Experiences with Micro Agricultural Water Management Technologies:

Tanzania

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An input to the Study on Agricultural Water Management Technologies for Small Scale Farmers in Southern Africa: An Inventory and Assessment of Experiences, Good Practices and Costs

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1. Introduction

1.1 Background

Water shortage 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. In Tanzania agriculture is the most important sector of the economy. However it is very much affected by inadequacy, seasonality, and unreliability of rainfall as well as periodic droughts. Tanzania has been experiencing food shortages, a problem which is mainly due to bad weather conditions in the country. Erratic rainfall is always hindering crop production, not to mention other factors. The government has recognized the problem, and has incorporated some mitigation measures within its development Vision.

While little progress has been achieved yet water is becoming a major problem in Tanzania and the world at large. Policy makers have vastly underestimated the influence of water scarcity on economic progress, food security and regional peace and stability. The water scarcity is posing yet a challenge of whether the little water available should be used for generation of electricity or left for domestic consumption or used for industries or for agriculture. This remains to be a riddle to the Tanzanian government, which endeavours to fight poverty and food insecurity.

The report by FAO on world food day, 2002 suggests that, while each person needs two to four litres of water a day to drink. Some 4,000 litres are required to produce the food we eat on a plate. Irrigated agriculture, which currently accounts for more than one third of the world's water use, is increasingly required to produce more food from limited land using less water. When looking at the issue of water scarcity, there comes a need for considering the new approach in irrigated agriculture that could offer a considerable

scope for saving water, increasing production and improving the well being in developing countries.

On realising this, the International Water Management Institute (IWMI) offered a consultancy work on agricultural water management to identify and cost adoption and impacts of small-scale water management technologies that are being practiced or promoted in the country by different stakeholders.

The main goal of the study being to provide descriptions of better and sustainable agricultural water technologies practiced in Tanzania that if properly used and widely adopted can increase agricultural productivity and incomes for smallholder farmers. Specifically, the study aims to:

(i) Fill the gaps in knowledge by completing an inventory of existing agricultural water technologies and practices in Tanzania; and

(ii) Identify those technologies/practices which are most promising and should be promoted.

The specific objectives of the study were as stipulated in the Terms of Reference (ToR) as to

(i) Document how donor, NGO, and private sector - promoted technologies and practices have been either adopted without modification, adapted using indigenous knowledge and practices, or not adopted despite efforts to promote them;
(ii) Document the ease or difficulty of implementation and maintenance, adaptability, cost effective, potential sustainability and actual/potential impact; and documents factors facilitating and constraining effectiveness of the technology/practice.
(iii) Characterize the various structures and strength of partnerships developed among farmers, private sector, government, and NGOs; and

(iv) Identify which of the technologies/practices that have been introduced and promoted are sustainable, indicating the location and other conditions under which they are most sustainable, the corresponding cost of the technology, and determining the potential for scaling up.

The outputs of the study are to produce:

(i) An inventory and characterization of agricultural water technologies and practices adopted in Tanzania.

(ii) A report that does the following:

?? Document good practices focusing on field experiences in the development and management of agricultural water technologies/approaches derived from farmers' local knowledge, external projects, agricultural research, etc;

?? Summarize the actors involved including up-dated details (NGOs/Pos, farmers organizations, government agencies, donors, international organizations such as FAO) and their respective roles in promotion of such technologies/practices;

?? Review RCSA programs piloting or promoting irrigation, especially under its initiative for ending hunger in Africa - Tanzania (IEH) program;

?? Make specific recommendations on "best bet" opportunities for scaling up agricultural water technologies that work, including where, under what conditions, etc. and

?? Lists the documents and reports used by the consultants when preparing the report.

1.2 Methodology

The consultancy work was undertaken by using a combination of methods as described in the following sections.

Data Collection

The secondary data were collected by reviewing of secondary information available in different reports, conference proceedings, and books from Sokoine University of Agriculture, Ministry of Agriculture and Food security, Ministry of Water and Livestock and NGOs.

Interview

Interviews were conducted using semi-structured questionnaire to different personnel such as, NGOs, private companies, private (group of) farmers, government offices and agencies,

Field Visits

The consultants carried out study visits to different sites where relevant water technologies and practices are practiced

1.3 Limitations

The major limitations that were encountered during the study were three. These are:

(i) The refusal by the USAID office to grant us permission to have an interview with them. However through telephone conversation, they gave us two

contacts of the NGOs (KickStart and Mbezi enterprise) that they support for promotion of micro-irrigation technologies. We managed to contact one of them (Kickstart).The other contact person (Mbezi enterprise) was unreachable every time we phoned to make an appointment. Probably he was out of the country.

(ii) The time for the study was too short. It took so long to receive the first installment of funds after signing the contract; as a result the substantial time remained for the study was undersized.

