS affected households. The potential of rooftop rainwater harvesting to mitigate water deprivation in other disadvantaged households is immense. The need to augment potable water for domestic use through rainwater harvesting is attainable and cannot be overemphasized.

The technologies being proposed for amplification are thus as follows:

(a) Roof harvesting with above ground tank
(b) Under ground tanks
(c) Small earth dams
(d) Underground water springs

3.7. Enterprise budgets for a sample of agricultural water technologies recommended

3.7.1 Contour ridging and minimum tillage technologies

The traditional contour ridging technology is what most farmers are using and this technology is where farmers plant on ridges 75-90 cm apart reconstructed every year; and (ii) weeding once and earthing up the ridge using a hoe. With minimum tillage, farmers do not need to till the soil since the technology advocate the use of herbicides. In Malawi, the most available herbicides are the post emergence Roundup and the pre/post emergence Bullet. It is recommended that Roundup is applied 7 days before planting and the residual herbicide Bullet within 3 days after planting in order to maintain the field weed free. The most important aspect about the system is that it does not require clearing and burning of crop residue since the residues are left on the surface.

Table 1. Contour ridging and minimum tillage enterprise budgets[ab]

Activity	Contour ridging	Minimum tillage
Clearing	162.50	0.00
Ridging	212.50	0.0
Seed cost	62.50	146.25
Roundup + Labour	0.00	175.00
Roundup application cost	0.00	40.00
Planting labour	37.50	75.00
Fertilizer cost	350.00	603.00
Fertilizer application cost	62.50	125.00
Weeding twice labour cost	375.00	0.00
Bullet cost + Labour	0.00	295.25
Bullet cost of application	0.00	40.00
Banking up	175.00	0.00
Harvesting	175.00	212.50
Cost/plot (0.1ha) kwacha	1,612.50	1,712.00
Cost per one hectare kwacha	16,125.00	17,120.00
Yield per hectare kilograms	800.00	6,098.00
Price of maize per kilogram	12.00	12.00
Gross income kwacha	9,600.00	73,176.00
Net income Kwacha	6,525.00	56,056.00

[a]Currency: 1 US $ = 63 Malawi Kwacha at October 2002.
[b] J. A. Valencia and N. Nyirenda (2003)

3.7.2 Treadle pump technology

It is noted that the proliferation of treadle pumps in Malawi still needs a thorough, objective assessment of the pros and cons of each model to facilitate an informed purchase decision by suppliers and farmers. Nevertheless, some data shows that with treadle pump use many farmers had increased the variety and quantity of crops in the dry season, which has enabled them to sell and get more money as shown in the table below.

Table 2. Treadle pump enterprise budget[a]

	Total Income	Total Cost of Production	Total Net Income	Average Income	Average Cost of Production	Average Net Income
No treadle pump	19,950	4,515	15,435	1,246.88	282.19	964.69
With treadle pump	210,584	52,096	158,488	13,161.48	3,256.00	9,905.48
Change in income	190,634	47,581	143,053	11,914.60	2,973.81	8,940.79

[a]Shigemichi Itamura and Kensaku Shinohara (2004)

3.7.3 Comparative analysis of different irrigation technologies and water management techniques

Table 3. Cost of irrigation for different irrigation technologies based on a bean crop[ab]

Costs (MK[1]/ha)	Motorized pump	Treadle pump	Watering can	Gravity	Residual moisture
Fixed costs					
Motorized pump	3,636.36				
Treadle pump		3,093.60			
Water can		57.78	173.33		
Sprayer	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Family labour	1,593.94	4,433.33	2,033.33	2,903.33	966.67
Total fixed costs	7,230.30	9,584.71	4,206.66	4,903.33	2,966.67
Variable costs					
Fuel	55,718.44				
Seed	2,800.00	2,800.00	2,800.00	2,800.00	2,800.00
Fertilizer	7,464.00	7,464.00	7,464.00	7,464.00	7,464.00
Pesticides	20,548.67	14,800.00	15,360.00	14,040.00	15,000.00
Hired labour		5,194.44			6,666.67
Total variable costs	86,531.11	30,258.44	25,624.00	24,304.00	31,930.67
Total costs	93,761.41	39,843.15	29,830.66	29,207.33	34,897.34

