Bern University of Applied Sciences
Berner Fachhochschule
Swiss College of Agriculture SHL
Schweizerische Hochschule
für Landwirtschaft SHL

Micro Irrigation for Small Scale Farming – An overview about technologies and methods

1. Packaged Systems

In this chapter pre-packed or pre-assembled irrigation systems (kits) are presented. They are all designed for small-scale, resource-poor farmers. The size of the systems goes from 20sqm to approximately 2000 sqm.

Baffle or Nepalese System

Description: Pre-packaged irrigation kit, developed by International Development Enterprises (IDE) in Nepal. Design: 8x 12 m, 8 drip lines, pre-punched drip-holes every 0.6m; drip lines can be shifted. Costs: approx. 20$/System.
Strengths: is solid and can be handled easy.
Weaknesses: the system is susceptible to clogging.

More information:
Information can be obtained from IDE Nepal:
http://www.ideorg.org/work/nepal.php

Microsprinkler IDE

Description: Pre-packaged mini-sprinkler kit, developed by International Development Enterprises (IDE) in Nepal. Design: The package consists of 15 sprinklers, 1 sprinkler irrigates an area of 6m in diameter. The system operates at a minimum pressure head of 8 meters. .
Strengths: suitable for nurseries, easy to manage.
Weaknesses: minimal pressure of 8m needed.

More information:
Information can be obtained from IDE Nepal:
http://www.ideorg.org/work/nepal.php

Bucket Kit by Chapin Living Waters

Description: Pre-packaged micro drip-irrigation kit, developed by ChapinLivingWaters.
Design: The package consists of all parts of the system (drip lines, emitters, filter, connectors) except the bucket (20liter-bucket is needed). 2-6 lines of vegetables can be irrigated (approximate area of 100sqm). The system operates at a minimum pressure head of 1 meter.
Costs: 22.50$/Kit
Strengths: suitable for vegetable gardens, can easily be assembled and managed.
Weaknesses: In most places no spare parts available because the kits are often donated.

More information:
Information can be obtained from:
http://www.chapinlivingwaters.org
Kits can be ordered at:
http://echobooks.org/product_info.php?products_id=271

(Pictures from:
http://www.chapinlivingwaters.org/bucket%20kit%20gardening.pdf)

Family Nutrition Kit IDE India

Description: The smallest existing pre-assembled and packaged drip irrigation kit, developed by IDE India.
Design: The kit comes in a ready-made layout, consisting of 4 drip lines, each of which is 5m long. A plastic bag with filter is part of the system, too. The system operates at a pressure head of 1 meter.
Costs: approx 5 $/Kit
Strengths: The smallest available drip-irrigation kit is designed for poor women-headed households; its aim is to improve food security. The kit is suitable for back-yard vegetable gardens and is easy to manage. Not susceptible to clogging. Spare parts and supporting services exist in some areas of the world, where IDE supports the creation of a market-based supply-chain (including local production) for the irrigation systems.
Weaknesses: The system is too small for market-production. The introduction of the IDE-systems requires a full-fledged project and donor-support.

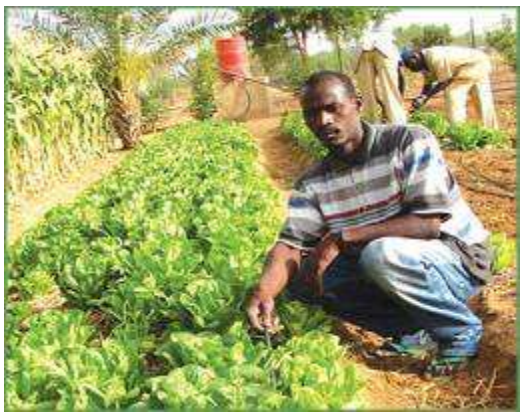
More information:
Information can be obtained from: http://www.ide-india.org/

Drum Kit and Customized Kit IDE India

Description: A pre-assembled and packaged drip irrigation kit, developed by IDE India. The size of the system is variable and can be extended to approx. 1 ha.
Design: The packaged kit consists of main tubes, drip lines, emitters, connectors, and a filter. A bucket of minimum 60l is recommended. The system operates at a minimum pressure head of 1 meter.
Costs: approx 25 $/Kit (for 200sqm)
Strengths: suitable for vegetable gardens, can easily be assembled and managed. Not susceptible to clogging. Spare parts and supporting services exist in some areas of the world, where IDE supports the creation of a market-based supply-chain (including local production) for the irrigation systems.
Weaknesses: The introduction of the IDE-systems requires a full-fledged project and donor-support.