(iii) Also, although the consultants tried their best to get all the necessary information for inclusion in the report, in some cases all needed information was not available, e.g. For some of the technologies the exact date the technology was adopted or invented, costs involved in the introduction of technology by the NGOs or government agencies were not possible to get.

2. Overview of Food Security, Hunger, Agriculture and Water

Almost 80% of Tanzanians depend directly or indirectly on agriculture for their livelihood. The majority of the farmers are smallholders with an average farm size of 1.2 ha per household (TARPII, 2005) whose production is remarkably low. The main crops grown include maize, sorghum, paddy, wheat cassava, banana, potatoes, horticultural crops, cotton, coffee, tea, and sisal. About 40 % of the total cropped area is under cereals while about 30% is under non-cereal food crops. The majority of farmers in Tanzania remain highly vulnerable to food insecurity. Rural incomes are not increasing fast enough; and the rate of growth in the agricultural sector is not satisfactory. Available records (1993 – 2003) show that the annual growth rate of the agricultural sector ranged between 1.9 % (1998), the lowest rate and 5.5% (2001), the highest rate. This is not good enough for a highly indebted poor country like Tanzania where sustainable growth must be agriculture led.

The household budget survey executed in 1991/2 showed a lower income in rural areas than in urban areas, identifying a severe poverty situation in rural area. Over 87% of all poor people live in rural areas where agriculture is the mainstay for their livelihood. The

proportions below the poverty line for basic needs and food requirements were 41% and 23% in rural and urban areas respectively. The recent household budget survey in 2000/01(MAFS, 2002) also presents a similar poverty situation, although improvements of 2% in rural areas and 3% in urban areas have been achieved. From the analysis carried out by the department of Food Security, Ministry of Agriculture and Food Security, the cereal deficit for the year 2001/02 was 820,000 tons at the national level (MAFS, 2002). In this regard, an improvement in farming is required to increase agricultural production. However, currently the country is being faced with a number of challenges to improve agricultural production. Some of the challenges are the HIV/AIDS and Malaria posing a threat of reducing the labour force, and the dependency of smallholder farmers on rain-fed agriculture although Tanzania has other water resource potential.

HIV/AIDS in Tanzania was first reported in 1983 and since then it has become a common household problem despite the efforts undertaken under the National AIDS Control Programme started in 1985 and various other national efforts, NGOs involvements, and community based organizations (CBOs). Now the HIV/AIDS is increasingly becoming the major underlying factor for hospital admissions and deaths. Hospital based data indicate that up to 50% of beds are occupied by patients with HID/AIDS related illness. Studies conducted in Dar es salaam, Hai (Kilimanjaro region), and Morogoro showed that HIV/AIDS is the leading cause of adult mortality especially among women. The number of adult HIV infection in Tanzania was estimated to be 745,320 in 1999 (NACP), but now the number is about 1.7 million. Thus, HIV/AIDS can no longer be viewed as just a health problem, it has to be recognized as a development problem. The impact of the epidemic is serious, given its widespread and the fact that it is now the major cause of adult mortality in many parts of Tanzania.

The epidemic has negatively impacted all sectors of development through not only pressure on AIDS cases and management of resources, but also through debilitation and depletion of economically active population, especially young women and men aged 15 – 45 years. The percentage of the population infected by HIV ranges from less than 3 across most of the country to more than 44.4 in certain sub populations. Available data

from severely affected communities show that AIDS often leads to social and economic disruption of affected individuals, families, and communities. The poorest households are least able to cope with the impact of adult deaths due to AIDS and are frequently unable to obtain even the most basic needs in the short term. Child nutrition, education, health, and living standards for the survivors may be severely affected.

Given the illness episodes per AIDS patient, the public expenditure on AIDS treatment is high. In the education sector we find children pulled out of school either due to a lack of money or needed to help at home. The social welfare sector is experiencing a large increase of AIDS orphans which were estimated to be about 700,000 in 2000.

The World Bank estimates that because of the AIDS epidemic, life expectancy by 2010 will be reverted to 47 years instead of the projected 56 years in the absence of AIDS. The bank further predicts that the mean age of the working population will decline from about 32 to 29 years between 1992 and 2010. The overall younger work force will have less education, less training, and less experience. The bank further estimates that AIDS will reduce average real GDP growth rate in the period 1985 – 2010 from 3.9% without AIDS to between 2.8 and 3.3% with AIDS. These factors will certainly have a profound negative impact on the overall economic performance of the country and its living standards.

Malaria also continues to be a major public health importance in Tanzania, although it is preventable, can be treated and cured. The total population at risk of malaria in Tanzania is estimated at 31.7 million people. The number of malaria cases is between 14 – 18 million per year. 100,000 deaths per year (11 deaths/hr) result from malaria. Equally worrying is enormous impact of malaria on households and on economic development of the country. It is estimated that malaria reduces economic growth by at least 1.3% per annum. Thus malaria imposes a heavy cost not only on a country's income but also on its rate of economic growth, and invariably on its level of economic development.

