Sub-surface Irrigation Using Buried Clay Pots for Climate Change Adaptation for Food Security in Ethiopia

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Background

It is believed that more than 2.5 billion people in developing world live in rural areas, producing their own food. Approximately one billion live below the poverty line. Most depend on the natural resource base for food production even though half a billion of them live in degraded ecosystems. These are one of the reasons for their poverty and food insecurity.[1]

Climate variability and climate change hinder development and poverty reduction. This is especially severe in Africa where the economic structure is dominated by rain-fed agriculture. More than 80 percent of the work force in Africa is engaged in agriculture, contributing greatly for export and food supply. Success in farming both for food and export is tied with climate. Longer-term climate change is predicted to increase the frequency and severity of climate impacts in Africa, worsening the food security situation.[2] Climate variability and change make agricultural output in these areas unpredictable as has been witnessed since the mid 1970s. Climate change distorts the timing and amount of seasonal rainfall leading to reduced food output. Climate change increases the frequency of climate related hazards, their intensity and impacts.

The productivity of subsistence farming is dependent on the natural resource endowment. Environmental degradation increases vulnerability to climate related impacts. There is a need for intervention using appropriate technologies that are manageable by the subsistence farmers that also includes natural resources management with a focus on sustainability and increased food security.

Problem Definition

Ethiopian (African) agriculture is in peril due to issues related to changes in climate and the environment. Irrigation is insufficient and water harvesting is absent. Climate change compounds problems by producing erratic and unreliable precipitation patterns resulting in agricultural drought. Indigenous food production systems are collapsing; food insecurity is endemic in many parts of the country, mainly in the rural areas.

Declines in seasonal rainfall are most pronounced both in the hot lowlands and dry cool highlands. While the people in the semi-arid lowlands depend on a system of nomadic animal husbandry, the highlanders practice subsistence farming. In this semi-arid region, traditional oxen-plough cultivation is practiced without the benefit of irrigation. Rugged terrain, primitive technology and poor infrastructure impose an unsustainable reliance on low input, low-yield, rain-fed subsistence agriculture. The rainfall in the highlands leads to erosion and with little benefit to the crops. It is imperative that crop and livestock productivity be boosted through improved irrigation if Ethiopia is to attain food security. The steep slopes and the rugged nature of the landscape do not allow "modern" irrigation infrastructure, even if it were affordable and available. We believe that interventions that use locally available and appropriate technologies

[1] http://www.rainwaterharvesting.org/Policy/Ecological-poverty.htm
[2] Science Daily (Apr. 11, 2007), IPCC Report Underlines Risks To Africa's Agriculture, Infrastructure, Wildlife And Coastal Zones From Rising Greenhouse Gases

can contribute to increased and sustainable food production system. The cheap, water saving and locally produced buried clay pot sub-surface micro-irrigation can foster food security while improving local economic conditions.

Goals and Objectives

The overall goals of the project are to contribute to the development of subsistence farmers in Africa by providing a sustainable appropriate technology to reduce the major constraints for food security through increased local food supply. The goal is also to prepare subsistence farmers to adapt to anticipated climate changes through capacity building that includes adaptation of infrastructure that focuses on efficient use of water to grow food and to increase and diversify household income.

The objective of the project is to introduce appropriate irrigation technology to increase the food security of subsistence farmers by adapting to the impacts of seasonal rainfall variability and long-term climate change. The technology of choice is water-filled clay pots for sub-surface irrigation. Buried clay pot irrigation enables subsistence farmers to produce food during dry seasons using water collected during rainy seasons. Off-season cultivation of perennial fruits and vegetables will improve nutrition by diversifying food intake. Buried clay pot irrigation is an inexpensive yet more efficient alternative even to drip irrigation.

Clay pots are easily manufactured from local materials by local women artisans. This will revitalize pottery production—an industry where women artisans have seen their livelihoods overtaken by imported metallic cooking utensils and plastic Jerry cans for water collection and transportation. And because clay is a natural resource, the production and eventual disposal of pots poses no environmental threats.

