Implementation of Affordable Micro Drip Irrigation Systems in Eritrea Pre-feasibility study

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Follow-up May 1 – May 5, 2001

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Executive summary

Background of the project

The aim of the project is to assess the implementation and adoption of affordable drip irrigation systems for small-scale farmers in Eritrea. The project approach is a marketing approach. This implies an initial phase during which support for implementation is given, after which dissemination of the new products must take place according to market rules and regulations and be economically viable.

Because the introduction of small-scale micro drip irrigation systems follows a market approach it is very important not to forget to assess the social and ecological impacts that such a fundamental change in the land use system may cause.

Why Eritrea?

Agriculture is the dominant sector of the Eritrean economy, engaging about 70 - 80% of the population. Almost 75 % of the arable land in Eritrea is situated in semi-arid or arid zones. At present only 22,000 ha (2 % of total arable land) is irrigated, but there is a potential to increase the area under irrigation to 600,000 ha (World Bank, 1994).
Currently the landholdings of most of the farmers in the areas where irrigation is possible cover less than one hectare. It is inevitable to find solutions how to intensify agricultural production to guarantee food sufficiency for the future.

Kits distributed during the mission

Altogether 29 kits were distributed to 18 testers in different agro-ecological zones. These irrigation kits were developed by IDE in collaboration with local specialists in India. Four types of kits were used for the pre-feasibility study:

Features	**Kitchen garden kit (bucket-kit)**	**Vegetable kit**	**Horticulture kit**	**Micro-sprinkler kit**
Area under irrigation	40 m^2	100 m^2	130 m^2	160 m^2
Approx. number of plants	36 to 72	150 to 300	50	Used for closely spaced crops
Required height of water source	1 meter	1 meter	1 meter	10 meter
Required volume of bin	Bucket with 20 l	Barrel with 200 l	Barrel with 200 l	Barrel with 500 l or tap
Type of crops	Vegetable crops	Vegetable crops	Perennial fruit crops	Vegetables, flowers, pulses, cereals etc.

Most important facts

- Advantage of the drip irrigation system: it is affordable, saves water, labour and fertilisers, and helps prevent soil erosion.
- Shortcomings of the system: spare parts and a piece of cloth to pre-filter the water should be added to the set.
- Gender issue: introduction of the bucket kit must focus on women; it is not yet clear who should be addressed with the other kits.

- Dissemination: the most efficient way is to address students of agricultural schools who will later be working in extension services, advice centres, or as farmers. But as soon as the sets are available on the market, a manual must be available that is suitable for literate and illiterate people. The important question of how to bill the farmers for the sets during the test phase has not yet been properly solved.
- Economic issues: an economic assessment of the returns of the kits is difficult in the current situation because of great price fluctuations on the market. When calculating the price one should not forget to include import taxes as well as additional costs for a bucket or barrel. Further additional costs originate from fencing in irrigated areas.
- Agronomic and ecological issues: knowledge generation must be a central concern when introducing the kits. If availability of water is limited irrigation needs may compete with the need for drinking water.
- Social and political issues: because of the insecure land tenure situation the horticulture kit is not suitable in Eritrea. The risk of losing crops due to redistribution of land is too high for farmers. Although we use a market approach to introduce the micro irrigation kits it must be clear that the resulting changes in land use practices will have also an impact on the social and ecological environment.

Follow-up:

The aim of the next phase is to monitor the sets in a field test with about 200 - 300 farmers. The sets will be adapted according to the findings of the pre-feasibility study. A further aim is to gather experience in how to introduce farmers. In addition the local demand for the kits must be assessed.

If the results of the test show that there is an interest and a market for the kits, the project must begin to be economically independent during an implementation phase.
In parallel with the test and implementation phases, monitoring of the social and ecological impact must take place.

Preface

Increased pressure on natural resources, especially on water and soils, incited Mr. Pablo Loosli to search for possibilities to improve livelihoods in Eritrea, especially in the large community of small-scale farmers. As large parts of the country suffers from water scarcity, he initiated the idea to introduce affordable micro drip irrigation systems. Together with other institutions he was engaged in the preparation of a pre-feasibility study. A joint first mission with CDE (Centre for Development and Environment), SDC (Swiss Development Cooperation) and IDE (International Development Enterprises) took place from 17 to 27 March. The aim of the mission was to check whether farmers were interested in the new technology as well as to search for local partners in Eritrea.

The overall response was excellent. All those visited, be it small-scale farmers or members of institutions or ministries were thrilled by the idea and encouraged all team members to continue. The team wishes to thank all people involved in the process. Special thanks go to the following institutions and individuals:

University of Asmara, College of Agriculture and Aquatic Science, especially Dr. Bissrat Ghebru who supported us in many different ways: (1) by putting at the team's disposal two excellent scientists, (2) by helping with many administrative questions, (3) by agreeing to have the College do backstopping during the test phase, (4) by offering College premises for presentation and testing of the affordable small-scale drip irrigation system (5) by being personally engaged and always also ready for a private engagement.