Tanzania water resources potential have been divided into eight river and lake basins. These are (i) Pangani River, (ii) Ruvu/Wami River, (iii) Rufiji River and (iv) Southern Coast basin. Others are (v) Lake Victoria, (vi) Lake Rukwa, (vii) Lake Tanganyika and (viii) Lake Nyasa basins. The major water uses are drinking and domestic water supply, irrigation water supply, livestock water supply, and hydro-power generation.

3. Analysis of Good Practices in Micro Irrigation and Rainwater Harvesting

In Tanzania different micro irrigation and rainwater harvesting technologies are practiced in different parts of the country. The inventory of agricultural water technologies has revealed that there are at least fourteen technologies practiced in Tanzania (Annex 1). The technologies include money maker treadle pumps, drip irrigation, roof catchment with above ground tank, charco dam and *fanya juu* terracing. Other technologies are ridging, mulching, minimum tillage (conservation agriculture), *ngoro* pits, *chololo* pits, silted sand valley and ladder terracing. These technologies are thorough explained and characterized in the inventory chart.

Different stakeholders have been involved in developing and promoting these technologies. The stakeholders include government, NGOs, private companies and farmers. According to the survey five technologies were identified to be the best practices and are recommended for up scaling in other places with similar condition where not practiced. The technologies are:

(i) The "Money Maker" treadle pumps
(ii) Drip irrigation (Family size kit)
(iii) Charco dams
(iv) Minimum tillage (Conservation agriculture) and
(v) Paddy field bunding

3.1 The "Money Maker" Treadle Pumps

The Money Maker treadle pumps are human powered micro-irrigation water pumps working on the principle of suction lifting using either one or two cylinder(s) and

piston(s) to draw water from a source below ground level (river, lake, and shallow well). Current there are three different types of Money Maker pumps, namely Money Maker Plus pumps, Super Money Maker Plus pumps and Money Maker hand pumps. The Super Money Maker Plus pumps have two pistons, whereas the other pumps have one piston. The pumps have maximum suction head of 7m and maximum pumping head of 14m. The pump's maximum flow rate is 1.5 liters per second and can irrigate 0.4 ha in 8 hours.

The technology is a product of imagination, enterprise, and shared vision led by Nick Moon (a craftsman and entrepreneur) and Martin Fisher (mechanical engineer) who combined their talents and formalized their contention that designing and marketing new technologies for business can kick-start sustainable economic growth. In 1991 they founded ApproTEC as a Kenyan nonprofit organization to put their theory into practice. The organization established a head office for Tanzania in Arusha, about 100 km west of Mount Kilimanjaro. With its new name of KickStart, the organization administers the program and coordinates the activities of all marketing officers in Tanzania from this office with support funds from USAID, DFID, and other donor agencies.

The NGO (KickStart) has two core competencies of organization:

? designing technologies that meet the needs of " base of the pyramid" (BOP) investors in developing countries, i.e. people living on less than $2 per day.

? facilitation of the set up of a private sector supply chain (from manufacturers through distributors and retailers to end users) that ensures widespread availability of the technologies, backed up by a social marketing, awareness and demand creation program.

It is due to these two competencies that within its 5 years of establishment, KickStart (ApproTEC) has managed to have the following outputs in Tanzania:

1. One manufacturer – Karam Engineering

2. Eight wholesalers
3. Forty nine retailers
4. 650 - Money Maker plus pumps sold
5. 10,216 - Super Money Maker Plus pumps sold
6. 461 - Money Maker Hand pumps sold.

The secret behind this rapid success is that for every dollar the KickStart receives from outside support is turned into up to 19.1 dollars in economic growth and the pump increases security of subsistence farming and generates increased income from the sales of irrigated crops. There is a major impact on each family that buys the Super Money Maker Pump. The average annual net incomes from farming in Tanzania has shown to increase ten-fold, from $120 to $ 1,200, through irrigation of high value fruits, vegetables, and flowers for domestic consumption and export. The purchasing price for a Super Money Maker pump is Tshs 99,500/=. The cost-benefit analysis for a Super Money Maker pump owner growing onion is as shown in Table 3.1.

Table 3.1: Cost –benefit analysis for a Super Money Maker pump owner in Tanzania

Type of cost/income	Amount in Tshs.
Costs of owning and operating a pump	
1. Depreciation cost, pump investment (10 yrs life span)	9,950.00
2. Maintenance costs (replacement of rubber components)	6,000.00
3. Labour costs (two people)	600,000.00
Sub-**Total costs**	**615,950.00**
Cost for growing Onion (3 cropping per year)	
1. Land preparation and weeding (0.4ha)	120,000.00
2. Seeds and fertilizer costs	180,000.00
3. Planting and harvesting	60,000.00
Sub-Total	**360,000.00**
Income	
Selling onions:0.07 kg/plant x 50,000 plants x 3 times per year @ Tshs 200/ kg	2,100,000.00
Net income from sales of crops = (Income – costs)	**1,124,050.00**

Note: 1 US$ is equivalent to Tshs 1,100/=

With such increased income farmers can afford to properly feed and clothe their families, send their children to school, obtain health care, build new houses and invest. The manually operated micro-irrigation pumps are helping small-scale farmers to emerge from poverty to prosperity and to transform them from subsistence to thriving commercial farmers.