Incorporating this ancient technology into local traditional knowledge will foster regional sustainable development as neighboring villages strive to increase their economic and environmental resiliency. We believe that farmers will continue to grow more food around their homesteads after the end of the project providing sustainable food sources.

Innovation

Buried clay pot irrigation was used to irrigate dry lands in the ancient world of North Africa[3] and the East. David A. Bainbridge quotes the book by Fan Sheng-chih Shu[4] who described the use of buried clay pot irrigation in China more than 2,000 years ago.[5] Although this form of micro-irrigation is ancient, it has not been nor is it being presently attempted in the semi-arid parts of Africa in general and Ethiopia in particular.

Buried clay pot irrigation uses unglazed, unvented, standard clay vessels placed into pits dug in the soil. The clay pots are banked with soil up their neck. When filled with water, the rate at which the water seeps through the micro-pores of the clay is influenced by the demand for water by nearby plants. The roots of these plants grow in the direction of the water being drawn through the porous clay due to the adhesion and cohesion of water molecules as plants transpire. The soil is also wet as long as the pot is filled with water.

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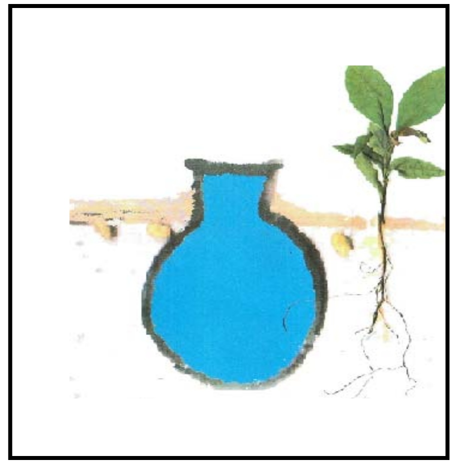
[3] http://www.vl-irrigation.org/cms/index.php?id=315&type=5

[4] Sheng Han, Shih. 1974. Fan Sheng-chih Shu: An Agriculturist Book of China written by Fan Sheng-chih in the First Century BC. Science Books, Peking. pp. 36-37.

[5] http://www.ecocomposite.org/restoration/claypot.htm

This method results in highly efficient water usage, *surpassing drip and surface irrigation*. Buried clay pot irrigation can save 50-70 percent of the water used by conventional drip irrigation.[6] And unlike surface irrigation where abundant water must be released frequently, buried pots need to be filled only about every two weeks.

The system is suitable for growing seedlings, annuals, perennials, and tree crops. Weed growth is restricted. Research has also shown that clay pots have a much greater success rate of plant maturity than conventional surface irrigation. Optimism about the efficacy of this method in Africa is based on a doctoral dissertation written by Angel Elias Daka of the University of Pretoria in 2001. Daka[7] tested the efficiency of the clay pot irrigation system in Zambia. David A. Bainbridge of the United States has also contributed to tests on the effectiveness of clay pot irrigation in the semi arid areas of the world.



According to R. C. Mondal of the Central Soil Salinity Research Institute of India[8], clay pot sub-surface irrigation is used in the following situations:

1. In arid areas where water is either scarce or expensive. The system saves water due the absence of surface evaporation. The plants take water according to their needs.
2. Soils are difficult to make level due to uneven slop or terrain. Since the source of water is the pot there is no need to change the slop or to level the land based on the need to distribute water evenly.
3. In areas where water is saline and cannot be normally used in surface methods of irrigation.
4. To provide local food in remote areas where vegetables are expensive. Clay pot irrigation system can be adopted at different scales. Households and individuals can grow vegetables in their backyard using any amount of pots.