Abraham Mehari, PhD aspirant and Lecturer in drip irrigation at the College of Agriculture and Aquatic Science, Department of Soil and Water Conservation, University of Asmara, who was part of the team and an excellent translator for different local languages.

Samuel Asgedom, PhD aspirant and Lecturer in Horticulture, Dept of Plant Sciences at the College of Agriculture and Aquatic Science, Department of Plant Science, University of Asmara, who was also part of the team and a good instructor in practical installation of the drip irrigation systems.

Redaekzi Gebremedhin, agronomist and owner of Ram Farm, who offered his friendship and numerous helpful connections and hints. He was one of the first who knew this drip irrigation system and left it with competent instructions to a farmer in Shiketti.

Sium Fesehaie, Manager of a Citrus Tree Farm in Alla Valley and a dairy production farm near Asmara. He is one of the few people already working with a drip irrigation system. He spent many hours with us and was always ready to share his knowledge and his friendship.

We thank the following institutions and persons for the chance to demonstrate the irrigation system and for the promise to participate in evaluation and implementation of the system: Brother Amilcare Boccuccia, Director of Hagaz Agricultural School, Semere Asmerom, Director of Halhale Research Center, Ermias Adhanom, Horticulturist in Halhale Research Center, Solome Tadesse, Agricultural Engineer (Irrigation) in Halhale Research Center, Solomon Tesfahun (Fafa), Director of Hamel Malo Agricultural College, and the farmers of Gahtelay, Menshib Village, Shiketti and Gaden.

Various officials in different Ministries and friends helped us to find good partners and encouraged us to implement the idea. Our thanks go specially to Gebremichael Hagos, WRD, Rainer Baudendistel, Swiss Consul, Josef Muller, SDR, Semere Amlesom, MoA, Amanuel Negassi, MoA.

Country profile

Eritrea is located in the eastern part of Africa between latitudes 12°42'N to 18°02'N and longitudes 36°30'E to 43°20'E. It is bordered by the Sudan in the West and North, Djibouti in the Southeast, the Red Sea in the East and Ethiopia in the South. The estimated total area of the country is 124,324 km^2, with a coastline of more than 1000 km. Administratively, Eritrea is divided into six Zobas with 54 Sub-Zobas and about 2,685 villages. The population of the country is estimated to be about 3.5 million, with a rural/urban ratio of 80 : 20. One seventh of the whole population live in the capital, Asmara. Roughly 50 % of the total population is below 18 years of age (FAO, 1994).

The country is divided into six major agro-ecological zones. The classification is based on broad similarities of moisture and temperature regimes, natural vegetation cover, soils and land use. The major zones are divided into a number of agro-ecological units (AEU) on the basis of more specific differences of landform, soil type, land cover or land use. So far, there are about 55 agro-ecological units identified (FAO and MOA, 1998). The following table indicates the major zones and their percentage cover in the country.

Table 1: Agro – ecological zones of Eritrea

Agro-ecological zone	Coverage (%)
Moist highland zone	7.4
Arid highland zone	2.5
Moist lowland zone	16.2
Arid lowland zone	32.3
Sub-humid escarpment zone	0.8
Semi-desert zone	38.8
Total	**100**

Source : Agro-ecological Map of Eritrea, FAO and MoA, 1998

Mean temperatures vary in accordance with the agro-ecological zones and range from 25°C in the highlands to 40°C in the lowlands. Rainfall ranges from under 200 mm a year in the lowlands to 600 – 800 mm in the wet highlands.

Agricultural Profile

Agriculture is the dominant sector of the Eritrean economy, engaging about 70 - 80% of the population. The sector contributes about 50 % of the Gross Domestic Product, apart from accounting for 70 % of the value of exports. Of the total population, 9 % are pastoralists, 70 % agro-pastoralists, the remaining people are workers, traders and fishermen.

Of the total potential arable land of 12,252,515 ha, the area presently under cultivation is estimated at 439,000 ha (3.6 %), out of which 417,000 ha (95 %) is rain-fed agriculture and 22,000 ha (2 %) is irrigated (FAO, 1994). There is a potential to increase the irrigable area to 600,000 ha (World Bank, 1994).

Horticultural production in Eritrea has a long history, starting from the first days of Italian colonisation and reaching a peak in the 1970's. During this time, Eritrea's total annual exports in the

sector, amounted to about US$ 4.5 million. This was then disrupted by the escalation of the political situation.

To encourage horticultural production - which was devastated due to prolonged war - the Ministry of Agriculture has to date constructed about 30 micro dams all over Eritrea. These are meant to encourage small-scale irrigation horticultural production.

Currently the landholdings of most of the farmers in the areas where irrigation is possible cover less than one hectare. Most small-scale farmers use furrow and basin irrigation systems for crops such as banana, citrus, papaya, mango, onion, tomato, pepper, potato and leafy vegetables.