Apart from the pump being for irrigation it is also being used for other purposes, like domestic and livestock water supply, and car wash (in peri-urban). Thus, the pump can be efficiently utilized without change in design. Because of its simplicity on operation and maintenance, pump owners need very minimum training for its installation, use, and maintenance.

It is thus not surprising that the pump has found acceptance and use in over 20 countries in Africa, Middle East, South East Asia, and America (USA).

3.2 Drip irrigation

This can be described as a water delivery system that involves application of water into the soil through a small sized opening directly on the soil surface, where the crop is planted. This is achieved by applying water at very slow rate. It enables to make use of limited amounts of water and fertilizer can be applied together with the irrigation water to grow high value crops (e.g. water melon, tomato, onions). For this drip system the water application to plants is by gravity and a small pump (powered or manually operated, e.g. treadle pump) is needed to pump water from an underground source into a storage tank with a capacity of about 200 to 1000 litres and raised 1.5 m above ground.

In Tanzania this technology has been promoted since 2003. The importation, promotion, selling, and distribution is done by a private company, namely Balton Tanzania Ltd with 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. The Balton (T) Ltd assists farmers who purchase the system with installation. In some instances where farmers purchase the system after being

sensitized by the government irrigation agency the installation assistance is also provided by the agency.

Since the promotion of the technology started (2 years ago) 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 m^2 to 2000 m^2. 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 m^2 costs Tshs 292,000.00. However it needs minimal labour 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 labour requirements because farmers buying the system are located near town and city centres where labour is expensive, and ground water abstraction is becoming popular.

The Cost- benefit analysis for owning the drip irrigation system is shown in Table 3.2. The results show that a farmer can earn about the same amount of income when he/she owns the treadle pump together with the drip system or when he /she owns the pump only from an acre of onions. Given the small amount of water used, its convenience of operation, and the minimal labour required the drip system is very attractive.

Table 3.2: Cost –benefit analysis for owning a Drip system in Tanzania

Type of cost/income	Amount in Tshs.
Costs of owning and operating a pump	
1. Depreciation cost, Drip system investment (10 yrs life span)	29,200.00
2. Annual maintenance costs (replacement of filter components)	40,500.00
3. Annual cost of owning and operating a treadle pump	15,950.00
4. Labour for pumping (one person)	300,000
Sub-Total costs (per year)	**3 85,650.00**
Cost for growing Onion (3 cropping per year)	
1. Land preparation and weeding (0.4ha)	120,000.00
2. Seeds and fertilizer costs	180,000.00
3. Planting and harvesting	60,000.00
Sub-Total	**360,000.00**
Income	

Selling onions:0.07 kg/plant x 50,000 plants x 3 times per year @ Tshs 200/ kg	2,100,000.00
Net income from sales of crops = (Income – costs)	**1,354,350.00**

Corrected by adding pumping labour cost of TSh 300,000 as her email exchange with Sylvester, 13-01-2006.

3.3 The Charco Dam Technology

The charco dam technology is used to impound runoff water by digging and constructing 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 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 designs and supervises 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 village community, the community contributes about 20 % of the capital cost plus other labour inputs which may be needed during the survey and planning phases. Because of the high capital costs (20 - 50 million Tanzania shillings), 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 operation and management of the dams. 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.

3.4 Minimum Tillage (Conservation Agriculture)

Minimum tillage (Conservation Agriculture), generally means zero (no) tillage or reduced tillage. It has labour saving properties and a potential solution to farm power shortage suitable in households under labour stress. 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.

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 labour, food security, and household income. HIV/AIDS and other diseases, such as malaria as well as urban migration and education are reducing the labour availability in rural households and increasing the burden of labour-intensive activities on women and children. Conservation agriculture technologies, specifically minimum tillage reduce labour 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 which is continuously increasing due to the effect of the global economy.

In Tanzania the technology was introduced in 1991 by the government through the Land Management Program (LAMP) to address land degradation problem. The program covered the semi-arid districts of Babati, Kiteto, and Simanjiro in Manyara region and two divisions in Singida rural district. Currently the technology is being promoted in Mbeya, Iringa, Morogoro and Kagera regions of the country.

The technology is promoted through extensive demonstration, formation of farmers associations, training, and provision of necessary inputs and materials, e.g. seeds, and minimum tillage tools.