More information:
Information can be obtained from:
http://www.ide-india.org/

Family Drip System Netafim



Description: Netafim, an Israeli drip-irrigation manufacturer, has developed a “small-scale” drip-irrigation kit for an area of 1000 -2000 sqm.
Design: The packaged kit consists of main tubes, drip lines, emitters, connectors, and a filter. A water tank is additionally needed to complete the system.
Costs: approx 150 - 240 $/Kit (for 1000 sqm).
Strengths: Suitable for commercial vegetable production, can easily be assembled and managed. Netafim is present in many countries of the world and can provide support.
Weaknesses: Probably too expensive for small-scale farmers. More complicated management, compared to others; susceptible to clogging.

More information:
Information can be obtained from:
http://www.netafim.eu/Irrigation_Products/Agriculture_Drip_Products/Irrigation_Systems%5B1345%5D/FDS_/

(Pictures:
http://www.netafim.eu/Irrigation_Products/Agriculture_Drip_Products/Irrigation_Systems%5B1345%5D/FDS_/Projects%5B1351%5D/)

2. Emitters

In this chapter a number of different types of emitters (or drippers) for small-scale drip irrigation systems are presented. Some of them can be produced by farmers, others are commercially promoted.

Microtube emitter (IDE India)

Description: The microtube emitter is a long, thin tube; pressure is reduced according to the length of the tube.
Design: The tubes have an inner diameter of 1-2 mm. They are typically 15-30 cm long, but can be longer if wished so.
Strengths: Compared to self-made emitters, the uniformity of these emitters is better. The handling (installation, replacement, etc.) is very easy. The emitters are not susceptible to clogging and cleaning is easy, (important, if the filter is not very fine).
Weakness: To guarantee a high uniformity of the emitters an exact production process is necessary.

More information can be obtained from: http://www.ide-india.org/

Microtube emitter (self-made)

Description: The microtube emitter is a long, thin tube; pressure is reduced according to the length of the tube.
Design: The tubes were made from the isolation layer of an electric wire with an inner diameter of 1.5mm and a length of 25 cm
Strengths: Uniformity is low but acceptable for small plots. The handling (installation, replacement, etc.) is very easy. The emitters are not susceptible to clogging and cleaning is easy, (important, if the filter is not very fine).
Weakness: Electric cable is expensive due to the copper wire. However, the copper can be sold at a good price on the market.

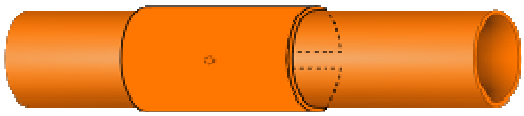
More information can be obtained from the practical training report of Sandra Boegli (SHL, Boegli 2007).

Baffle emitter (IDE Nepal)

Description: The baffle emitter consists of a short plastic tube, which is shifted over the hole in the drip line.
Design: IDE Nepal uses baffle emitters in its pre-packaged drip-irrigation system (see above).
Strengths: Clogged emitters can easily be cleaned by shifting the baffle. Uniformity of the IDE-manufactured system is acceptable.
Weaknesses: Emitters of the Nepalese system are very susceptible to clogging due to very small pre-punched holes in the drip lines (important, if the filter is not very fine).

More information can be obtained from http://www.ideorg.org/work/nepal.php

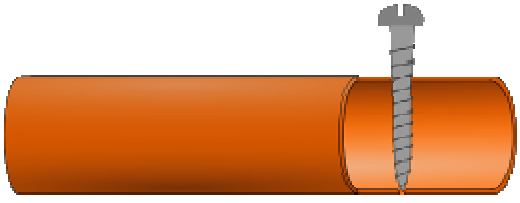
Baffle emitter (self-made)



Description: The baffle emitter consists of a short plastic tube, which is shifted over the hole in the drip line (made with a thin wire or needle) and thus brakes the dashing water.
Design: Baffles can easily be made from plastic tubes, e.g from a tube used as drip line (details see illustration on the left).
Strengths: Clogged emitters can easily be cleaned by shifting the baffle and cleaning the hole.
Weaknesses: Uniformity of self-made emitters is very low due to differences in the size of the holes. The baffle is not a real pressure reducer and can therefore not even such differences.

More information can be obtained from the practical training report of Sandra Boegli (SHL, Boegli 2007).