Given the scarce and unpredictable rainfall, the introduction of micro drip-sprinkler irrigation kits could increase production. The low costs of the kits, their easy operation and maintenance, and suitability for areas less than a hectare makes them highly valuable and important. Moreover, subsistence farmers could be encouraged to join the horticultural sector. In addition, the kits could be beneficial to women since in most cases they provide substantial labour input especially in households headed by women. Women can be crucial to the success of smallholder irrigation and could contribute to food security in rural communities.

Economic profile

The actual political situation allows no assessment of market-prices because of fast and fundamental changes in the market (eg prices for some crops almost duplicated within one year).

Project description and conclusions of pre-feasibility study

The aim of the project is to assess the implementation and adoption of affordable drip irrigation systems for small-scale farmers in Eritrea.

The irrigation system was developed by IDE (International Development Enterprises, India) together with local specialists in India and the support of SDC (Swiss Development Cooperation). Since its development, the affordable drip irrigation system has successfully been tested in various countries e.g. in India, and several states in Africa and South America. Tests have shown that water consumption for crop growing could be at least cut by half, moreover the mean yield can double. The advantage of the system is not technical, but economical: it is easy to handle and the components as well as the whole system are much cheaper than other systems on the market. To summarise, the three most important points are the following:

- Drip irrigation saves water and fertilisers;
- Drip irrigation saves labour and time;
- Drip irrigation increases yields and the quality of products.

The project is divided in three parts:

- Pre-feasibility study (March 17 – March 28, 2001, follow-up in May 2001);
- Test phase (foreseen for September 2001 – March 2002);
- Implementation phase (2002 - ...).

During the first mission, the pre-feasibility study and preparations for a test phase with selected farmers and institutions were undertaken. Main activities during the pre-feasibility study were:

- To find and contact individuals and organisations interested in affordable drip irrigation systems for small farms;

- To find and instruct "testers" willing to test one of the affordable drip irrigation systems and to report on their experiences;
- To visit irrigation farmers and to discuss their experiences, problems, and the advantages of the system;
- To begin assessing the social, economic, ecological and environmental factors that affect affordable drip irrigation;
- To identify with experts the possible economic benefits of affordable drip irrigation in Eritrea.

The following team members were part of the pre-feasibility study:

- Paul J. Loosli-Maruf, MSc, geographer, project initiator, consultant for CDE Switzerland;
- Brigitta Stillhardt, MSc, geographer, University of Bern, CDE, Switzerland;
- Sudarshan Suryawanshi drip irrigation specialist, consultant for IDE, India
- Dr. Bissrat Ghebru, Assistant Professor, University of Asmara, College of Agriculture and Aquatic Sciences, Eritrea;
- Abraham Mehari, MSc, Lecturer, University of Asmara, College of Agriculture and Aquatic Sciences, Eritrea;
- Samuel Asgedom, MSc, Lecturer, University of Asmara, College of Agriculture and Aquatic Sciences, Eritrea.

The responsibilities for reporting, doing a follow-up and planning the test phase are shared between the University of Asmara, College of Agriculture and Aquatic Sciences and the University of Bern, Centre for Development and Environment.

Thanks to the partners we found (see Introduction) the mission was very successful and mission results are promising. The goals formulated in the terms of reference were very ambitious (see Annex) but thanks to the optimal situation it was possible to achieve all goals. The most important "findings" are listed below.

- We identified about 18 institutions and farmers willing and able to test the products and to help with the introduction of a test on a larger scale.
- We found a network of institutions to work with – and competent local partners for the follow-up (Dr. Bissrat Ghebru, Samuel Asgedom and Abraham Mehari, College of Agriculture and Aquatic Science, University of Asmara).

Test phase

The results of the pre-feasibility study and the contacts established during the first phase will be used to design the test phase. The aim of the test phase is to monitor the sets in a field test with different farmers in different agro-ecological environments. The sets will be adapted according to the findings of the pre-feasibility study. A further aim is to gather experience in how to introduce farmers. It will also serve to assess the local demand for the kits. Distribution is within the responsibility of the team from CAAS, University of Asmara. Administration, co-ordination, backstopping and technical support are within the responsibility of CDE.

Implementation phase

If the results of the test show that there is an interest (and a market) for the kits, the project must begin to be economically independent during the next phase. The responsibility of the project can then be to find local importers and traders and to facilitate contacts between them and IDE. The goal of this is to set up a viable supply chain.

Because of the fact that the introduction of small-scale micro drip irrigation systems follows a market approach it is very important not to forget to assess the social and ecological impact that such a fundamental change in the land use system may cause! This needs to be studied thoroughly.