It is believed that **"c**lay pot irrigation will prove most useful in helping farmers grow crops successfully in areas with salinity problems".[9] The maintenance of a stable soil moisture by "buried clay pot irrigation enables crops to be grown in very basic or saline soil or with saline water under conditions in which conventional irrigation would fail."[10]

[6] E. Daka, Development of a technological package for sustainable use of Dmbos by small-scale farmers, Thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy: Land Use Planning Department of Plant Production and Soil Science Faculty of Natural and Agricultural Sciences, University of Pretoria Promoter: University of Pretoria, April 2001

[7] A. E. Daka, Development of a technological package for sustainable use of Dmbos by small-scale farmers, Thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy: Land Use Planning Department of Plant Production and Soil Science Faculty of Natural and Agricultural Sciences, University of Pretoria Promoter: University of Pretoria, April 2001

[8] R.C. Mondal, (Director, Central Soil Salinity Research Institute, Karnal-132001, India,) Pitcher Irrigation, http://www.fadr.msu.ru/rodale/agsieve/txt/vol2/8/art6.html (read on 7/7/2009)

[9] David A. Bainbridge, Buried clay pot irrigation: a little known but very efficient traditional method of irrigation Agricultural Water Management, Volume 48, Issue 2, June 2001, Pages 79-88 2001. Page 85

[10] Ibid.

The size of pots depends on the availability of labor for water refills as small pots would need frequent refilling. The refilling would also depend on the water needs of the plants that suck the water through their roots. Many report that the average refilling of the average pot is every two weeks.

Clay pots are used both to grow trees and plant seeds which "should be placed within 1 to 3 cm of the outer edge of the buried clay pot."[11] Some suggest that for an average pot the number of vegetables should not be more than four. The system can be used both for vegetables and tree crops production.

Table 1. Water savings (in mm/season equivalent) for common vegetables under Clay Pot and Conventional Watering Can Irrigation Systems[12]

Crop	**Clay-pot irrigation (mm/season)**	**Conventional Watering can (mm/season)**	**% Water savings**
1. Beans	203	450	55
2. Cabbage	45	150	70
3. cauliflower	250	500	**50**
4. Maize	200	500	**60**
5. Onion	67.5	225	**70**
6. Rape	180	400	**55**
7. Tomato	195	650	**70**

The yields of the common vegetables using clay pot irrigation are similar to that of conventional or drip irrigation. According to Daka, the huge savings in water for water intensive vegetables such as tomatoes was not at the cost of yields. As the work of Daka shown on table 1 illustrates, the water saving using clay pots is between 55 and 70 per cent. *The above information and others show that the system can replace drip irrigation on account of cost, water saving, local availability of the clays and its relevance to be understood by local farmers.*

Beneficiaries

All smallholders in the semi-arid zones of Africa who are vulnerable to climate and environmental change as well as those who make pottery.

Project Description and phases of implementation

Phase I - training and establishment of a demonstration site. Initially, 20 household heads will lead to the creation of peasant experts on the use of clay pots for sub-surface irrigation as well as the development of water sources. The peasant expert trainees will be trainers to other farmers in the village as well as outside the village. Because the semi-arid zone does not have enough water for people and animals the project will also incorporate the development of a water sources. This will involve water harvesting on micro-reservoirs during the rainy season and/or the development of water wells in an appropriate geological site. Training manuals will be prepared in the local language and the support of the local government will be included.

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[11] http://www.paceproject.net/Userfiles/File/Soils/buried%20clay%20pot.pdf

[12] A. E. Daka, Development of a technological package for sustainable use of Dmbos by small-scale farmers, Thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy: Land Use Planning Department of Plant Production and Soil Science Faculty of Natural and Agricultural Sciences, University of Pretoria Promoter: University of Pretoria, April 200. Page 182.

The demonstration project – this will be on either the land of the trainees or on cooperative land. The success of the demonstration site will be an important tool to convince farmers about the usefulness of the project. With a successful pilot project the subsistence farmers in and outside the village will adopt the new technology and begin the path to a sustainable livelihood. The demonstration project will also lead the farmers to request that they be added to the project. Considering that the clay pots are relatively cheap and locally available we believe that the demonstration project will lead to spontaneous adoption with technical support from the peasant experts trained at the project.

Phase II - adaptation phase – these is when farmers are able to use the system and increase their output and income. The development of water sources will be something that farmers will continue to demand from the government or outsiders once the adaptation phase is included.

Phase III - sustainability phase – the success of the project is when farmers have incorporated the new technology into their farming system and there is no need for external actors to be there. Sustainability also indicated by the resilience of the farmers to hazards such as drought.