Screw emitter (self-made)



Description: The screw emitter consists of a screw, screwed into the drip line. Water drips out of a tiny hole at the lower side of the drip pipe, caused by the tip of the screw. Water discharge can be regulated.
Design: The screw is screwed into the drip line until the tip punches the lower wall of the pipe. The flow of water can be regulated by slightly tightening or loosening the screw.
Strengths: Emitters can be constructed and maintained easily. Water discharge can be regulated. Clogged emitters can easily be cleaned by loosening the screw.
Weaknesses: Uniformity of this self-made emitter is very low, and regulation has to be checked in every irrigation cycle.

More information can be obtained from the practical training report of Sandra Boegli (SHL, Boegli 2007) and of the diploma thesis of Simon Spoehel (SHL, Spoehel 2006).

Other types of emitters

Besides the here presented emitters, a wide range of emitter types exist which are available on a commercial basis:

Examples:
Hydrodrip: http://www.plastro.com/

3. Various self-made irrigation system technologies for small-scale farming

Farmers around the world invent and adapt irrigation technologies to fit their specific purpose and context. In this chapter, a number of such irrigation technologies are briefly described.

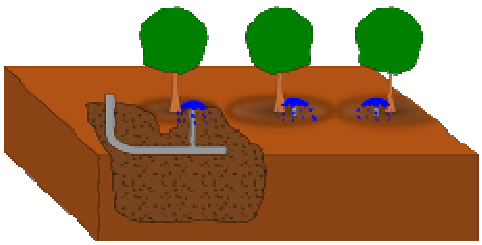
Canari (from Burkina Faso)

Description: The “canaris” (=pitchers) are buried in the humid soil and are kept there until the soil has dried out. Afterwards the canari is removed. A planting hole remains, where compost is added before planting. The method is best suited to grow vegetables, one or two plants per hole.

Strengths: It is not an irrigation technology as such, but the method uses scare water resources very efficiently. Once installed, watering saves time and water.
Weakness: Suitable pitchers may not be available everywhere. The technology works only for small-scale vegetable production and in heavy soils.

More information can be obtained from CEAS Burkina Faso: http://www.ceas.ch/burkina.html

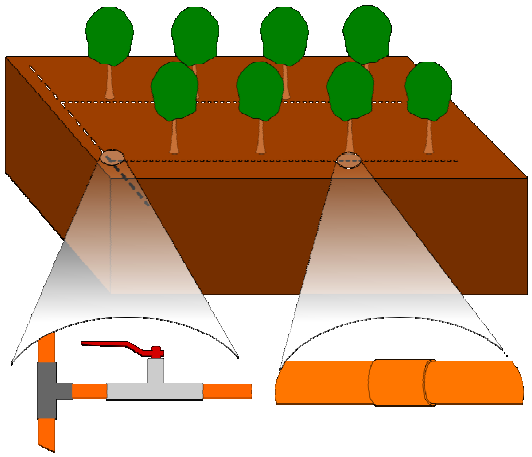
Fruit tree irrigation (seen in Burkina Faso)



Description: This irrigation system consists of subsurface tubes which are installed permanently in a fruit tree plantation (mangos, avocados, etc.). Each tree has fixedly installed emitter, placed close to the stem. The system has to be operated with relatively high pressure. The water is stopped from run-off by a small basin formed around the tree.
Strengths: The system allows irrigating trees very targeted. Once installed, operation is easy and saves time.
Weakness: Procurement of tubes is costly; therefore the system is most suitable for cash crops.

More information can be obtained from CEAS Burkina Faso: http://www.ceas.ch/burkina.html

Sub-surface fruit irrigation (seen in Senegal)



Description: Simple system to irrigate trees. It consists of subsurface tubes with baffle emitters (see above). The whole system is buried in the soil, approx. 30 cm under the surface. Emitters are put closely to the stem.
Strengths: Water is applied to the root zone of the trees and thus used very efficiently. There occur practically no evaporation losses, because the water never reaches the surface. Once installed, the system remains permanently in the soil for years.
Weakness: Procurement of tubes is costly; therefore the system is most suitable for cash crops. The system operates with relatively high pressure (water from water tower).