First findings concerning the implementation of affordable micro drip irrigation systems:

The mission has achieved its ambitious goals thanks to the support of the College of Agriculture and others, and we generally found a vivid interest for the technology wherever it was demonstrated. The following points are the key lessons learnt:

a) Advantage of the system

- Drip irrigation saves fertiliser, and increases both the quality and quantity of yields.
- For the bucket kit, saving labour is the best argument.
- Soil erosion through water can be limited thanks to punctual irrigation.
- The evaporation rate is smaller than with flood irrigation.

b) Shortcomings of the system

- What is missing in the packages, especially in the micro sprinkler kit package, are spare parts.
- A piece of cloth should be added to the sets to pre-filter the water (to prevent the filter from clogging).
- Micro sprinkler systems are not suitable in areas with frequent strong winds.
- Micro sprinklers are not suitable in areas without running tap water. Moreover there must be enough pressure or the possibility of installing the set at a height of at least 10 m.

c) Gender issues

- Address the women directly to disseminate the small bucket kits, because small vegetable gardens are within their responsibility.
- Except for the bucket kit the question who is responsible to work with the kits is not clear. In Hagas for example female scholars are responsible for testing the kits, in other places the interest of male farmers, especially in the sprinkler kits, was much higher than the interest of female farmers.

d) Dissemination issues

- Farmers around Asmara are currently difficult to reach because they recently installed a new furrow irrigation system and water is available in sufficient quantities.
- To disseminate the new technology in an efficient way, it is ideal to address students of agricultural schools, who will be working later in extension services, advice centres, or as farmers.
- The question how to bill farmers during the test phase for the tested set is still open and not easy to answer. It has to be solved before the test begins. If the set is given for free we create an inequality between the "testers" and other interested farmers. Also how carefully the sets will be used if they are given for free? If the farmers are asked to bare the full costs now, how can the price to be paid later on the market be calculated?
- For a broader introduction of the sets the "how to install" manual must be available in the national language – or even better in a form also usable by illiterate people. For the test phase a draft manual must be available.

e) Economic issues

- Import taxes on items for agricultural purposes (2 %, not only on the value of the material but also on shipping costs, the argument being that shipping costs increase the value of the material.) seems to be much lower than for other imported goods, but with all additional costs total import taxes amount still to about 10 %.
- An economic assessment of the returns of the kits is difficult in the current situation because of great price fluctuations on the market (e.g. market prices for tomatoes fell very rapidly from 8 Nakfa per kilo to 1.5 Nakfa per kilo because of the seasonality factor).
- When calculating the costs of the sets one should not forget to include the additional costs of a bucket or a barrel. This essential part is not included in the pre-packed sets.
- Additional costs originate from fencing in the irrigated area and have to be taken into account when calculating the overall costs of a set.

f) Agronomic and ecological issues

- Most small-scale farmers have no practice in working with small-scale irrigation systems. Knowledge generation must be a central topic when introducing the kits. (Check the possibility through agricultural extension services/ the Ministry of Agriculture / agricultural colleges)

- If availability of water is limited irrigation needs may compete with the need for drinking water, e.g. in Keren a farmer did not get permission from the community to use tap water.
- All domestic animals must be prevented from entering irrigated areas. Cattle cause damage when stepping on the tubes or drippers, chicken are known to pick seedlings.
- The higher efficiency of the drip irrigation system leads also to a smaller return flow of water to the groundwater storage. More intensive use of water resources can lead to accelerated overexploitation of the aquifer.

g) Social and political issues

- It was mentioned that farmers might need official approval of a local authority to participate in a test phase.
- Because of the insecure land tenure situation (dessa land tenure system: arable land is within the responsibility of the community and land redistribution takes place every 7 – 9 years) the horticulture kit is not suitable because the risk of loosing crops due to redistribution of land is too high for farmers. This kit is designed for perennial crops such citrus trees or papaya trees.
- Although we use a market approach to introduce the micro irrigation kits it must be clear that the resulting changes in land use practices will have also an impact on the social and ecological environment. As yet, no assessment of this impact has been made; it must be part of a careful follow-up and monitoring. E.g., how do farmers invest the additional income: if they increase the herd size (traditional saving system), the pressure on the scarce grassland may increase. Or how do farmers deal with additional demand for water? What influence does irrigation have on biodiversity? How do farmers substitute the higher demand for plant nutrients? Is there any strategy to deal with salinity of soils? Etc.

Description of Affordable Micro Irrigation Technology (AMIT)

What is micro (drip) irrigation technology?

Slow & regular application of water directly to the root zone of plants through a network of economically designed plastic pipes and low discharge emitters.

What is an "AMIT kit"?

A user-friendly package of small drip systems; these can be prepared by assembling major components of the kit and supported with required information to make it ready to use by smallholders for commercial crop cultivation.

The most important feature of micro irrigation, i.e. 'More Crop per Drop,' has drastically transformed agricultural practices in countries like Israel, where commercial farming has replaced subsistence farming. It is an ideal way to produce high value crops as it reduces water use, increases crop yield and gives good quality produce within less time and with less investment compared to traditional ways of cultivating and irrigating commercial crops. However the majority of smallholders in developing countries are deprived of this amazing technology due to its high initial cost and non-adaptability to smallholdings. Until recently it was too expensive to be affordable for poor families and too large for tiny plots of land. International Development Enterprises (IDE), a non-profit voluntary organisation has now overcome this problem by developing a range of small and easy-to-use micro irrigation kits at affordable prices to produce high-value crops.