[a] 1 USA $ = 114 Malawi Kwacha (MK), September 2003.
[b] Kadyampakeni (2004)

Table 4. Gross margin analysis for the different irrigation technologies based on a bean crop[ab]

Treatment	Gross margins (Malawi Kwacha[1])		
	Male farmers	Female farmers	Mean
Motorized pump	-23,953.33	-11,380.00	-17,666.67
Treadle pump	65,664.50	29,687.56	46,141.56
Watering can	2,521.40	76,418.00	27,176.00
Gravity irrigation	183,372.08	97,136.00	146,276.00
Residual moisture	17,360.00	5,923.00	9,709.33

Significant differences: $t_{0.01,8\ calculated}=4.527 > t_{0.01,8\ tabulated}=2.306$ ($P\leq0.01$);

[a] 1 USA $ = 114 Malawi Kwacha (MK), September 2003.
[b] Kadyampakeni (2004)

3.7.4 Diversion of Flood Water from Ephemeral Streams

Yield increase: 2.5 t/ha
Increase in Gross margins: K18,230.00/ha
Increase in Return to labor: K3.125/pday
Benefit:Cost Ratio: 1.55

3.7.5 Rainwater harvesting

Table 5. Above ground rainwater harvesting system based on bill of quantities for 50-m^3 brick tank[a]

Item	No. of units		Cost
Cement	137.37	bags	178,583.00
Wire mesh	49.24	kg	6,351.96
Reinforcement mesh	76.13	kg	9,820.77
Gutters	50	m	15,000.00
Yard piping	36	m	9,000.00
Bricks	3,869	number	3,869.00
Sand	119.20	m^3	238.39
Quarry stone	2.02	m^3	7,810.60
Subtotal			**11,917.99**
Total			**230,673.80**

[a] 1 USA $ = 124 Malawi Kwacha (MK), November 2005.

Table 5. Below ground rainwater harvesting system based on 10-m^3 tank[a]

Items	Quantity	Unit cost	
Cement	24 bags	K1,400/bag	33,600.00
Sand	10 tons	K6,000/trip of 4 ton	15,000.00
Bricks	200	K120/brick	24,000.00
Water proof cement	4 bags	K1,400	5,600.00
Labour	24 mandays	K200/day	4,800.00
Total cost			83,000.00

[a] 1 USA $ = 124 Malawi Kwacha (MK), November 2005.

4. REVIEW OF AGRICULTURAL WATER PROGRAMS UNDER THE INITIATIVE TO END HUNGER IN AFRICA (IEHA)

This program, whose framework has earlier been applied by certain NGOs in Malawi, was instituted with the mandate to reduce poverty through irrigation and smallholder markets where in principle, pro-poor rural market systems are created based on water management and identification of market opportunities. Key elements of the vision include: the establishment of a framework to operationalise integrated market system for the rural poor; organise smallholder farmers to be competitive with large scale industries; incorporate sustainable natural resource management; and, realise gender equity and environmental sustainability goals.

It has been established from USAID, that the initiative has not been instituted in Malawi. However, USAID, embarked on a 2004 initiative called Hi-Life that involves eight (8) NGOs. The NGOs include: National Smallholder Farmers Association (NASFAM), Catholic Relief Services (CRS), Africare, CARE Malawi, Save the Children Foundation (USA), Salvation Army, and World Vision International, among others. The nature of the work is in support of pro-poor (expenditure) projects in line with the Malawi Poverty Reduction Strategy Paper of 2002 or its revised successor the Malawi Growth Strategy Paper. This section reviews work by the National Smallholder Farmers Association (NASFAM) and Total Land Care that exemplify market-led approaches to irrigated (and rainfed) agriculture as a precursor to the institutionalisation of the IEHA.