The minimum tillage improves soil structure compared to conventional tillage due to reduced/absent degrading processes in crop residues, soil organic matter and soil fauna activities and altered soil texture composition caused by tillage operations. Thus it is potential for sustainable land resources management. Results from on-farm demonstration trials conducted in Karatu, and Hanang districts showed that sub soiled treatments with cover crops recorded the highest maize yields ranging between 4.68 and 5.48 tonnes/ha, compared to conventional tilled non-sub soiled treatments which recorded maize yields ranging between 0.88 and 1.08 tonnes/ha. It was also noted that the labour requirement was reduced from 67 days per season in conventionally ploughed plots to 37 days in the treatments with cover crops in the fourth year as a result of the elimination of tillage and reduced weeding requirements (Mariki, 2004).

3.5 Paddy Field Bunding

Paddy fields 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.

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, as a result farmers are now producing surplus for their own consumption.

Rice production in the regions has become a good additional cash crop. As the crop has a readily available market in Zanzibar Island and Middle East countries. The cost benefit analysis for the crop is shown in Table 3.3.

Table 3.3: Cost –benefit analysis for paddy bunding in Sukuma land ,Tanzania

Type of cost/income	Amount in Tshs.
Cost for growing paddy	
1. Land preparation and weeding (0.4ha)	30,000.00
2. Seeds and fertilizer costs	6,000.00
3. Transplanting	15,000.00
4. Harvesting	10,000.00
5. Threshing	10,000.00
5. Storage	37,500.00
Sub-Total	**108,500.00**
Income	
Selling: 300.00 Tshs/kg of rice x 50 kg/bag x25 bags/0.4 ha	**375,000.00**
Net income from sales of crops = (Income – costs)	**266,500.00**

The net profit of Tshs 266,500.00 shown in Table 3.3 is characteristic of revenue expected from growing cereal crops in Tanzania. Though the profit looks small, the assured crop harvest in semi-arid areas where harvest failures for rain-fed crops is common is enough to explain the widely adopted paddy cultivation using bunded fields.

4. Review of Agricultural Water Programs under the Initiative to End Hunger in Africa (IEHA)

The Agricultural water program under the initiative to End Hunger in Africa (IEHA) has not been implemented in Tanzania. However the government of Tanzania through the Ministry of Agriculture and Food Security on realizing the extent of poverty among the rural population, as rainfall period is shorter and erratic thus limiting production of crops has been considering irrigation as one of the most important aspects in attaining agricultural development. As a result Tanzania brought the subject of irrigation to the forefront in their agricultural priorities. A number of large–scale irrigation schemes were initiated, but unfortunately too dependent on government subsidies for their operation and maintenance, failed to meet the desired expectations. The poor performance of irrigation seems to have contributed to stagnation in new irrigation development.

However the importance of irrigated agriculture is mostly highlighted during the period of drought and food scarcity. For instance in 1974/75 major food crisis led to institutional reforms, which involved the irrigation sub sector. Expatriates were recruited from India to become regional irrigation experts because of lack of indigenous expertise. However the program could not bear the intended fruits due to the fact that it was badly planned, under financed and under equipped.

Following the liberation of Tanzania's economy and the implementation of the government strategy on National Agricultural Policy that permitted institutional changes focusing at grassroots level, in 1994, the National Irrigation Development Plan (NIPD) was launched. The NIPD aimed at stability in crop production and increased food. Since 1994, some development has been made but there are still some constraints to be

alleviated before meaningful irrigation development is achieved. There have also been a number of government policies formulated after the preparation of NIPD.

However, with a rapid increase in the demand for water for hydropower production, irrigation and other economic uses that followed the economic liberalization process, water is increasingly becoming scarce. During the period of water scarcity, Mbogo, 2001 reported that conflict of interest arises amongst water users. It is being reported that competition between users is increasing each year. However preferential allocation of the little available water to certain sub sector poses a difficult challenge.

In 2002, the Tanzanian government in collaboration with donors developed a National Irrigation Master Plan. The plan envisages the need to review the current performance of the existing irrigation schemes and the introduction of low cost technologies for irrigation with a wide sector approach. The development target of the plan is to establish sustainable irrigation development system by year 2017, with a strategic approach of expanding the irrigated area through development of irrigation schemes.

The plan has provided a schedule of activities to be executed aimed at enhancing the performance of the irrigation sub sector, however failed to recognise the need to identify alternative technologies with high irrigation efficiency, instead relied on emphasizing only surface irrigation and the need to protect environment.

When looking at the issue of water scarcity, there comes a need for considering the new approaches in irrigated agriculture, so that rainwater harvesting and micro irrigation be given its due priority. This could offer a considerable scope for saving water, increasing production and improving the life standard of small scale farmers.