IDE has been working on affordable micro irrigation technology in India and Nepal since 1995. In the process a range of products and configurations have been tested and developed for smallholders. These products are in the form of ready-to-use kits, assembled and packaged so that they can be sold off the shelf and a farmer can install and use them on his own. Most of the components in a typical low-cost micro irrigation system are manufactured from polyvinyl chloride, various types of polyethylene and polypropylene by small manufacturers. IDE has found that the manufacturing

technology is a simple extrusion or injection molding process, and manufacturers of plastic pipes can easily adopt it. While working with smallholders in India, Nepal, Vietnam and China, IDE observed that affordable micro irrigation technology enables smallholders to cultivate cash crops with a small amount of water, as well as increase crop intensity so as to profit from a two to three times higher income than when cultivating traditional crops. Farmers can increase their area under irrigation by expanding the drip system. The development of a supply chain for affordable micro irrigation kits involving manufacturers, assemblers, dealers, nursery growers and commercial farmers can be a major contribution to micro enterprise development in a particular area and increase trade of inputs and outputs.

Types of AMIT Systems:

Table 2: Salient features of AMIT kits developed in India

Features	**Kitchen garden kit (KGK)**	**Vegetable garden kit (VGK)**	**Horticulture garden kit (HGK)**	**Micro-sprinkler kit (MSK)**
Major components	Main line, lateral lines, micro-tubes, filter, pegs, fittings etc.	Main line, lateral lines, micro-tubes, filter, pegs, fittings etc.	Main line, lateral lines, micro-tubes, filter, pegs, fittings etc.	Main line, lateral lines, micro-sprinklers filter, fittings etc.
Area under irrigation	40 m^2	100 m^2	130 m^2	160 m^2
Number of emitters	36	150	50	15
Approximate number of plants	36 to 72 for spaced crops; also used for row crops	150 to 300 for spaced crops; also used for row crops	50 horticulture / orchard crops.	Mainly used for closely spaced crops
Required height of water source (minimum)	1 meter	1 meter	1 meter	10 meter
Discharge per emitter	2 l/h	2 l/h	2 l/h	50 l/h
Required content of water storage bin	Bucket with 20 l	Barrel with 200 l	Barrel with 200 l	Barrel with 500 l or connect to tap
Type of crops	Vegetable crops	Vegetable crops	Perennial fruit crops	Vegetables, flowers, pulses, cereals etc.

Advantages of AMIT

1) **Affordability:** AMIT kits enable the farmer to start from a very small system and then expand the area under irrigation in phases. If economically profitable, the elements can be produced, assembled and manufactured locally.
2) **Low water application rate**: A truly distinctive feature of irrigation is the low water application rate. Low application at frequent intervals keeps the soil saturated with optimal soil, air and water ratios, which is good for healthy plant growth.
3) **Uniformity of water application**: High uniformity of water application is achieved in comparison to the traditional systems. Uniform water application means that all plants receive almost the same amount of water. An even, consistent application of water results in better and more uniform yields because each plant is given as much water and nutrients as it needs for optimum growth.
4) **Water and nutrient saving**: A major advantage of drip irrigation is the fact that water and nutrients are well placed in the root zone of plants, thus eliminating all the conveyance losses that occur in traditional systems. Nutrient leaching and soil erosion are minimised. Hence the systems contribute to water and nutrient saving.

