# THE ECONOMIC FEASIBILTY OF DRIP IRRIGATION IN AFGHANISTAN

## A STUDY CONDUCTED FOR THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

**BY**

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# Executive Summary

Drip irrigation is the most water-efficient method of irrigation, and in developed countries is often the most cost-efficient method for high-value crops as well. However, its use by poor farmers in countries such as Afghanistan is hampered by the high initial investment required. The purpose of the assignment was to analyze the costs of drip irrigation in Afghanistan, estimate the cash flows it requires, evaluate the economic feasibility of drip irrigation using appropriate financial measures, and make recommendations on crops for which drip irrigation is cost-effective.

The team stayed in Afghanistan from Feb. 3 to March 14, 2004. The team interviewed organizations and individuals involved in drip irrigation Afghanistan. The team visited plots and farmers of IF Hope in Nangarhar, CADG in Helmand and Kandahar, and Roots of Peace in Parwan, as well as greenhouses equipped with drip irrigation of ICARDA in Kabul, Helmand and Parwan, and of Mercy Corps in Helmand.

The conclusions regarding tree crops must be qualified, in that they are based on yields with drip and improved surface irrigation (ISI) found in other developing countries under similar environmental and developmental conditions, given that no data exists yet in Afghanistan regarding tree crop yields under drip. The actual life of the equipment in Afghan conditions (which the team assumed as 5 years) also has a major impact on economic feasibility.

The team's economic analyses and conclusions are summarized in Table 6.1. Our main findings are the following:

1. Drip irrigation makes financial sense in Afghanistan primarily when there is a relatively high cost associated with the use of water, which justifies the relatively high capital costs of drip irrigation systems.
2. In addition, drip systems make sense when the water is scarce, and saving water to expand the farmer's irrigated area is a high priority for that farmer.
3. Therefore, drip irrigation in Afghanistan should be used exclusively (except for greenhouses – see #1. below) when the water source is a tube well, karez, and/or piped water supply, given the general scarcity of water from such systems, and the associated costs.

Other, more specific findings are:

1. *The highest-priority place for drip systems should be in greenhouses.* At present yields and prices, drip-equipped greenhouses show a very respectable Internal Rate of Return (IRR) of 41%, compared with IRR of just 8% for greenhouses with surface irrigation. In greenhouses, the drip system pays for itself in just 0.64 years.
2. The depth of pumping (i.e. cost of water) has a critical influence on the economy of drip irrigation. With a deep tubewell (120m or more), drip is consistently more remunerative than ISI, and the investment for converting from ISI to drip has a significantly higher return than the investment in converting from traditional methods to ISI, for all fruit species investigated – grapes, pomegranates, almonds, apricots and apples.
3. On the other hand, under current conditions, for shallow wells (12-15m) ISI is more remunerative than drip, and conversion from traditional to ISI has a higher return for investing in drip, consistently for all the above tree crops.
4. This signifies that as water mining lowers the water table, drip will become more attractive.
5. In all cases, both drip and ISI are economically far superior to traditional practices.

6. Including the effect of intercropping in tree crops during the first few years always helps the cash flow, but does not change the relative priority of drip, ISI and traditional irrigation.
7. In vegetables and field crops the picture is more mixed – some (e.g. watermelons, maize, wheat) have very low profitability under any method. Others (tomatoes, eggplant, okra, peanuts, potatoes) are very profitable with drip, but *even more profitable* with ISI.
8. *Drip is economically justified under present conditions for all fruit examined and for high-value annual crops (e.g. tomatoes, eggplant, okra, peanuts, potatoes). where the farmer's water availability is limited, so he cannot get more water simply by drilling another well.*

In sum, the overall finding of the study is that – except for greenhouses, where drip irrigation is clearly and highly profitable under present conditions – drip irrigation in Afghanistan is not a panacea for the short term, but an important element of agricultural development policy for the medium term (5-7 years). As the groundwater level drops, and as yields improve through the application of simple and cheap technologies such as quality seeds, correct fertilization and pest control, transplanting, etc., the economic attractiveness of drip will increase. Because of the long lead time necessary to demonstrate the effect of drip in fruit trees, it is essential to start *now* a focused program of acquiring experience with drip and demonstrating it to farmers, especially for fruit crops. Not starting such a program *now* would be tantamount to the case of the farmer who said to the extension agent, "you are telling me that this sapling will take seven years to bear fruit, and do you expect me to plant it *already*?"

Therefore, *the main recommendation of this study is to establish in each district of priority to USAID one vineyard, one orchard of the most important tree crop, and one of another locally important tree and/or high-value vegetable crop, to gain local experience with the yields possible under drip in local conditions and to demonstrate the system to farmers.* The total investment cost of such a program per province would be less than $100,000.

Other recommendations of the study are:

1. All commercial greenhouses should be equipped with drip systems.
2. Drip demonstrations should be discontinued on low-value crops such as wheat, corn and watermelons, and the funds oriented to tree crops and high-value vegetables.
3. *Gravity drip systems* with micro-drippers should be introduced in Afghanistan, as they can decrease drip system capital and operating costs by eliminating the need for booster pumps.
4. External drippers should be used with drip systems, as they are much easier to clean than the internal drippers currently used in some areas.
5. Simultaneously, emphasize other agricultural interventions that have high cost-effectiveness and fast payoff with low farmer investments, such as quality seeds, hybrid seeds where appropriate, quality saplings, transplanting, proper use of fertilizers, integrated pest management, and replacing canals from wells to fields by pipes to reduce seepage losses.