Recently Rainwater harvesting (RWH) technology has received high attention from policy makers and planners in Tanzania. Rainwater harvesting is now part of key elements of the Agricultural Sector Development Strategy (ASDS) and the Participatory Irrigation Development Programme (PIDP). In Tanzania, in dry areas, rainwater is often

available in abundance during the rainy season but most of it is not accessed and put in beneficial use before it evaporates or flows into saline sinks. Rainwater harvesting technologies overcome the problem of poor and extreme distribution of water resource through storage and transfer. Rainwater harvesting for crop production is a promising and generally appropriate way of upgrading rain fed agriculture in the semi-arid tropics. It is especially interesting given the fact that farmers experience crop yield reductions more often due to poor rainfall distribution rather than inadequate total rainfall

Development of rainwater harvesting approaches could be complemented by the micro irrigation technologies, which have make use of little water for agricultural production. The term "micro-irrigation" describes a family of irrigation system that apply water through small devices. These devises deliver water onto the soil surface directly into the plant or below the soil surface directly into the plant root zone.

5. Summary of key Actors in Micro Irrigation and Rainwater Harvesting

Key actors in micro irrigation and rainwater harvesting technologies in Tanzania include the following:

(i) Government agents (Local and International);
(ii) Non Government Organizations (NGOs);
(iii) Private(trading and manufacturing) companies;
(iv) Universities (through research, extension, and consultancy).

5.1 Government

The main government agents that deal with micro-irrigation and rainwater harvesting are two. These are (i) drilling and dam construction agency under the Ministry of Water and Livestock Development and (ii) Offices of the District Agriculture and Livestock Development Officer (DALDO) dealing with extension services. The drilling and dam construction agency was started recently as the government has been shifting its roles and interventions from direct involvement in productive and commercial activities towards

provision of social and economic infrastructure as well as providing technical assistance and advisory services. These are further discussed in the following sections.

Drilling and Dam Construction Agency

This agent has its main office in Dar es Salaam (Annex 2). Its main activities are to carry out drilling of wells and design and construction of dams for government and private projects. It also has a laboratory for testing soils for civil engineering works (roads, buildings, and hydraulic structures). The agency is well equipped in terms of educated manpower and equipments.

District Agriculture and Livestock Development Office

The offices of the District Agriculture and Livestock Development officers are found in all Districts of Tanzania. The offices deal with delivering extension services for agriculture and livestock development. The offices have been actively involved in promotion of number of technologies. For example in Babati and Karatu Districts, the offices have been promoting conservation agriculture in their areas. In Bukombe and Bariadi Districts, the offices of DALDO have been involved in promoting rainwater harvesting for livestock production through the Rural Water Supply and Sanitation Programme (RWSSP). The RWSSP receives funds from the government and other donor agencies such as The Royal Netherlands Government; World Bank etc. The Address Book from Posts has all the address. However some of the addresses and contact personnel are shown in Annex 2.

5.2 Non Government Organizations

There are two NGOs that deal with promotion of the treadle pumps. These are (i) KickStart in Arusha and (ii) Mbezi Enterprise with head office in Iringa (Annex 2). These NGOs receives part of funds from USAID.

KickStart

KickStart was founded in 1991, and it was formaly called ApproTEC. KickStart as Non Governmental Organization has a mandate to help millions of people escape from poverty and to kick-start sustainable economic growth in developing countries. Since then, over 36,000 poor families in East Africa have used the simple money-making tools and their entrepreneurial spirit to kick-start profitable new businesses, their family wealth and local economic growth.

KickStart takes the following approach to achieve its development goals:

(i) Identify high potential small scale business opportunities
(ii) Develop technologies and business packages
(iii) Train private manufacturers to produce the new technologies
(iv) Promotes the new technologies and installs them in the private sector
(v) Monitors the cost-effectiveness and impacts of its program

Mbezi Enterprise

This is another NGO that deals with promotion of treadle pumps in Iringa and Mbeya Regions of Tanzania. As mentioned earlier we could not visit them because the contact person was every time unreachable through the phone during the study period. The phone number and the name of the contact person are as shown in Annex 2.

5.3 Private Companies

There are two private companies dealing with technologies in the area of micro irrigation. These are (i) Balton Tanzania Ltd and (ii) Karam Engineerig Works Ltd, both located in Arusha (Annex 2). These are briefly discussed below

Balton Tanzania Ltd

Balton (T) Ltd was formally registered in Tanzania as Tanzania Transcontinental Trading Company Ltd (TTTC) since 1964. Balton (T) Ltd is a subsidiary of Balton CP Ltd of London England. Balton (T) Ltd is a pioneer of irrigation technologies in Tanzania. The company is among the largest importers and distributors of fertilizers, agrochemicals, irrigation and water treatment technology, poultry feeds and accessories, sprayers and green houses technology.

Balton (T) Ltd has been in the forefront in supporting farmers through timely distribution of inputs at fair prices, farmers training, conducting demonstrations and credit facility to stockists in specified, strategic areas all over Tanzania. Its mission is to reach more and more farmers with solutions to problems in all crops.

Karam Engineering Works Ltd

Karam Engineering Works Ltd is a workshop involved in general fabrication works. The main activities of the company include repairing of agricultural machinery, fabrication of grain dehulling and milling machines and general fabrication works, which include making of grills, windows etc.