5) **Controlled root zone environment**: One of the most important aspects of drip irrigation is the fact that constant soil moisture content is maintained in the root zone. It provides tolerance to salinity and control of diseases in addition to precise application of water.
6) **Improved disease control**: Although difficult to quantify, it appears from a number of reports that disease control is enhanced under a drip irrigation regime, because soil moisture and chemical application levels can be closely controlled, whereby frequency and timing of chemical applications are easy to manage. In addition the spread of micro-organisms by water movement is greatly reduced since surface water run-off is eliminated.
7) **Difficult terrain**: Micro-irrigation has made vast areas of previously unused land useful for agriculture. It can be used on difficult soil and terrain conditions. Irregular or undulated terrain poses far fewer problems for a drip-irrigation system than for conventional methods. The costly "laser levelling" often required for furrow or flood irrigation systems is not required with micro-irrigation. In some areas micro-irrigation systems are installed on very steep slopes that would be difficult or impossible to irrigate by other methods.
8) **Problem soils**: Drip irrigation systems are often ideally suited to "problem soils". The low water application rate is ideal for heavy clay soils with low infiltration rates, as the water can be applied slowly enough for the soil to absorb it without causing surface runoff. With sandy soils under conventional irrigation systems, much of the water applied is lost through deep and fast percolation. Drip-irrigation overcomes this problem due to frequent application.
9) **Efficiency of fertiliser application**: Drip irrigation systems are effective when it is necessary to apply fertilisers and chemicals in the root zone. Efficient vegetative growth is supported by the frequent and direct application of fertilisers to crops. Improved control of fertiliser placement and timing also leads to greater fertiliser efficiency.
10) **Improved tolerance to salinity**: In general, drip irrigation reduces the sensitivity of most crops to saline soil and/or water conditions, due to the maintenance of low water tension in the root zone. When plants extract water from the soil, ions are taken up selectively, leaving an increased concentration of salt that makes it more difficult for the plant to take up water from the soil. Frequent application of water under drip-irrigation continually reduces this concentration, and moves salts away from the plant out to the edges of the root zone. These salts precipitate out of the water at the edge of the wetted perimeter. The process is called "micro-leaching".
11) **Energy conservation**: If compared to furrow or flood irrigation, drip irrigation systems are more efficient, reducing the amount of water to be pumped, and hence reducing energy consumption.
12) **Increased yield**: Under traditional irrigation methods, plants extract water from the soil from field capacity down towards permanent wilting point. During this transition in soil moisture, it becomes increasingly difficult for the plant to extract water from the soil, and therefore the water use rate decreases. This reduction in water use is accompanied by reduction in the growth rate of plant and reduction in yield. Ideally, an irrigation system should maintain the soil moisture level slightly below field capacity to achieve maximum yields. With its controlled application, the drip irrigation system makes this possible.
13) **Improved quality**: Crop quality under drip-irrigation is improved for many of the same reasons that the yield is improved. The slow, regular, uniform application of water and nutrients results in even growth.
14) **Reduced labour costs**: One of the major advantages of micro irrigation systems is that it saves labour costs compared to other methods of irrigation. In addition to the immediate reduction of labour, indirect savings are often possible due to reduced number of weeding sessions, elimination of fertiliser application as a separate operation and fewer harvesting rounds due to more uniform ripening.
15) **Improved crop control**: Another major advantage of drip irrigation is taht it allows the grower to have improved control of irrigation. Growers can apply water or withhold it in response to weather changes, they can apply more or less fertiliser to speed up or delay growth, schedule irrigation and field operations so as to avoid conflicts, quickly apply selected nutrients or pesticides in response to the immediate needs of the crops.
16) **Application for various crops**: The AMIT-system is suitable to a wide range of crops:

- **Fruit crops:** almond, apple, apricot, coconut, cherry, fig, grape, litchi, citrus, mango, orange, olive, papaya, pear, peach, pistachio, plumb, pineapple, strawberry, sapota.
- **Vegetable crops:** tomato, capsicum, cabbage, cauliflower, broccoli, peas, egg-plant, cucumber, lettuce, melons, pepper, potatoes.
- **Field crops**: maize, cotton, groundnuts, sugarcane, sunflower, cereals.
- **Ornamentals:** floriculture crops.

Kits Distributed during the Mission

The total amount of kits distributed during the pre-feasibility mission was 25: 10 bucket kits, 5 horticulture drum kits, 5 vegetable drum kits and 5 micro sprinkler kits. Another four kits were brought through other channels to Eritrea, which leads to a total of 29 distributed kits. One important aim of distribution was to reach institutions, because testing and follow-up can be better guaranteed in collaboration with institutions than through individual farmers.

Table 3: Drip- and Sprinkler Kits distributed during the field stay

Site	Contact person	Type of kit			
		Bucket kit	Horticulture drum kit	Vegetable drum kit	Micro sprinkler kit
Adi Jemel	Solomon Ghebrekidan	1	-	-	-
Afdeyu	Semere and Daniel	1	-	-	-
Akurdet	Osman Damer	-	-	-	1
Asmara	Dr. Josef Muller	1	-	-	-
Barentu	Hadera Negos		1	-	-
CAAS, University of Asmara	Dr. Bissrat Ghebru Abraham Mehari Samuel Asgedom	1	1	1	1
Dekemhare	Dr. Mussie	-	-	-	1
Elabered	Ahmed	-	1	-	1
Gaden, Alla valley	Issayas	-	-	1	-
Gaden, Alla valley	Sium Fesehaye	1	-	-	1
Ghahtelay / Ghinda	Berhane	1	-	-	-
Hagaz	Teodros	-	-	1	-
Hagaz Agricultural College	Brother Amilcare	1	1	1	1
Hal Hale, Research Centre of the MoA	Ermias Adhanom, Horticulturist, Solome Tadesse, Agricultural Engineer (Irrigation)	1	-	1	-
Hamel Malo Agricultural College	Solomon Tesfahun (Fafa)	1	1	-	-
Mendefera	Grazimach	1	-	-	-
Mensheb village	Shibli and Yemane	2	-	-	-
Shiketti	Beyene Kiflet	1	-	-	-
Total		**13**	**5**	**5**	**6**

During presentation of the different sets we observed that the horticulture kit did not interest the farmers as much as the other kits. Two different explanations were given for this fact:

- Land ownership is not clear and local land redistribution is to be expected every 7 to 10 years. The design of the horticulture set is optimised for trees or bushes. Citrus trees, coffee or other perennial cultures require a long term planning, therefore the risk of loosing investments is too high for farmers.
- Farmers mentioned several times that the amount of water coming through the micro drippers cannot be sufficient for trees. Experience showed that this is a problem of perception that cannot be solved by using scientific explanations. Most probably, ownership problems are also involved here: the higher the risk the lesser the willingness for experiments.