## Acknowledgments

The team wishes to express its gratitude to leaders and staff of the NGOs visited who, notwithstanding that the team's visits coincided with the very busy planting season, made all efforts to provide the information that made the team's work possible. Special thanks are due to the ALP/S administrative and security teams, which made the mission remarkably trouble-free considering the security conditions of Southern Afghanistan. Thus for any possible shortcomings of this study, its authors must take full responsibility.

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## Section 1. The Cost of Installing and Using Drip Irrigation in Afghanistan

*Specific Task #1: Examine the cost of installing and using drip irrigation in Afghanistan. Of interest are those areas with chronic water shortages. These include the South and West principally but problems exist in other parts of the country.*

### 1.1 The Cost of Drip Systems

**IF Hope** is installing systems for grapes and stone fruit in Nangarhar Province. So far they have installed only 0.8 ha for stone fruit and citrus in their nursery near Jalalabad. They plan to start soon installing 3.5 ha with a progressive farmer in Ghani Khel district (of which 1.5 ha will be financed by the farmer himself in cash). The system will consist of a 25 $m^3$ storage tank, a 10m-head pump with filter and fertigation tank, mains and drip lines. The planned cost is about $1500 per ha.

**Roots of Peace** is installing drip systems for grapes and almonds in the Shamali Plains of Parwan. For 1 jerib (0.2 Ha), a complete drip irrigation system including a water tank costs $300 from IDE of India ($1500/ha). They also use family drips for an area of 20 sq.m., which cost $2 ($1000/ha) per kit in India, or $3 ($1500/ha) installed in Afghanistan.

**CADG** has installed in the Kandahar/Helmand are about 41 systems for tree crops, vegetables and field crops. These are manufactured by Netafim, an Israeli company that is known for high quality and provides sufficient spare parts. These systems cost $2500/Ha (pump and filters = $1100, lines and drippers = $ 1400; this cost is probably FOB Israel, not if commercially supplied in Afghanistan). The systems are designed for 1.0 ha, and thus appropriate for farms in Kandahar/ Helmand, which average 1-2 ha under irrigation. The pumps and filters are mounted on wheel barrows and mobile. The rest of the system consists of main lines, drip lines and self-compensating drippers. **CADG** has also experimented with family drip systems but discontinued them as (i) they are by definition suited for poverty reduction (family nutrition improvement) rather than for market-oriented production, (ii) their cost is no cheaper than the above ($100-$120 for a 500 m2 system, equivalent to $2000-$2400/ha, *without* a pump), and (iii) they clog rapidly.

**Park Panel,** a Turkey-based company, which is interested in exporting **Sunstream** drip equipment to Afghanistan, does not yet have installations here. However, they have kindly sent detailed cost estimates for three designs requested by the study team:[1]

(a) 1 ha vineyard, 3m between rows: cost = $1822, plus $332 for in-between lines for intercrops;
(b) 1 ha almonds, 4m between rows, cost = $2492, plus $262 for in-between lines for intercrops;
(c) 1 ha vegetables, 1.5m between rows, cost = $2403.

These prices are for the main lines, drip lines, drippers, accessories and fittings only. A drawback of the Sunstream equipment is that it is not conceived for small farmers: The smallest Sunstream booster pump/filter/fertigation tank unit has capacity of 20 $m^3$/hour, can irrigate about 2 ha and costs about $2000. This is an indivisible cost for a smaller farmer who cannot irrigate 2 ha by drip. In addition, a cost of about $500 for the water tank must be added to each of the above.

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[1] These prices do not include transport, any customs duties and installation, the pump unit and the water tank. Their prices are stated in euros, and a exchange rate of US$1.20 / 1 euro was used. The prices quoted are for a 200mx50m field, where the maximum drip line length is 50 m. If the allowed line length is 100m (worse water distribution), the prices are a bit lower: $1668/ha for vineyard, $2420/ha for almonds, and $2224/ha for vegetables.

**Ein-Tal** company of Israel, whose equipment has performed very satisfactorily on USAID projects in Central Asia, has equipment specifically conceived for small farmers. In particular, they have pioneered the *gravity-drip* system, using *micro-drippers* that work at extremely low pressure (1m or less). Annex C shows that the total cost of a gravity-drip system for an orchard is about $2,200 (of which $1,600 in year 1, $400 in year 3 and $200 in year 5 as the trees grow and require more micro-drippers), plus $500 for the water tank and $300 for an earth mound to place it above ground. This system eliminates the capital costs of the booster pump (about $1,100), as well as its operation costs (about $250/year) and maintenance (about $50/year), as well as replacement of the pump after about 5 years. Thus *gravity-drip would be cheaper than the above Netafim and Sunstream equipment*.

**The Study Team's estimates**, detailed in the footnotes to Workbook 1 – Perennial Crops and Workbook 2 – Annual Crops, calculated the following costs for a 1-ha pressure drip system:

- For almonds, 4x4m spacing – $750
- For apples and apricots, 5x5m spacing – $600
- Extra cost for interplant lines – $834
- Tomatoes, eggplants, okra, peanuts, potatoes, wheat – $1770
- Watermelons – $1820
- Onions (because of the dense planting) – $4660

These are the cost for the lines, drippers and accessories. To this must be added in all cases about $1100 for the booster pump and $500 for the water tank.

The costs may be reduced by obtaining PVC pipes – the main cost items – from e.g. Pakistan or India, and only the specialized parts (e.g. micro-drippers) from US, Europe or Israeli origin. However, *the PVC pipes must be ISO-certified to be ultra-violet (UV) and frost-resistant;* otherwise they may not survive more than one season, and will prove to be false economy.