The village of Atebes has been selected tentatively to begin the project. We believe that 100 household heads will participate in training during the first year life of the project. The training involves five sessions. Atebes is a good site as it represents a high land arid zone, with no current practice of irrigation and it has no perennial water source except for a recent water well. That well is not used by the majority of the households because of its location on the periphery of the village and due to the scattered settlement of the people. One the other hand, the village is connected by a new road that passes through the middle making it easily accessible.

The socio-economic profile and current farming practices of the farmers will be identified. We now know that there is no single household that uses irrigation. The construction and/or renovation of suitable water harvesting equipment will be undertaken.

Farmers' committees will be consulted in all decisions. Vegetable seeds will be provided. Various species will be planted to determine the suitability of buried clay pot irrigation among a spectrum of crops. Local government agents involved in water, agriculture and rural development including extension agents and administrators, will be engaged. Careful comparison between test plots, standard agricultural land, and controls will be used to determine success limiting the growth of weeds. There will not be any problem related to land due to the land reform that gave equal access to all including women.

Year II will include 200 participants in the project. In phase III, the remaining 100 households will be included in the third year.

Finally, outcomes will be assessed through exit project evaluation and profile to quantitatively see the differences in income due the new innovation.

<u>Measuring Results</u>

The beneficiary subsistence households will be evaluated based on the impacts of a second harvest outside the traditional farming season due to the adoption of the new technology. It is anticipated that the growing season will be lengthened by at least four months. Crop diversity is also expected to increase by adding the cultivation of cabbage, lettuce, tomatoes pepper, potatoes and other fruit crops during the dry season. Costs for purchasing spices and herbs from the market will be reduced while revenue from the sales of excess products should increase by approximately 30 percent initially to be doubled or tripled in the long run. Farmers will also have vegetables added to their food menu that is now dominated by cereals and beans. Farmers may eventually increase their cash income as water harvesting activities increase and more of the region is irrigated. Perennial fruit production (both indigenous such as berries, fig, guava and exotic – e.g. apple) will require time to demonstrate economic impact, but will increase long-term sustainability. Eventually, the diffusion of the technology will increase to spontaneous adoption in the nearby villages and beyond.

Site Description

The village of Atebes in Tigray, Ethiopia, is 20 kilometers west of Adigrat. Ripples recently described the village as:

> The isolated village of Atebes, located in the eastern zone of Tigray, Ethiopia, does not have a school, a road or other important social services.[13]

The village's 500 families are subsistence farmers. They tend the semi-arid highlands of the Tigray Regional State, 2,800 meters above sea level. Traditional oxen-plough cultivation is practiced. Rugged terrain and poor infrastructure force a reliance on low-yield, rain-fed agriculture. Being a cool climate, wheat, barley, chickpeas, beans, lentils, and flax are grown during the rainy season; prickly pear cactus has become a famine food. Soil degradation is worsening. Rainfall has become unreliable. Climate variability threatens the people of Atebes. All residents of Atebes have equal access to land. There are areas between the ridges that are useful for water harvesting.

Sustainability

•Once the clay pot watering system is accepted by farmers, it will lead to the economic revitalization, increased efficiency, and new income for those who create the clay pots.
•Farmers will increase their income by selling vegetables and spices beyond the conventional harvest season.
•The lessons learned from the project will be expanded to the neighboring villages through informal and formal interactions.
•Children, women, and schools will be involved in the implementation of the project so that the system can be incorporated into the traditional knowledge.
•The local government extension agent will be involved to share the experience.
•Continued capacity building through education and meetings based on the traditional system and elders' participation will be encouraged.
•Clubs will be organized and competitions introduced to create a sense of social cohesion of the participants.

Growth Potential

•The success of the project will drive its own growth.
•Raw materials are locally available. New interactions will arise between food producers and potters. Climate change is challenging the farmers' livelihoods while metal and plastic household utensils reduce the need for potters. The project will have multiple impacts on multiple communities.