Annex 1 Terms of Reference

1. Visit to the first 3 Testers (Redaegzy [moist highlands], Father Angelo[moist highlands] and Sium Fesehaye [1500 m asl, sub-humid eastern escarpment]) with the purpose of reporting on first experiences and problems.

a) Discussion of the situation with the Indian specialist (check list);
b) Introduction to the local situation (Sudarshan Suryawanshi) (economy, situation in general, agro-climatic conditions, land use, land tenure);
c) Collect ideas, data for further program steps.

2. Identify and contact new testers, with the purpose of disseminating / introducing programme for micro-irrigation. Select, demonstrate and assist in the assembling of adequate micro-irrigation sets. Collect data on traditional irrigation systems and discuss expectations with regard to the new technology. Registration of relevant data on test sites and testers (including address, current agricultural production (quality and quantity), general remarks and pictures).

   a) Selection criteria according to the overall limiting factors "water", "labour" and "space":
   Producers in periurban vegetable belt around Asmara (above 1800 m asl, highland area. Contact: Rainer Baudendistel!)
   University of Asmara, College of Agriculture and Aquatic Science, Dr. Bissrat Ghebru
   Hagas (Don Bosco research and school, semi-arid lowlands)
   Halhale (Government research station, moist highlands)
   Keren / Anseba (possible optimisation of an intensely used traditional irrigation system: onion, tomato, semi arid western hills, about 1500 m asl)
   Afdeyu (Research site of CDE, University of Asmara and MoA, moist central highlands). Combined with a visit of TOKER Land Husbandry Programme in Serejeka
   Deki Lefay (Project site of a Swiss NGO, documented in a 1997 CDE baseline study; sub-humid southeastern part, about 1600 m asl)
   Test sites in eastern lowlands (e.g. Seafire, Massawa, semi-arid desert, Red Sea coast)

3. Collect and select names and sites of institutions and individuals for further testers. Adaptation and modification of selection criteria according to information gathered, in particular according to know-how of Sudarshan Suryawanshi, Consultant IDE (International Development Enterprises). (Phase 2: at least 100 sets)

4. Evaluation / estimation of costs and benefits for users of the drip system as well as of the social framework of participants.

5. Gather information concerning costs and benefits for local assembly, manufacturing, import, possible marketing strategies, interests expressed by agri-input-dealers, distributors etc).

6. Mission report, including an extended address list, information about selected farmers, exhaustive evaluation of door openers, including recommendations for short- and long-term partners.

Annex 2
Timetable and experiences of the pre-feasibility study

Date	Organisation / person(s) met, activity	Purpose
17/03/2001	Flight Zurich – Asmara	
18/03/2001	Meeting Sium Fesehaie	Briefing experience of drip irrigation
	Meeting Redaegzi Gebremedhin	Briefing Shiketti
	Visit farm Sium Fesehaie	Newly installed irrigation system
	Visit to Josef Muller, SDR	Briefing about purpose and aims of the mission
19/03/2001	Meeting Rainer Baudendistel, (Swiss Honorary Consul) and Josef Muller (SDR)	Briefing about purpose and aims of the mission
	Meeting Dr. Bissrat, CAAS	Briefing about purpose and aims of the mission, discussion about forms and content of possible collaboration
	Meeting Habtom	Hand over of maps
20/03/2001	Meeting Gebremichael Hagos, Director WRD	Briefing about purpose and aims of the mission, discussion about topics and possible demonstration sites Handing over of CD with digitised maps
	Meeting Amanuel Negassi, Head Irrigation Unit, MoA	Briefing about purpose and aims of the mission, discussion about topics and possible demonstration sites
	Meeting Semere Amlesom, Head Soil and Water Conservation Research Unit, MoA	Briefing about purpose and aims of the mission, discussion about topics and possible demonstration sites
	Visit farm Sium Fesehaie, Alla valley	Monitoring of a sprinkler kit and a bucket kit, installed two month ago
	Meeting with farmer in Gaden	Discussion about drip irrigation
21/03/2001	Meeting Hal Hale Research Station (MoA)	Discussion with Director of Research Station, presentation of drip irrigation sets to the staff
	Visit in Shiketti	Monitoring of the first installed garden kit
	Visit of CAAS, University of Asmara	Presentation of drip irrigation sets to staff and students
22/03/2001	Meeting with Father Amilcare, Director Hagas Agricultural School	Discussion with Father Amilcare and presentation of drip irrigation sets to the students
	Meeting with Solomon Tesfahun, Director Agricultural College, Hamel Malo	Discussion with Solomon Tesfahun and presentation of drip irrigation sets to the students
23/03/2001	Meeting with the Director of BISELEX (privat company, importing Israeli drip irrigation components)	Discussion about the experience of BISELEX with drip irrigation (market, installation, problems, etc)
	Visit of irrigated farm in Gahtelay	Discussion with farmers about their experience with a large system, presentation of the small irrigation sets
24/03/2001	Visit of "Seaphire"	Collecting information about a project with shrimp production and salicornia plantations
	Travel to Mensheb	Presentation of drip irrigation sets to farmers
25/03/2001	Travel to Gaden	Presentation of drip irrigation sets to farmers
	Visit of Sium Fesehaies farm	Discussion about his experience with drip irrigation
26/03/2001	Visit to Rainer Baudendistel	Final briefing about the mission
	Visit to the Water Resources Department	Briefing about the mission
	Final meeting at the Agricultural College	Discussion of findings, discussion about follow-up,
	Meeting with Tseggai	Discussion of logistic problems
27/03/2001	Flight Asmara - Zurich	