### 1.2 Cost of Tubewells

For the reasons detailed in Sec. 4, *we recommend the use of drip systems in Afghanistan principally where the source of water is a tubewell.* Thus the cost of drip irrigation should consider tubewell cost. In Helmand a tubewell typically irrigates 10-15 jeribs (2-3 ha). The cropping pattern typically concentrates on high-value crops such as orchard (interplanted with vegetables or alfalfa) and poppies. In South Helmand the tubewells are of median 14m depth. Such a well costs the farmer about:

30,000 Afs ($600) for drilling the well
25,000 Afs ($500) for the pump and diesel motor
5,000 Afs ($100) for piping and perhaps a small earth reservoir and mud pump house
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60,000 Afs ($1200) total

In the Kandahar area the wells are deeper, as much as 120-160m if away from irrigated valley bottoms. A typical well costs the farmer about:

240,000 PKR ($4,000) for drilling the well
110,000 PKR ($1,833) for the pump, diesel motor and piping
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350,000 PKR ($5833) total

### 1.3 Cost of Greenhouses

For the reasons discussed in Sec. 4, *we recommend drip systems in greenhouses*. ICARDA installs with farmers quality-made greenhouses of 9x30m size, costing $2500 each ($9.25/sq.m.), drip system included. At first these were distributed for free, but now farmers must pay 20% ($500) – either up front or half in advance and half after the first harvest. Some farmers who have received a greenhouse and thus do not qualify for a subsidy are even willing to pay the full cost of additional greenhouses. The team met one such a farmer who has ordered ten (10) greenhouses.

Mercy Corps has been building more rustic 4x20m greenhouses, usually without a drip system, costing $300 each ($3.75/sq.m. without drip system), but is now upgrading to ICARDA standard. CRS (Catholic Relief Services) in Herat builds rustic family greenhouses without drip systems.

## Section 2. The Market Values of High-Value Crops

*Specific Task #2: Detail the principal market values for crops considered to be "high value." These include fruits, nuts, vegetables, grapes, and others. Much of this information can be gotten from the US AID RAMP Project. Evaluate the reasonableness of these values.*

The study team has gathered all the written information it could find about the farmgate prices of fruit, nuts, vegetables and field crops:

1. "Assessment Survey of Horticultural Crop Production and Marketing in Afghanistan", Jan. 2003
2. RAMP Cost-of-Production Tables
3. CADG Lashkar Gah
4. ALP/S – UC Davis: Afghan Fruit and Nut Analyses
5. "Market Sector Assessment in Horticulture – Phase 2-3, Feasibility Studies and Business Plans", Annex I, by Raphy Favre *et al*, UNDP
6. "Competitiveness for Afghanistan's Fruits, Nuts and Vegetables" by Dr. Kennth Swanberg, RAMP, Oct. – Dec. 2004
7. "Fruit, vegetable and wheat prices, March 2003 – June 2004", IF Hope, Jalalabad

The team collated the information from these sources in Table 2.1, and added to them price information gathered from farmers and extension agents during field visits. Where prices throughout the year are available, e.g. IF Hope, they show enormous fluctuations. Thus in its financial projections the team tried to assess the most representative *average farmgate price during the harvest season.* More extensive information by RAMP, UNDP, Mercy Corps and CADG, including yields and (in the RAMP data) also production costs and gross & net income, is presented in Tables 2.2 to 2.6. Some of the results of these studies are discussed in the following.

According to **ICARDA**[2], the most promising crops for export in the short term are dried apricots, pomegranates, raisins, cumin and pine nuts. Long-term export opportunities are dried figs, grapes and melons. There is also domestic demand for potatoes, onions, carrots, tomatoes and cucumbers.

[2] "Needs Assessment Report - Horticultural Market Survey", ICARDA, 2003

According to RAMP Costs of Production, high-value vegetable crops are carrots, cauliflower, chili, melon, onion, tomato and potato. High-value field crops are chickpea, cowpea, peanut and sesame.

**The UNDP study**[3] indicates that almonds, pomegranates, grapes and apricots are potential high value crops with export potential. This study shows farmgate prices of $2/kg for almonds in shell, $0.46/kg for pomegranates, $0.32/kg for apricots, $0.26/kg for table grapes, and $0.20/kg for apples. There are possibilities for onion, tomato and cucumber production in counter-season for Pakistan.

Based on this information, the study team selected the following as "high-value crops" for the economic analysis of drip irrigation:

- **Perennials:** Grapes (table and raisin), pomegranates, almonds, apricots and apples;
- **Vegetables:** Greenhouse cucumbers, tomatoes, eggplant, okra, watermelon;
- **Field crops:** Peanuts, potatoes, onions;
- **Cereals:** Two non-high-value crops were also examined – wheat and maize.

Table 2.7 shows that the above are practically all the crops of importance in Afghanistan except:

- rice, which is obviously not appropriate for drip irrigation;
- walnuts and pistachios, which are typically grown semi-wild on steep hillsides; and
- minor fruit species (mulberries, cherries, plums, peaches and pears), which are expected to show similar results to the apricots and apples investigated by this study.

# Section 3. Technical and Agronomic Factors Influencing the Potential for Drip Irrigation in Afghanistan

*[Additional section – not in the Scope of Work]*

## 3.1 The Advantages of Drip Irrigation

In Afghanistan, as elsewhere, the advantages of drip irrigation are:

- Water efficiency (about 95% for drip, 40%-50% for surface irrigation, including canal losses)
- This reduces tubewell pumping costs and enables tubewells to irrigate larger areas;
- Less labor for irrigation, weeding and fertilizer distribution;
- Better control of fertilizer application and thus economies in fertilizer use;
- Reduced plant diseases and thus less pesticide costs;
- Higher yields;
- Earlier maturing and higher percentage of large fruit, both resulting in higher prices;
- Soil texture improvement, resulting in increased long-term productivity;
- Drip irrigation can be used with higher-salinity water than other types of irrigation.