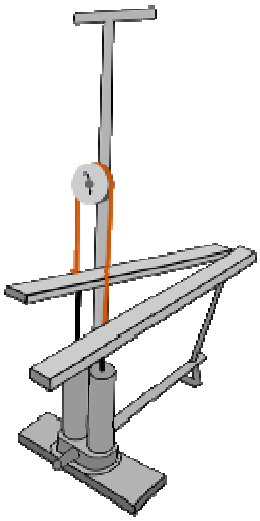
More information can be obtained from CEAS Senegal: http://www.ceas.ch/senegal.html

Shifting drip irrigation by rows (seen in Burkina Faso)

Description: It is a simple "self-made" system, consisting of sub-surface supply lines which remain permanently in the soil and of drip lines with baffle emitters (other emitters are also possible) which are shifted from one row to the other.
Strengths: The system uses water efficiently and is suitable for small-scale vegetable production.
Weaknesses: Installation, maintenance and operation are easy, but some experience is needed to use the system optimally.

More information can be obtained from CEAS Burkina Faso: http://www.ceas.ch/burkina.html

Treadle pump (for example developed by IDE India)



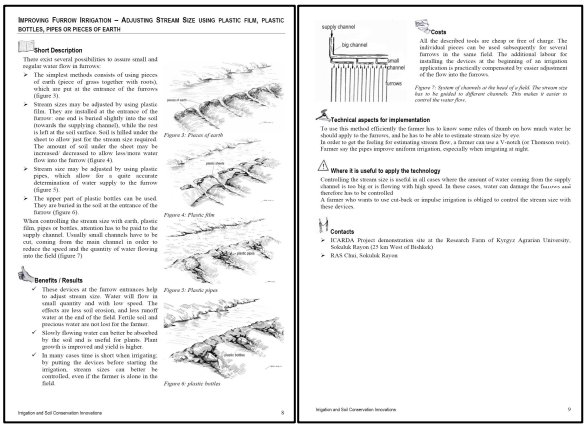
Description: The treadle pump is simple, human-powered device which can be manufactured and maintained at low cost in rural workshops in developing countries. Its acceptance in Bangladesh, where it was first developed in the early 1980s, has been described as extraordinary. Over 500 000 pumps are now in daily use in that country. The functioning principle is based on suction lift using a cylinder and piston to draw water from a source below ground level, for example a river or shallow groundwater. Two pistons are used, each connected to a treadle. The operator stands on the treadles, pressing the pistons up and down in a rhythmic motion.
Strengths: Simple technology, relatively cheap, works without electricity. The pump is promoted by various organizations in developing countries.
Weakness: Procurement of the pump can be a problem if no local organization is promoting it. The pump is suitable only for small-scale farming.

More information can be obtained from IDE India:
http://www.ide-india.org/ide/treadlepump.shtml
the FAO: http://www.fao.org/docrep/005/X8293E/X8293E00.HTM
or NGOs: e.g. http://www.se3we.ch/

4. Ready-to-use extension materials on irrigation

The materials presented below were developed for the Rural Advisory Services (RAS) in Kyrgyzstan. The documents explain in simple words affordable irrigation and water- and soil conservation technologies and principles of irrigation. Though the material was designed for the Kyrgyz context, the described technology may be interesting for other arid zones in the world, too.

Irrigation Catalogue (developed in Kyrgyzstan



IMPROVING FURROW IRRIGATION – ADJUSTING STREAM SIZE USING PLASTIC FILM, PLASTIC BOTTLES, PIPES OR PIECES OF EARTH

Short Description

There exist several possibilities to assure small and regular water flow in furrows:

- The simplest methods consists of using pieces of earth (piece of grass together with roots), which are put at the entrance of the furrows (figure 3).
- Stream sizes may be adjusted by using plastic film. They are installed at the entrance of the furrow: one end is buried slightly into the soil (towards the supplying channel), while the rest is left at the soil surface. Soil is billed under the sheet to allow just for the stream size required. The amount of soil under the sheet may be increased/ decreased to allow less/more water flow into the furrow (figure 4).
- Stream size may be adjusted by using plastic pipes, which allow for a quite accurate determination of water supply to the furrow (figure 5).
- The upper part of plastic bottles can be used. They are buried in the soil at the entrance of the furrow (figure 6).

Figure 3: Pieces of earth

Figure 4: Plastic film

Figure 5: Plastic pipes

Figure 6: plastic bottles

When controlling the stream size with earth, plastic film, pipes or bottles, attention has to be paid to the supply channel. Usually small channels have to be cut, coming from the main channel in order to reduce the speed and the quantity of water flowing into the field (figure 7).