Karam Engineering Works Ltd started to be involved in the manufacture of Money Maker pumps when they were contracted by KickStart. Karam Engineering was trained by the Nairobi-based Technology Development team and uses the exact same jigs and fixtures as they do in Kenya. Production and distribution of the Super Money Maker pumps began in October 2001, and Karam Engineering is now supplying the entire country of Tanzania. A current production rate is about 500 pumps per month.

5.4 University

Since 1991, the Faculty of Agriculture of Sokoine University of Agriculture has been implementing research program, extension, and consultancy in rainwater harvesting, through the Soil and Water Management Research Group (SWMRG). The Group was formed in 1990. The major focus of SWMRG has been the semi-arid areas of Tanzania and the major thrust of the research work has been on management of rainwater through rainwater harvesting. A core team of fifteen founder members forms the SWMRG with different backgrounds in Agriculture.

Some of researches that have been undertaken by SWMRG include:

(i) Rainwater Harvesting research project in Homboro, Dodoma region,
(ii) Evaluation and promotion of rainwater harvesting in semi-arid areas of Tanzania.
(iii) Improved rain-fed cropping system incorporating rainwater harvesting
(iv) Assessment of rainwater harvesting techniques for domestic uses and crop production in the semi-arid areas of Njombe District.

The on-going research activities include:

(i) Improvement of soil fertility management practices in rainwater harvesting systems
(ii) Improving the management of common pool resources in rainwater harvesting systems.
(iii) Smallholder system innovations in integrated watershed management

5.5 The Most Effective Organization

All key actors in micro irrigation and rainwater harvesting technologies in Tanzania, [government agents (local and international), non-government organizations, private companies, and universities] can be equally effective depending on what type of

technologies they are dealing with. However, for the key actors that are explained in this report, NGOs mainly KickStart was found to be the most effective in promoting micro irrigation technologies. As has been explained above it is the most effective because of the approach they use in achieving their development goals.

6. Conclusions and Recommendations

The vast majority of Tanzanians are smallholder subsistence farmers, whose production depend on rain fed. Rainfall in Tanzania is characterized to be short and unreliable hindering crop and livestock production. As a result farmers in Tanzania remain vulnerable to food insecurity.

Water is becoming a major problem in Tanzania. The water scarcity is posing a big challenge of whether the little water available should be used for domestic consumption, or for agriculture or for other activities.

The country is also faced with the problem of HIV/AIDS and Malaria pandemic, which are posing a threat of reducing the labour force. The rural to urban migration is found to be critical. In Tanzania urban population is increasing at a rate of 6.9% per annum and doubling every 10 to 12 years. Since the urban dwellers rely on food supply from rural areas, this therefore increases the pressure on the rural areas to produce even more food.

In Tanzania the war on poverty is essentially the war to improve agricultural production. Rain-fed agriculture can no longer be dependable. Irrigation, especially, simple and small-scale irrigation systems are key to food security and improved yields. Efforts by the government, NGOs, and other stakeholder to assist farmers to increase their agricultural production have been going on in the country.

The inventory of agricultural water technologies has revealed that there are at least fourteen technologies practiced in Tanzania. The technologies include money maker treadle pumps, drip irrigation, roof catchment with above ground tank, charco dam and

fanya juu terracing. Other technologies are ridging, mulching, minimum tillage (conservation agriculture), *ngoro* pits, *chololo* pits, silted sand valley and ladder terracing.

The analysis of the technologies identified five technologies as the best practices that are recommended to be up scaled in other places where they are not in use. The proposed technologies are the money maker treadle pumps, drip irrigation, charco dams, minimum tillage and paddy field bunding.

The money maker treadle pump is a manual pump that can be owned, operated and managed by household or an individual. The cost-benefit analysis for a pump owner growing onion shows a positive net benefit. The increased income can make a farmer to properly feed and clothe the family. Apart from the pump being used for irrigation it can be used for other purposes like domestic, and livestock water supply without change in design. The KickStart mode of promotion needs to be copied when promoting this technology

The drip irrigation was described as a water delivery system that involves application of water into the soil through a small sized opening directly on the soil surface. Although this technology seems to be expensive for the small-scale farmer to afford, the cost benefit analysis showed the investment is viable for onion production. The technology has also other advantages such as small amount of water is used for production and its convenience of operation. It also needs minimum labour requirement. Adoption and the use of drip irrigation technologies in Tanzania were found to be associated with high value crops such as flowers and vegetables grown mainly for marketing.

The charco dam technology was found to be very suitable in semi-arid areas where farmers keep livestock. Promotion of the technology will result in minimizing shortage and unreliable water sources, which creates permanent stress to livestock, especially during dry season. It will also minimize deforestation and accelerated soil erosion resulting from semi-normadic animal husbandry practiced in response to water shortage. However in promoting this technology the respective community must be involved from

the beginning, to bring the sense of ownership. Since the technology is expensive the government or donor agencies intending to promote it must agree with the community on the percentage contribution for construction of the dam.