The factors limiting the wide application of drip irrigation are (i) the relatively high initial investments required, and (ii) the relatively sophisticated level of management. However, the rapid recent adoption of tubewells in Afghanistan shows that Afghan farmers, notwithstanding their conservatism, are rapid to adopt a new technology when they are convinced of its economic benefits, and are quite able to maintain a pump (which is the part of drip system requiring the most maintenance). Furthermore, notwithstanding the lack of rural credit, many farmers have investable

[3] "Market Sector Assessment in Horticulture – Phase 1, Market Research", UNDP, June 2004

funds (e.g. from poppy cultivation). Thus the main challenge in introducing drip irrigation is to find out where it is profitable, and demonstrate it to the farmers.

### 3.2 The Effect of the Land Distribution Situation on Adoption of New Technologies

Orchards are prime users of drip irrigation. Upon arrival at Afghanistan, the team heard from various sources that "Afghan farmers have very small holdings and therefore cannot plant improved orchards, since they cannot forgo the income from their existing orchards until the new ones bear fruit". Our observations, as well as UNDP data[4], *do not confirm this assertion for Afghanistan in general* (although it may be true for certain localities). While it is true that most farmers are smallholders with typically only 1.14 hectares of irrigated land and 0.5 hectares of rain-fed land, Annex A shows that *70% of the irrigated land in Afghanistan is in farms that have 5 ha or more of irrigated land.* Such farms *(29% of all farms) can* spare a hectare for planting a new orchard. The main constraint to planting improved orchards is the conservatism and risk-averseness of most farmers, not the lack of farms of sufficient size.

### 3.3 Availability of Improved Planting Material

Many NGOs have established fruit tree nurseries throughout Afghanistan. Foremost in this respect is IF hope, which has two giant nurseries (21 and 52 ha), producing 1.5 million forest trees and almost 1 million fruit trees, which they distribute to farmers free of charge. There are also over 70 private nurseries in different areas, but the quality of their saplings is uneven. Roots of Peace is working with private nurseries to improve their operations.

### 3.4 Technical Obstacles to Drip Irrigation Based on Surface Water

Many technical considerations complicate the use of drip irrigation based on surface water:

1. In the canals, when the water arrives, there is a lot of it to flood the fields – farmers have no incentive to save water;
2. The water payment per year (per hour of irrigation, which depends on land size and soil type) per jerib is fixed, again giving no incentive to save water;
3. In such conditions, it is extremely difficult to change the mentality of the farmers, who believe that the more water the better;
4. Water is supplied to a given canal only once every 8-14 days. Thus to use drip irrigation the farmer must have a reservoir to hold water in the interim. For vines, assuming maximum daily requirement of 3.3mm, 1 hectare would need a storage tank of 277-486 $m^3$ capacity, which would significantly increase investment costs.
5. Water shortages in the canals in July/August have been reported in Helmand, so even if a drip system is installed the plants may be subject to water stress and diminished yields.
6. The high turbidity of canal water causes frequent clogging of filters (which must be cleaned every hour) and drippers. The extra labor and expense for maintenance motivates farmers to return to surface irrigation (except where the payoff of drip is large and immediate, as in the case of greenhouses).

This host of factors leads us to conclude that ***at present, drip should be introduced only where well water, karez water or piped water is available.*** This is indeed the usual practice of most NGOs that are introducing drip irrigation in Afghanistan.

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[4] "Market Sector Assessment in Horticulture – Phase 2-3, Feasibility Studies and Business Plans", Annex I

### 3.5 Water Availability in Helmand and Kandahar Provinces

In Helmand water is becoming scarcer due to insufficient upkeep of the canals. Irrigation frequencies range from 4 times a week to once every 2 weeks. If a farmer has a well only 4 to 6 m deep then the drip irrigation system's pump is sufficient. If, however, the well is deeper, then the farmer needs a diesel pump to feed water into the drip irrigation system. CADG has installed drip irrigation demo plots where the farmers canal water and have a well as back-up; also in areas that lie above the irrigation canal, where the water is pumped from the canal into the drip system.

Due to the shortage of canal water, Helmand and Kandahar are major tubewell regions. Many tubewells have been drilled for supplementary irrigation in canal-irrigated areas. Increasingly farms are being established outside canal command areas, based on tubewells only. The intense tubewell drilling is causing lowering of the water table and in some localities the drying out of karezes. According to the CADG Lower Helmand Agricultural Machinery Survey of 2003, at that time six districts of South Helmand had 5676 pumps and 4589 tubewells. Tubewell depth ranged from 6 to 160 m, with a median of14m and over 90% of the wells in the 6-50 m range. As there are more tubewells in North than in South Helmand, and as since 2003 the number of tubewells has at least doubled, the present number of tubewells in Helmand Province is likely to be over 20,000.

The Director of Agriculture of Kandahar Province estimates that in 10 of its 17 districts, where some information is available, the number of tubewells is at least 30,000 and may be as much as 70,000. In Nangarhar Province we have also seen the high numbers of tubewells.

Thus we can conclude that *there are enough tubewells in Kandahar, Helmand and Nangarhar provinces so that all donor funds allocated in the foreseeable future to promotion of drip irrigation* (where it is economically justified) *can be used in tubewell areas*. Thus *there is no need to promote drip irrigation in canal-irrigated areas*, where it is less cost-effective and more technically difficult.