Benefits / Results

- ✓ These devices at the furrow entrances help to adjust stream size. Water will flow in small quantity and with low speed. The effects are less soil erosion, and less runoff water at the end of the field. Fertile soil and precious water are not lost for the farmer.
- ✓ Slowly flowing water can better be absorbed by the soil and is useful for plants. Plant growth is improved and yield is higher.
- ✓ In many cases time is short when irrigating; by putting the devices before starting the irrigation, stream sizes can better be controlled, even if the farmer is alone in the field.

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Figure 7: System of channels at the head of a field. The stream size has to be guided to different channels. This makes it easier to control the water flow.

Costs

All the described tools are cheap or free of charge. The individual pieces can be used subsequently for several furrows in the same field. The additional labour for installing the devices at the beginning of an irrigation application is practically compensated by easier adjustment of the flow into the furrows.

Technical aspects for implementation

To use this method efficiently the farmer has to know some rules of thumb on how much water he should apply to the furrows, and he has to be able to estimate stream size by eye.
In order to get the feeling for estimating stream flow, a farmer can use a V-notch (or Thomson weir). Farmer say the pipes improve uniform irrigation, especially when irrigating at night.

Where it is useful to apply the technology

Controlling the stream size is useful in all cases where the amount of water coming from the supply channel is too big or is flowing with high speed. In these cases, water can damage the furrows and therefore has to be controlled.
A farmer who wants to use cut-back or impulse irrigation is obliged to control the stream size with these devices.

Contacts

- ICARDA Project demonstration site at the Research Farm of Kyrgyz Agrarian University, Sokuluk Rayon (25 km West of Bishkek)
- RAS Chui, Sokuluk Rayon

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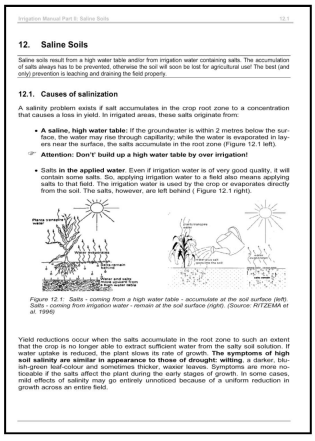
The irrigation catalogue was designed for the Rural Advisory Services in Kyrgyzstan, but may be of interest in other areas of the world, too. It contains a collection of 16 irrigation and soil conservation innovations, gathered from all over the world. The technologies are easy to implement for resource poor farmers and are promising for the situation in Kyrgyzstan. Each innovation is shortly described with its benefits, costs and the most important considerations for the implementation. The catalogue is a working tool for extensionists and farmers: It helps farmers, who are willing to improve their irrigation practices, to select an appropriate technology. The catalogue is available in Kyrgyz and English.

More information: Training, Advisory and Innovation Centre (ZOKI) in Bishkek, Kyrgyzstan or SHL (Christoph.studer@bfh.ch)

Irrigation Manual (developed by SHL for the Kyrgyz context)



Irrigation Manual Part II: Saline Soils 12.1

12. Saline Soils

Saline soils result from a high water table and/or from irrigation water containing salts. The accumulation of salts always has to be prevented, otherwise the soil will soon be lost for agricultural use! The best (and only) prevention is leaching and draining the field properly.

12.1. Causes of salinization

A salinity problem exists if salt accumulates in the crop root zone to a concentration that causes a loss in yield. In irrigated areas, these salts originate from:

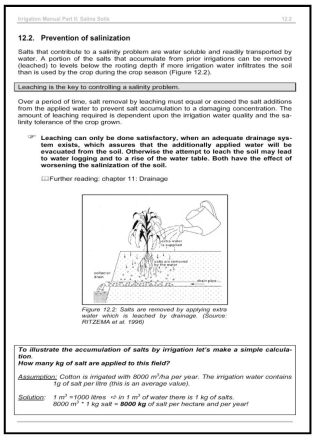
- **A saline, high water table:** If the groundwater is within 2 metres below the surface, the water may rise through capillarity; while the water is evaporated in layers near the surface, the salts accumulate in the root zone (Figure 12.1 left).

☞ **Attention: Don't' build up a high water table by over irrigation!**

- Salts **in the applied water**. Even if irrigation water is of very good quality, it will contain some salts. So, applying irrigation water to a field also means applying salts to that field. The irrigation water is used by the crop or evaporates directly from the soil. The salts, however, are left behind (Figure 12.1 right).