NASFAM is a member owned, democratically governed and non-profit organisation providing business services to its smallholder members. NASFAM is made up of commercial agribusiness associations that are independent, self governing and financially viable. NASAFAM provides "soft services" such as information services, training, policy advocacy and outreach to reduce the public-private sector divide. The irrigation program for NASFAM concentrated on paprika, sugar beans and maize all for cash and produced using treadle pumps, residual moisture, gravity irrigation and sprinkler system irrigation without providing any input support. Farmers were told in advance that there was a ready market for sugar beans and they had to find their own market for maize and paprika, the latter, via the Paprika Association of Malawi. Coupled with training on the irrigation technologies, farmers successfully disposed of their produce although there were some attendant problems. Notable problems included the need to link treadle pump irrigation with water harvesting; linkages/partnerships between buyers, input suppliers and people with technical know-how.

Total Land Care (TLC) in partnership with the Ministry of Agriculture spearheaded development of an extension/credit system for small scale irrigation and production of quality extension and training materials for staff and farmers. TLC has also succeeded in the evaluation of treadle pump models and in the training of government and NGO trainers. The organisation has also succeeded in linking farmers to markets.

The extension approach involved the areas' potential in terms of available land and water, markets, farmer interest and community structure/ leadership. The role of TLC in facilitating development and the nature of its support services were explicitly explained to empower the community to adopt, refine and expand the treadle pump irrigation. TLC provided the means to establish village-based revolving funds through market surveys and village-based extension approach. Market surveys helped to identify the best subsector/ products/ opportunities for smallholder market channels, segments and trends. TLC facilitated the formation and operation of village revolving funds in which villagers form clubs that agree terms for start-up support from TLC after which the club becomes independent with 12 calendar months.

The critical lesson learnt was that the attractiveness of irrigation to smallholder farmers does not only depend on potential to stabilise food security and market opportunities but more on the type of extension package provided. A credit based extension package coupled with intensive training and supervision and the establishment of farmer-managed revolving fund is needed.

5. SUMMARY OF KEY ACTORS IN MICRO IRRIGATION AND RAINWATER HARVESTING

It has been argued in this paper that government programmes in irrigation and water harvesting have performed just as well as those implemented by non-governmental organisations. It is perhaps how the project cycle has been used by various actors that has enabled varying success stories and also less successful endeavours. This section briefly describes the thrust by different actors that has impacted the realm of water technologies.

5.1 Role of Government of Malawi

Government has been the main driving force behind the development of smallholder irrigation and water harvesting initiatives in Malawi through the Smallholder Flood Plains Development Programme, the Department of Irrigation and the Department of Land Resources Conservation. This it has done through the promotion of self-help and government irrigation schemes and various water harvesting structures. In 1990/91 there were 17 self-help schemes covering an estimated1, 753 ha of land and involving 3, 635. The objectives were to increase rice production and exports, settle farmers and improve farmers' incomes. In 1998 there were 16 Government schemes located in the Karonga lakeshore area, the Salima-Nkhotakota lakeshore area, the Lake Chilwa Plain and the Lower Shire Valley. To-date, the schemes covered a total area of 3, 600 ha. All of these schemes except two are based on gravity-flow abstraction from rivers and the irrigation distribution systems consist, in general, of unlined open earth canals designed to supply plots of 0.4 – 0.8 ha.

The governments departments namely, Department of Land Resources Conservation and the Department of Irrigation have since partnered with NGOs and donors to advance irrigation and water harvesting technologies. Of notable importance was the sustainable small scale irrigation development project under the Government of Malawi-European Union Public Works Programme that lasted 5 years till 2004. A total of 2900 treadle pump irrigation schemes and 67 stream diversions have been established. In similar manner, the Emergency Drought Recovery Programme funded by the World Bank provided funding for the first comprehensive water harvesting works across the country.