### 3.6 Drip Irrigation in Greenhouses

An exception to the above statement is the case of greenhouses. The structure of a 300 sq.m. surface-irrigated greenhouse costs about $2200. Experience in other countries such as Azerbaijan and Uzbekistan, is that *in greenhouses drip irrigation easily increases yields in farmer conditions by 30%-50%* (sometimes even by 100%-200%). In addition, drip irrigation significantly reduces crop diseases, improves product quality, increases the percentage of large sizes, and makes the crop mature earlier – all of which increase product price. Thus *the investment of about $300 to equip a 300 sq.m. greenhouse with a drip system makes the basic investment of about $2200 in the structure more effective, and pays for itself in just 0.64 years.* Worksheet 2 shows that with current yields and prices in ICARDA greenhouses there is a satisfactory IRR of 41% on the total investment, while without drip systems (yields assumed 30% lower) the IRR would be only 8%. Furthermore, we have observed that in greenhouses, where the profit from drip is large and immediate, farmers do take the extra care needed to operate a drip system even with canal water. Thus *we recommend that drip systems be always installed in greenhouses,* even with canal water, if water availability during the growing season is assured. In villages that have electricity, the farmers could use small electrical pumps to drip-irrigate greenhouses, thus reducing pumping costs.

## Section 4. Characteristics of Drip Systems Currently Installed in Afghanistan

*Specific Task #3: Compile a list of drip irrigation systems that have been installed in Afghanistan to the extent possible. Evaluate the cost of these systems, their present use, crops grown using the systems, maintenance costs, and who provides technical assistance and replacement parts.*

### 4.1 List of Systems

- **Roots of Peace** has installed in their Bagram nursery a simple gravity drip system, costing only about $300, on about 2800 sq.m. If funding is available, they plan to establish in 2006 drip irrigation demo plots for grapes and almonds.
- **ICARDA** has in 2005 installed about 42 greenhouses with drip irrigation in Kabul (Badan Bagh) Agricultural Research Station), Helmand, Nangarhar, Parwan, Kunduz and Ghazni provinces, to produce cucumbers and other vegetables. In early. 2006 ICARDA and Mercy Corps have constructed 30 more greenhouses with drip in Kunduz, Bagram and Takhar.
- **IF Hope** has 0.8 ha of drip irrigation for stone fruit and citrus saplings on their large nursery near Jalalabad. The system uses a 3-HP low-pressure (10 meters) electric pump, equipped with a 10 cu.m. tank and a fertilizer injector. They are establishing 3.5 ha of almonds on a model farmer's land (of which, the equipment for 1.5 ha is paid for by the farmer).
- **CADG** (Central Asian Development Group) has installed in Kandahar and Helmand provinces during the 2004-2005 some 41 drip demo plots with total area of 19.4 ha, to irrigate vegetables, field crops, new vineyards and fruit tree orchards.
- **Mercy Corps,** under a DFID contract, has installed 5 very small (10x30m) low-cost family drip kits made in India. It has also installed two open-field drip systems. All irrigate tomatoes and eggplants. Yield data are not available.

### 4.2 Present Use/Crops Grown

- **Roots of Peace** focuses on almonds and grapes (both table grapes and raisins) for export.
- **ICARDA** grows in its greenhouses mainly cucumbers. Tomatoes, peppers and peas are also grown, as well as leaf vegetables (spinach, watercress, mint, parsley) during the winter.
- **IF Hope** uses drip irrigation for almond, apricot, plum and citrus saplings.
- **CADG** plants in its drip demo plots: (i) grapes, (ii) new fruit tree orchards (almonds, pomegranates, apricots and peaches), and (iii) annual crops (tomatoes, eggplant, watermelon, okra, cabbage, peanuts, cotton and sunflower).
- **Mercy Corps** concentrates on vegetables (esp. tomato, eggplant, okra), both in their greenhouses and open-field drip plots.

### 4.3 Replacement Parts

- **CADG** relies on the Netafim company, which has a good supply of spare parts and technical backup. They train their agents to become drip irrigation dealers after end of project.
- **Afghan Solar company** has been selling and installing solar systems and pumps in Afghanistan for the last 4 years. It installed a solar pump with drip irrigation at the Badam Bagh Agricultural Research Station. It has over 40 distributors throughout Afghanistan and plans to have over 100 by end of 2006. It plans to import drip irrigation equipment and spare

parts from India, Germany and the USA if future demand requires it. It is also in contact with other manufacturers. This company supplies ICARDA.

- **Park Panel** of Turkey has expressed interest in supplying drip systems to Afghanistan, but do not have a representation here.

We recommend working with suppliers such as those above to assure the availability of drip parts.

### 4.4 Maintenance Costs

Manufacturer's estimated useful life for the equipment currently being installed is 5-6 years for pump motors, 5-7 years for drip lines, 8-10 years for piping and for pump control heads. Given the rough treatment that equipment is likely to receive in Afghanistan, we have conservatively estimated 5 year life for all drip system components, and a maintenance cost averaging 5% annually.

### 4.5 Technical Assistance

- **Roots of Peace** is doing extension work with grape and almond production. At present they are working with 2000 farmers in an area of 400 Has. They are introducing trellising in 150 farmers' plots, as well as new grape varieties, three grape packing houses (one with cold storage), and drying sheds to produce green raisins, which fetch a much higher price.
- **CADG** conducts a massive extension program in Helmand and Kandahar to introduce via demo plots new techniques such as improved seeds, weeding, fertilizer, pest management and irrigation scheduling.
- **ICARDA** is installing greenhouses with drip irrigation, mainly for cucumber production.
- **IF Hope** is producing nearly 1 million/year high-quality saplings of almonds, apricots, peaches, cherries and citrus. It plans to install 6 drip demo plots in 4 districts.