Figure 12.1: Salts - coming from a high water table - accumulate at the soil surface (left). Salts - coming from irrigation water - remain at the soil surface (right). (Source: RITZEMA et al. 1996)

Yield reductions occur when the salts accumulate in the root zone to such an extent that the crop is no longer able to extract sufficient water from the salty soil solution. If water uptake is reduced, the plant slows its rate of growth. **The symptoms of high soil salinity are similar in appearance to those of drought: wilting**, a darker, bluish-green leaf-colour and sometimes thicker, waxier leaves. Symptoms are more noticeable if the salts affect the plant during the early stages of growth. In some cases, mild effects of salinity may go entirely unnoticed because of a uniform reduction in growth across an entire field.



Irrigation Manual Part II: Saline Soils 12.2

12.2. Prevention of salinization

Salts that contribute to a salinity problem are water soluble and readily transported by water. A portion of the salts that accumulate from prior irrigations can be removed (leached) to levels below the rooting depth if more irrigation water infiltrates the soil than is used by the crop during the crop season (Figure 12.2).

Leaching is the key to controlling a salinity problem.

Over a period of time, salt removal by leaching must equal or exceed the salt additions from the applied water to prevent salt accumulation to a damaging concentration. The amount of leaching required is dependent upon the irrigation water quality and the salinity tolerance of the crop grown.

☞ **Leaching can only be done satisfactory, when an adequate drainage system exists, which assures that the additionally applied water will be evacuated from the soil. Otherwise the attempt to leach the soil may lead to water logging and to a rise of the water table. Both have the effect of worsening the salinization of the soil.**

📖Further reading: chapter 11: Drainage

Figure 12.2: Salts are removed by applying extra water which is leached by drainage. (Source: RITZEMA et al. 1996)

To illustrate the accumulation of salts by irrigation let's make a simple calculation.
How many kg of salt are applied to this field?

Assumption: Cotton is irrigated with 8000 m^3/ha per year. The irrigation water contains 1g of salt per litre (this is an average value).

Solution: 1 m^3 =1000 litres <> in 1 m^3 of water there is 1 kg of salts,
8000 m^3 * 1 kg salt = **8000 kg** of salt per hectare and per year!

The manual consists of 2 parts:
Contents of Part I: Basics of Irrigation: Irrigation factors: climate, water, soil, crop; irrigation management of important crops; drainage and salinization; overview of important irrigation methods

Contents of Part II: Furrow Irrigation: Furrow layout; instructions for irrigating the furrows; improved methods of furrow irrigation; fertigation; operation and maintenance of canals

The manual is available in Russian, Kyrgyz and English.

More information: Training, Advisory and Innovation Centre (ZOKI) in Bishkek, Kyrgyzstan or SHL (Christoph.studer@bfh.ch)

5. Demonstration package – Get your own kit!

IDE India, with the support of SDC, developed a **small and handy micro-irrigation kit to demonstrate** the functionalities of the low-cost drip-irrigation systems. The demo-kit comes with two manuals: One explains how the system is operated and the other gives background information on how to develop sustainable markets with low-cost drip-irrigation.

The package includes:

- a demonstration-kit: it is half the size of the Family Nutrition Kit (10 sqm) and shows how low-cost drip-irrigation works,
- a technical manual: it explains how to install and operate IDE's drip-irrigation systems,
- a market manual: it explains the market development and dissemination strategy which should be developed when introducing drip-irrigation systems.

6. Studies and Documents from SHL

- Analysis of water-harvesting and drip-irrigation technologies in the Watershed of the Calico River, Matagalpa, Nicaragua (M. Staeuble 2005)
- Developing a Manual for Testing Low-Cost Micro-Irrigation Systems (S. Spöhel 2007)
- Developing and Testing Simple Methods to Estimate Water Needs of Salad (U. Schwenk 2007)
- Evaluation des performances économiques et techniques d'un nouveau moyen de gestion rationnelle de l'eau d'arrosage dans un contexte agro écologique au Sénégal (S. Boegli 2007)
- Kyrgyzstan – Assessing the Potential of Micro Irrigation Systems (L. Pluess 2004
- Supplemental Drip Irrigation in Coffee (U. Scheidegger, L. Plüss, S. Spöhel)
- Supplemental irrigation of coffee - Irrigation water needs of coffee – a calculation tool. (M. Graf 2008)
- Water Harvesting, Storage and Use for horticultural crops in the dry season in the Calico River Watershed (S. Spoehel 2006)
- Where and when does micro-irrigation work? - A comparison of market-based approaches in different contexts (C. Kunz, 2008)

For more information:
Visit our website www.shl.bfh.ch or contact simon.spoehel@bfh.ch