5.2 Role of non governmental organisations

5.2.1 Irrigation projects/ programmes by NGOs

A varied range of irrigation and water harvesting products have been offered by several local and international NGOs. These include safety net programs, asset building for households or communities, value chain approaches, and food security initiatives e.g., by CARE Malawi, Action Aid, Concern Universal, Concern Worldwide, Sasakawa Global 2000, Total Land Care, and World Vision Malawi. Further, farmer associations have also been proactive in advancing irrigation and water harvesting culture amongst farmers. These include: the Association of Smallholder Seed Multiplication Groups (ASSMAG), and the National Smallholder Farmers Association (NASFAM).

5.2.2 NGOs/ institutions with potential to advance irrigation/ rainwater harvesting

Presently, through the Civil Society Network on Agriculture (CISANET), an umbrella NGO for all NGOs working on agriculture in Malawi, there has been a request that volunteers evaluate past irrigation initiatives in Malawi. The first presentation will be heard on January 25, 2006. While different players have paraded their success stories in the irrigation sector, a comparative analysis of different initiatives has not been done. However, based on present information, one can single out the following NGOs and institutions as having shown the potential (technical expertise, breadth (national level) and relevant linkages) to pioneer successful projects/programmes:

Irrigation	**Rainwater Harvesting**
World Vision International	World Vision International
Total Land Care	Sasakawa Global 2000
Department of Irrigation	Department of Land Resources Conservation
OXFAM	Rainwater Harvesting Project – Bunda College
Smallholder Floodplains Development Project	

5.3 Role of the private sector

The largest irrigation schemes in Malawi, namely Nchalo Sugar Estate in Chikwawa and Dwangwa Sugar Estate, are owned by a private firm called Illovo. Private companies producing tea and coffee also practice irrigation. Apart from the numerous tinsmiths that produce watering cans participation of the private sector is limited in as far as small-scale irrigation technologies are concerned. In the Indigo Business Directory of 2001 there are 21 companies listed as being involved in irrigation. In a survey of 27 organisations in 1997, 20 organisations indicated that they were involved in testing, installation, training, procurement and after-sales of irrigation equipment, mainly pumps, motors, pipes and sprinklers. Most of these are small organisations operating as agents of larger companies outside. They are mostly located in the Cities of Blantyre and Lilongwe and have not been able to provide similar services to the rural based smallholder farmers.

Most of the registered building and civil engineering contractors in the country are concerned mainly with building projects and relatively few can be said to have direct experience of the construction of irrigation and drainage works. The Department of Irrigation has in the past contracted out jobs to two contractors owned by ex-staff members of the department and these have been able to carry out the construction of small-scale structures, canals, drains and head works. However, they generally lack heavy earthmoving capacity. Most engineering plant is, in fact, owned and operated by a very limited number of contractors specialising in road-works.

5. 4 Status of local manufacturing and services for irrigation technologies

The local manufacture of irrigation technologies for smallholder agriculture is almost non-existent. While there are a lot of local artisans manufacturing and repairing watering cans, most of the technologies currently being promoted among smallholder farmers are imported. For example, there are only three companies/organisations with capacity to manufacture the treadle pumps, for example. These are APED Engineering, MIRTDC and VICS despite that a number of local artisans were trained. Besides this local manufacture has not led to a reduction in the price of the technology. Locally made pumps are more expensive than imported ones.

Most of the technologies in use have been imported into Malawi directly by the Department of Irrigation and do not have any local dealership. In order to provide for service of the technology in rural areas, training in simple maintenance has been conducted for the farmers. Because of lack of technical knowledge and even simple equipment, farmers have not been able to carry out the necessary maintenance with the result that frequent breakdowns, especially among motorised pumps, are commonplace.

5.5 Marketing and trade in irrigation technologies

Apart from the numerous tinsmiths that produce and sale watering cans participation of the private sector is limited in as far as small-scale irrigation technologies are concerned. In the Indigo Business Directory of 2001 there are 21 companies that are listed as being involved in irrigation. A survey in 1997 found 20 companies that were involved in testing, installation, training, procurement and after-sales services of irrigation equipment, mainly pumps, pipes, motors and sprinklers. Most of these companies are small companies located in Blantyre and Lilongwe and have not been able to provide the same services to rural areas of the country.