## Section 5. Evaluation of Economic Analyses of Existing Drip Systems

*Specific Task #4: Evaluate any economic analyses that have been completed on existing drip irrigation systems.*

### 5.1 International Experience with Drip Irrigation

Experience in other developing countries shows consistently high yield increases and water savings from drip irrigation:

- Yield increases of 10% to 47% (averaging 27%) and water savings of 15% to 68% (averaging 38%) in field crops and vegetables in India (Table 5.1);
- Another India study shows yield increases of 23% in grapes, 98% in pomegranates, 50% in tomatoes, 88% in watermelon and 27% in cotton, and water savings of 36%-53% (Tab. 5.2);
- Reported grape yield increase of over 60% (from 15-25 to 25-40 MT/ha) and water savings of 70% from the Nasik area of India;
- Water savings of 20% to 50% and yield increases of 10% to 30% in Jordan, Morocco, Turkey, Egypt and Tunisia (Table 5.3);
- Another study in India shows benefit/cost ratios with drip irrigation of 4.75 for pomegranates, 2.05 for grapes and 1.91 for tomatoes, compared to 2.8, 1.48 and 1.25 with surface irrigation (Table 5.4);

- Still another study from India shows yield increases due to drip of 45% for pomegranates, 25% for grapes, 50% for tomatoes, 48% for potatoes and 64% for radishes (Table 5.5).

## 5.2 CADG Estimates

CADG has test-plot results on yields under drip compared with traditional irrigation. However, **the results reported in "CADG – RAMP Database Yield Data Sheet" are clearly erroneous** (e.g. yield increases for okra from 7.5-10 MT/ha to 284, 285, 342 and 608 MT/ha, tomato from about 12 MT/ha to 49, 50, 57, 84, 236, 240, 244 and 464 MT/ha, eggplant from 8 MT/ha to 110 and 200 MT/ha). Therefore, **these CADG test-plot results were not taken into account in this study.**

*The only economic study of drip irrigation in Afghanistan, to our knowledge, is a 3-page CADG report on the results of their six-hectare drip irrigation farm in Zhare Dasht District, Kandahar*[5] (Table 5.6) The revenue assumed in this study is reasonable ($3000/ha/year, based on tomato yield of 25 MT/ha at $0.12/kg), and so are the cultivation costs (total $716/ha/year). Based on these, the report calculated that the investment is profitable, with a payback period of 1.06 years.

A minor shortcoming of this report is that labor costs (except for weeding) and maintenance costs of the drip equipment were not included. *The main error of this report, however, is that it compared drip irrigation with doing nothing – but this is not the choice faced by the farmer.* The options that the farmer has are to (i) sink a tubewell and farm traditionally, (ii) sink a tubewell and use improved surface irrigation (ISI), or (iii) sink a tubewell and install a drip system. These options are compared in Table 5.6. This comparison shows that *with CADG's own costs and yields, **drip irrigation** (payback period = 1.06 years) **is superior to traditional irrigation** (payback = 2.09 years), **but is not as cost-effective as improved surface irrigation** (payback = 0.87 years).*

## 5.3 Other Cost-of-Production Studies

**RAMP** Monitoring & Evaluation team has done extensive cost-of-production studies for fruit, nuts, vegetables, legumes, cereals, feed crops and exotic crops, based on improved surface irrigation.

The **UNDP** horticulture feasibility study (*op. cit.*) has done business plans for fruit and nuts, also based on improved surface irrigation.

**IF HOPE** has done financial projections for Almonds, pomegranates, apricots and apples.

These studies were all based on best practices and surface irrigation. The study team has carefully noted the results of these studies, and used some of their numbers in its projections.

[5] "Introducing Innovative Agriculture Technology in Southern Afghanistan – From Desert to Dollars", CADG

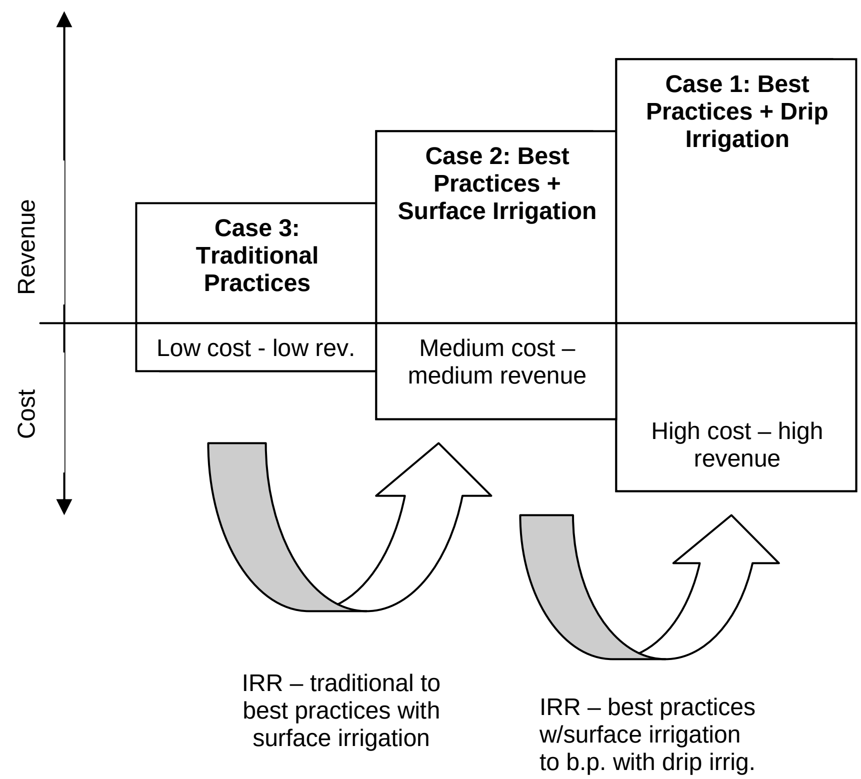
## Section 6. Economic Analyses of Drip Irrigation for High-Value Crops