Follow up 1 – 5 May

Date	Organisation / person(s) met, activity	Purpose
01/05/2001	Meeting with Dr. Bissrat Ghebru and Abraham Mehari Haile	Discussion of the next steps, preparation of a questionnaire
	Visit of Afdeyu	Handing over spare parts for the river station
02/05/2001	Travel to Keren	Retrieval of a sprinkler kit (not enough water)
	Visit of Hamel Malo Agricultural School	Monitoring of the installed sets, discussion with the users
	Meeting Osman Damer in Akurdet	Presentation and installation of a sprinkler kit
03/05/2001	Meeting Hadera Negos in Barentu	Presentation and installation of a horticulture kit
	Visit of Hagas Agricultural School	Monitoring of installed kits and discussion with the users
04/05/2001	Travel to Adi Jemel	Presentation of a bucket kit to farmers

Annex 3: Addresses

Name	Institution/Fuction	Address	Tel	Fax	email
Abraham Mehari Haile	Lecturer for drip irrigation	University of Asmara College of Agriculture and Aquatic Sciences P.O. Box 1220 Asmara	00291 1 16 26 07		Abraham@caas.uoa.edu.er
Amanuel Negassi	Head of Irrigation and Soil and Water Conservation Unit	Ministry of Agriculture P.O. Box 1048 Asmara	00291 1 18 11 06		Amanuel@eol.com.er
BISELEX	Import factory of Israeli drip irrigation systems	P.O. Box 785 Asmara	00291 1 12 74 55 and 00291 1 12 44 14	00291 1 12 39 74	Biselex@eol.comer
Dr. Bissrat Ghebru	Assistant Professor, Plant Genetics & Breeding	University of Asmara College of Agriculture and Aquatic Sciences P.O. Box 1220 Asmara	00291 1 16 26 07	00291 1 12 79 14	Bissratg@caas.uoa.edu.er
Brigitta Stillhardt	Geographer, CDE	CDE Hallerstrasse 12 CH-3012 Bern	O: 0041 31 631 38 93 P: 0041 31 333 63 61	O: 0041 31 631 85 44	bst@giub.unibe.ch
Brother Amilcare Boccuccia (Sun –Tue in Asmara)	Director of Hagas Agricultural College	Don Bosco Agricultural college Hagas	00291 1 18 18 14 (tel. Asmara, Sun – Tue)		
Father Angelo	Principal of Don Bosco School of Salesian Brothers	Dekemhare			Sdbdek@eol.com.er
Gebre Christos	Vice Minister MoA	Ministry of Agriculture P.O. Box 1048 Asmara			
Gebremichael Hagos (Woody Arbate)	Head of the Water resources Development Unit (WRD)	Ministry of Land Resource and Environmental Protection P.O. Box 1488 Asmara	00291 1 12 04 04		
Ghebremicael Temnewo	Director Water Use & Management Division	P.O. Box 1488 Asmara	O: 00291 1 12 03 55 P: 00291 1 11 96 36	00291 1 12 46 25	
Halhale	Research station MoA		00291 1 18 30 35		
Josef Müller	SDR (Swiss Disaster Relief Unit)	Ogaden Street No 13 P.O. Box 3099 Asmara	O: 00291 1 12 77 34 P: 00291 1 18 55 38	00291 1 18 55 38	Sdrjam@eol.com.er
Mebratu Illassu	Ministry of Agriculture and Chef of Ass. Of Eritrean Scientists in Agronomic Sciences (AEAS)	Ministry of Agriculture P.O. Box 1048 Asmara	00291 1 18 14 80		
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Semere Amlesom	Head Land Resource and Environmental Protection	MoA P.O. Box 1048 Asmara		00291 1 18 14 15	
Simon Abraham Tesfasion		P.O. Box 4031 Asmara			
Sium Fesehaie	Manager Citrus Tree Farm and dairy production Alla valley	P.O. Box 3303 Asmara	00291 1 12 23 22	00291 1 12 08 39	

Name	Institution/Fuction	Address	Tel	Fax	email
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Urs Heierli	Senior Advisor Private Sector Promotion	SDC Division Employment and Income Room 1412 Freiburgstrasse 130 CH-3003 Bern	0041 31 322 63 37	0041 31 323 08 49	Urs.Heierli@deza.admin.ch
Yohannes Nazengue	CH-Eritrean with a Flower farm	Asmara	00291 1 12 00 17		