5.6 Design standards, norms and quality criteria for irrigation technologies

According to the Malawi Bureau of Standards (MBS), there are no Malawi standards on irrigation technologies at present. The only Malawi Standard available is MBS 348:1991 for AFRIDEV deep-well hand pump which is not designed for irrigation purposes although it may be used for very small scale irrigation. In the absence of Malawi Standards there are International Standards developed by the International Organisation for Standardisation (ISO) which can be used. The Bureau can enforce such Standards if need be and if found necessary, it can also adopt such standards, making them legal frameworks for Malawi. The MBS have no immediate plans to develop own Standards for irrigation technologies, but would be willing to do if need be.

6. RECOMMENDATIONS AND CONCLUSIONS

While the National Irrigation Policy and Development Strategy (NIPDS) were developed, there has not been much circulation of the paper for use by different players. Furthermore, relevant documents that include the pillars of the NIPDS and its critique; the assessment of capacity for irrigation development in Malawi, and the evaluation of previous irrigation development initiatives in Malawi needed to have been brought in the fore front to guide or inform the kind of systems, technologies and practices relevant for growth of the irrigation sector. And, perhaps more importantly to provide impetus for review of relevant policy initiatives in the Ministry of Agriculture.

It is quite clear from this study that smallholder farmers in Malawi have not had a wide selection of technologies to suit their technical and financial ability, the type of water source to be utilised, types of crops to be grown and their fields' terrain. Thus there is still great need to create an enabling environment for demand driven uptake of irrigation technologies by widening the choice of technologies available to the smallholder farmer. In this paper some of the irrigation and water practices that have been identified as having potential for application under smallholder conditions in Malawi have been described.

The lack of standards relevant to smallholder irrigation technologies is a serious weakness, especially at a time when efforts are being made to promote such technologies on a wider scale. It means, among other things, that purchasers of the technologies have no means of comparing the quality or performance of such technologies produced or supplied by different manufacturers. In addition, there is no way of co-ordinating the technical standards of technologies used in various donor programmes which may lead to serious repair and maintenance problems as a result of incompatibility of components and systems. It is, therefore important that standards be developed for the irrigation technologies being promoted in the country.

The process of identifying alternative technologies is by nature an on-going process since new technologies are continuously being brought onto the market and indeed public domain. Throughout the technology identification and selection process the type of crops (or animals) to be grown by the farmers has not been used as part of the criteria. It is often expected that the appropriate crops will be chosen for the technologies identified. In addition technologies need to be identified as systems that encompass categories defined as water abstraction technologies, water lifting devices, water conveyance systems and water distribution technologies. For water lifting technologies the power source must be looked into carefully in order to lessen economic or social burden on farmers.

ANNEXE 1. REFERENCE ADDRESSES/ CONTACTS FOR INSTITUTIONS IN MALAWI ON AGRICULTURAL WATER TECHNOLOGIES

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ANNEXE 2. REFERENCES

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Valencia, J.A. and N. Nyirenda. 2003. The impact of conservation tillage technology on conventional weeding and its effect on cost of production of maize in Malawi. In: Mloza-Banda, H. R. and Salanje, G.F. Proceedings of the 19th Biennial Weed Science Society Confrence for Eastern Africa. Lilongwe: WSSEA.

ANNEXE 3. ACRONYMS USED IN THE INVENTORY

ADB	African Development Bank
ADD	Agricultural Development Division
CADECOM	Catholic Development Commission
CPAR	Canadian Physician for Aid and Relief
EPA	Extension Planning Area
ELDP	Evangelical Lutheran Development Programme
IGA	Income generating activities
NASFAM	National Smallholder Farmers' Association
MAFE	Malawi Agroforestry Network
MASAF	Malawi Social Action Fund
MoA	Ministry of Agriculture
RDP	Rural Development Programme
PROSCARP	Promotion of Soil Conservation & Rural Production
TA	Traditional Authority
GoM	Government of Malawi