*Specific Task #5: Based on the information collected above, provide economic analyses for drip irrigation for several crops considered to be high value. These analyses should include ROI, NPV, and any other measure considered appropriate for decision makers on Drip Irrigation.*

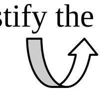
### 6.1 Methodology of the Study

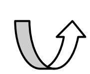
The study compared three options of crop production: (i) traditional practice, (ii) best practice with surface irrigation, and (iii) best practice with drip irrigation. For the reasons discussed in Annex B, we consider the Internal Rate of Return (IRR) to be the most appropriate tool for this type of analysis. However, the team also calculated the Net Present Value (NPV), the Return on Investment (ROI) and the Payback Period (PP). The three options are shown in Diagram 6.1.

**Diagram 6.1: Methodology of this Study**




Previous IRR calculations of fruit plantations in Afghanistan (RAMP, CADG) have looked at the costs and benefits of investing in improved practices or drip irrigation *in isolation* – only compared the benefits of the improved practices with their costs, as if the alternative is to do nothing, and usually obtained high IRRs. However, *this is not the situation faced by the farmer*. The farmer has to decide:

1. Whether the *additional* benefits of adopting best practices with surface irrigation justify the *additional* cost – this is the situation shown on the diagram by the left-hand arrow 

2. And then, whether the *additional* benefits of adding drip irrigation to the best practices outweigh the *additional* cost of drip – this is shown by the right-hand arrow 

The present study investigates these options. The IRRs of traditional, ISI and drip "on their own" were also calculated. In addition, for vineyards we investigated the option of planting with ISI, and switching to drip when the vines mature. We also examined the economic effect of intercropping.

## 6.2 Methodological Remarks

- **Crop yields, input quantities and input prices** were obtained from written information of RAMP, UNDP horticultural feasibility studies (*op. cit.*), California practice (vineyard costs), CADG, IF Hope and Mercy Corps information. However, *the main sources of data were in-depth interviews with farmers and extension agents*. The limitation of this method is that the data is very region-specific and even (e.g. for the cost of tubewells) location-specific. However, we believe that the results can be generalized – if in a certain region drip irrigation is (or is not) profitable for the farmer interviewed, this is probably true for the region.
- **Yields for tree crops under drip irrigation** are not yet available in Afghanistan. These were based on experience of other countries, especially with small farmers in India.
- **Labor costs** were counted at market price, regardless of whether the labor was supplied by the owner or hired. Thus income to the owner is the net profit shown, plus the value of his family's labor. This explains why farmers do plant crops which show negative benefits, e.g. watermelons: growing them is less remunerative than the current wage rate, but as long as the farmer covers the cost of his purchased inputs, he earns *something* for his labor. Labor wages were taken as 200 Afs/day in Helmand/Kandahar (where they are inflated by poppy labor demand) and 100 Afs/day in Nangarhar and central provinces. In both cases 25 Afs/day was added as value of lunch usually provided to agricultural workers.
- **Intercropping** is the usual practice in tree crops in the first few years, to help the cash flow. A sensitivity analysis done for Almonds showed that while intercropping adds a few percent to the IRR for both drip, ISI and traditional irrigation, it does not change the order of priority among them. Therefore for most tree crops, no intercropping was taken into account.
- **Opportunity cost of water:** In addition to the fuel savings with drip (and to an extent with ISI) due to having to pump less water, a value was assigned to the water savings of drip and ISI, equal to the cost of pumping that amount of water. *This is not double-counting but a minimal value of the benefit to the farmer of having this water to irrigate additional crops.*
- **Product quality:** Especially in grapes, improved practices (e.g. trellising) can have a significant impact on product *quality* and thus on selling price. This was not taken into account, which *underestimates the benefits of improved practices*.
- **Precocity:** However, drip irrigation has also the advantage of crops maturing earlier and thus bringing higher prices. Where this significantly affects the average price (e.g. watermelon) it was taken into account.
- **Interest:** Most vegetables are grown by farmers on small areas with the farmers' own finances (sale of the standing crop occurs mostly in cereals). Farmers who plant fruit trees are mostly those who can do it with their own means. Therefore the cost of credit was not included in the calculations.
- **Land rent:** Since most small farmers own their land, this was not taken into account. However, the methodology discussed in Sec. 6.1 (looking at the *marginal* IRR of converting from traditional to ISI and from ISI to drip) takes as opportunity cost of land the next-best option. This has a far higher value than the land rent assumed in other studies.