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[13] RIPPLES, Spring 2008. http://www.water.org/FileUploads/Ripples_2008_03.pdf

•The mountainous landscape and its vulnerability to drought encourage micro-irrigation.
•There is political and economic support from the regional government that is committed to technology transfer and food security.
•Growth will be made permanent due to being able to simultaneously develop perennials and annual vegetables and spices.
•The project is easy to adopt since it does not require sophisticated nor unfamiliar techniques.
•The project is easy to replicate by other villages and likely to spread region wide spontaneously.

Work Plan

1. Governance
    a. Initiate with the local government leaders in the ministry of agriculture and water development as well as extension agents in order to coordinate the intervention and avoid.
2. Profile the potential beneficiary farmers before the intervention and document the technology they use, household income and assets.
3. Identify those farmers that are willing to be part of the demonstration project.
4. Discuss with farmers the type of intervention such as to either work on a common land that will serve as a training site or work with individual progressive farmers that are willing to test the technology.
5. Train farmers about the project and identify the types of waters sources to develop and use for the sub-surface irrigation.
6. Select group leaders that will follow up the day-to-day project development and implementation.
7. Identify traditional potters and provide training and equipment to those who are willing to supply pots to the project based on recommended designs to fit the intended purpose.
8. Evaluate the project to see outcomes with lasting impact on the livelihood of the community and potential positive impact on the nearby villages.

Challenges for Implementation

•Farmers might be reluctant to participate in a project that jeopardizes other forms of ongoing food aid.
•The project is timed to begin immediately after the end of the rainy season but farmers are busy during the harvest. There are also weddings and other social activities following the harvest. Effort will be required to encourage the farmers to focus on work. There will be a need to identify the insertion of the project into the rural calendar of the community. There might be a need to negotiate schedules so that the farmers who are involved in the project can maximize their time and commitments.
•More than 36 months might be required to diffuse the innovation.
•Initially, there would be a shortage of clay ports but an exchange system could alleviate this.


Ethiopia
International boundary
National capital
Railroad
Road
Track
0 50 100 150 Kilometers
0 50 100 150 Miles
Mercator Projection, 720N
Red
Sea
Gulf
of
Aden
INDIAN
OCEAN
SUDAN
ERITREA
DJIBOUTI
SAUDI
ARABIA
YEMEN
SOMALIA
KENYA
UGANDA
Khartoum
Asmara
Addis
Ababa
Djibouti
Sanaa
Mogadishu
Port
Sudan
Sawākin
Kassala
Teseney
Āk'ordat
Keren
Nak'fa
Massawa
Dehalak Deset
(Dahlak Island)
Al
Qunfudhah
Abhā
Jīzan
Al
Ḩudaydah
Mocha
Ta'izz
Aden
Assab
Bab el
Mandeb
Āksum
Ādīgrat
Mek'elē
Maych'ew
Gonder
T'ana
Hāyk'
Debre
Tabor
Bahir Dar
Weldiya
Āsayita
Desē
Debre
Mark'os
Debre
Birhan
Dirē
Dawa
Hārer
Jijiga
Hargeysa
Burao
Berbera
Erigavo
Nek'emtē
Nazrēt
Metu
Gambēla
Jīma
Shashemenē
Awasa
Goba
Ārba
Minch'
Kibre
Mengist
Negēlē
Dolo
Odo
Imī
Godē
K'ebrī
Dehar
Werdēr
Degeh Bur
Laascaanood
Galcaio
Hobyo
(Obbia)
Beledweyne
Ceelbuur
Luuq
(Lugh Ganana)
Baidoa
Baardheere
(Bardera)
Merca
Moyalē
Moyale
Marsabit
Wajir
Lake
Rudolf
Kelem
Lokichokio
Lodwar
Kapoeta
Administrative
Boundary
Pibor
Post
Nāsir
Kurmuk
Āsosa
Ad
Damazin
Al
Jabalayn
Kūstī
Wad
Madanī
Al
Qaḑārif
Himora
'Aţbārah
Moroto
Soroti
Gulu
Provisional Administrative Line
Boundary representation is
not necessarily authoritative.
Base 802400AI (R02760) 12-99