Minimum tillage (conservation agriculture) is being recommended for promotion due to its advantages over the conventional tillage method. Minimum tillage reduces labour requirements, contributes to household food security by making more efficient use of rainwater and by increasing soil fertility by using cover crops, and reduces expenditure on hiring farm power services and purchase of fertilizers. The government, donors, NGOs in promoting this technology could just invest extensively in demonstration, formation of farmers association (groups), training, and provision of necessary inputs and materials.

Paddy fields bunding is an indigenous technology predominantly practiced in Mwanza, Shinyanga, and Tabora region. The technology can be used in other semi-arid areas. The recommendation for promoting this technology is the fact that the demand and the price for rice is increasing in Tanzania. Thus rice production has become a good additional cash crop. Therefore paddy field bunding can provide sustainable increase in smallholder farmers' income, and addressing rural poverty. The cost benefit analysis for using the technology in paddy production showed a positive net income. In promoting the technology the government or NGOs can encourage mainly farmers' visits.

Annex 1: An inventory and characterization of agricultural water technologies and practices adopted in Tanzania

Annexes 2: List of contacts

S/N	Name	Organization	Postal address and Email
1.	Brian Grant	Country Director KickStart	P.O Box 12816 Arusha Bgrant722@yahoo.com
2	Michael Fredrickson	Director, Mbezi Enterprise	Mobile phone +255 744 897387
3	Apolinary Soka	Irrigation Department Balton (T) Ltd	P.O Box 14666 Arusha irr@balton.co.tz
4	Aloys Kahinga	Director Karam Engineering Works Ltd	P.O Box 2323 Arusha Karam1994@hotmail.com
5	P. Nyaruke	Assistant Director Drilling and Dam Construction Agency	P.O Box 55658 Dar es Salaam ddca@raha.com
6	R.M Shetto	Head Mechanization Ministry of Agriculture and Food Security	P.O Box 9071 Dar es Salaam drd@ud.co.tz
7	E.S Munuo	DALDO Babati	P.O Box 335 Babati
8	B. Mwawado	DALDO Karatu	P.O Box Karatu
9	G. Kadigi	DALDO, Bukombe	P.O Box 2 Ushirombo
10	M.P Mtiba	DALDO, Bariadi	P.O Box
11	M.N. Mzava	Assistant Director Irrigation Ministry of Agriculture and Food Security	P.O Box 9192 Dar es Salaam irrigation@kilimo.go.tz
12	A. Maro	Irigation Engineer, Traditional Irrigation and Environmental Development Organization	P.O Box 8909, Moshi tip@kilionline.com
12	H. F. Mahoo	Team Leader Soil Water Management Research Group, Sokoine University of Agriculture	P.O Box 3003 Morogoro swmrg@suanet.ac.tz

Annex 3: List of documents reviewed/cited

ApproTec Annual Report 2003/2004

Bishop-Sambrook C, J. Kienzle, W. Mariki, M Owenya, and F. Ribeiro (2004). A study of the suitability of reduced tillage and cover crops for households under labour stress in Babati and Karatu Districts Tanzania. Conservation Agriculture as a Labour Saving Practice for Vulnerable Households. Pages 73

Danida (1997). Watershed Development Proceedings of Danida's 2nd International Workshop on Watershed Development, Partcipatory and Sustainable Development. Edited by Power S, P. Makungu, and A Quraeen.

ERB (2005). Engineers Registration Board. 3rd Annual Engineers' Day. "Vision 2025: Engineering contribution in poverty reduction" Proceedings March 18 – 19, 2005 Karimjee Hall, Dar es Salaam.

MAFS (2002). Ministry of Agriculture and Food Security. The National Irrigation Master Plan, Main report. Irrigation and Technical Services Division, Irrigation section, Dar es Salaam Tanzania.

Mariki, W.L. 2004. The impact of Conservation Tillage and Cover Crops on Soil fertility and crop production in Karatu and Hanang Districts in Northern Tanzania. TFSC/GTZ Technical Report, Arusha Tanzania 1999 – 2003.

Mrisho M, S. Abulla, E. Affari, R. Njau, A. Mushi, R. Mandike, A. Mwita, K. Mchatta, K. Senkoro and H Mshinda (2001). Assesment of malaria situation and control activities in Tanzania. Proceedings of the twentieth Annual Scientific Conference of the Tanzania Public Health Association, November 19 – 23, 2001. pp 20 -26

SWMRG (2005). Soilwater Management Research Group. Activities and Findings 1992 – 2004

TARP II (2005). Adoption of Technologies for Sustainable Livelihoods. Assessment of the effects of TARP II – SUA research projects one year after Project completion.

Annex 4: Some of Pictures illustrating different water technologies