### 6.3 Results of the Economic Analysis

***Table 6.1 summarizes the results of the economic analysis.*** The details are found in Workbook 1 – Perennial Crops Budgets and Workbook 2 – Annual Crops Budgets. Table 6.1 shows that:

**A.** **Greenhouses** are the highest-priority place for drip systems. *At present yields* in ICARDA greenhouses and current prices, drip-equipped greenhouses show a very respectable IRR of 41%, while with surface irrigation the IRR would be only 8%. Otherwise stated, the net added revenue from installing drip system in a greenhouse is $529/year, so that a, so that ***a drip system costing $338 pays for itself in just 0.64 years.***

**B.** **Perennial crops:**

1. For **grapes**, the economic returns of drip and improved surface irrigation (ISI) are about equal – a bit better for ISI in the case of shallow (15m) wells, a bit better for drip in the case of deep (120m) tubewells (when the water is more expensive). Both are a lot more profitable than traditional cultivation. Some alternatives such as (i) gravity drip irrigation (which saves pump and fuel costs) or (ii) installing the drip system when the vines are several years old improve the IRR for drip. For shallow wells, converting from traditional to ISI has higher return than converting from ISI to drip. For deep wells, it is vice versa.
2. For **almonds** with a shallow well, ISI (IRR = 29%) is slightly superior to drip (IRR = 28%), but for deep wells drip (IRR = 24%) is decidedly superior to ISI (IRR = 15%).
3. For **apricots** similarly, with a shallow well ISI (IRR = 29%) is superior to drip (IRR = 25%), but for deep wells drip (IRR = 21%) is superior to ISI (IRR = 15%).
4. for **apples** too, with a shallow well ISI (IRR = 46%) is superior to drip (IRR = 39%), but for deep wells drip (IRR = 34%) is superior to ISI (IRR = 28%).
5. For **pomegranates** with a shallow well, ISI (IRR = 42%) is superior to drip (IRR = 34%). With a deep well, drip (IRR = 30%) is marginally better than ISI (IRR = 29%). Payoff for converting from traditional to ISI is very high (IRR = 65% for deep well, 140% for shallow).
6. In all cases, drip and ISI are highly superior to traditional methods, and the return for converting from traditional to ISI (with shallow wells) or drip (with deep wells) is quite high.

**C.** **Vegetables** vary widely (all calculations were done on the basis of shallow well):

1. For **Tomatoes**, the IRR of drip irrigation is extremely positive at 151%, with a payback period of 1.6 years; but this is eclipsed by ISI, which shows an *infinite* IRR (i.e. the benefit stream is always positive) and a PP of 0.9 years. This means that *as long as yields are about 16.7 MT/ha for traditional practices, 22.7 MT/ha for ISI and 28.4 MT/ha for drip, it is more cost effective to concentrate on yield increases with surface irrigation – through good seeds, correct fertilization, pest control, transplanting, re-transplanting, trellising, etc.*[6]
2. For **eggplants** the case is similar. The IRR of drip irrigation (assuming a yield increase of 25%) is very positive at 79%, with a payback period of 2.2 years; but this is upstaged by ISI,

[6] This is corroborated by the CADG report (*op. cit*.) about the performance of drip irrigation on a six-hectare commercial vegetable farm. Although the report shows very good returns to drip irrigation, with a PP of 1.06 years, a review of their figures (Table 5.6) shows *even better* returns to ISI, with a PP of just 0.87 years. An example of what can be achieved by best practices with surface irrigation is the USAID experience in Southern Kyrgyzstan, where the average yields of 300 farmers were increased in a single season from 25 MT/ha to 40 MT/ha, through a total investment of $33,000 in extension services.

which shows an infinite IRR (i.e. the benefit stream is positive in all years), and a PP of 0.5 years. This means that *with current yields of about 10 MT/ha for traditional practices, 17 MT/ha for ISI and 21-25 MT/ha for drip, it is more cost effective to concentrate on yield increases with surface irrigation* through improved practices.

3. Likewise for **okra**, the IRR for drip (at 22.5 MT/ha) is 102%, but the IRR for ISI (at 18 MT/ha) is *infinite*. For Okra too, it is better to concentrate on ISI with improved practices.

4. **The case of an all-vegetable commercial farm:** *The only exception* to the above conclusion is if a farmer wants to create a 100% vegetable (or vegetable and tree crop) farm, ***and*** his water availability is limited so he cannot simply sink another well. In this case, although the IRR (i.e. return to *capital*) of ISI is still higher than of drip, *the farmer would maximize his income by installing an all-drip system* to economize on his most scarce resource – water.

5. **Watermelons,** oh the other hand, show *infinitely negative* IRRs for both ISI, drip and traditional irrigation. This means that at yields of 18 MT/ha for traditional, 24 MT/ha for ISI and 30 MT/ha for drip, and prices of about $60/MT, *watermelon cultivation does not cover its costs including labor*. Farmers nevertheless do grow watermelons because they cover their input costs, so they get *something* for their labor, albeit not current wage rates.

**D. Field Crops** (all calculations done on the basis of shallow well)**:**

1. **Peanuts** – like tomatoes, eggplants and okra – are very profitable with drip (IRR = 100%), but even more so with ISI (infinite IRR).

2. For **potatoes** the same holds true: drip is extremely profitable (IRR = 345%), but for ISI the IRR is infinite.

3. **Onions,** on the other hand, are not profitable with drip (IRR = 12%), since the small distances between rows and between plants necessitate a very costly drip system. On the other hand, for ISI the IRR is infinite.

4. For **Cereals** (wheat and maize), the IRRs are negative both in the case of drip, ISI and traditional irrigation. These results confirm what every farmer would tell – that at present fuel and grain prices with small-pump technology, even at the rather satisfactory yields assumed (wheat – 3.0 MT/ha with ISI and 3.75 MT/ha with drip, maize – 6.66 MT/ha with ISI and 8.86 MT/ha with drip), *pumped irrigation for wheat and maize is not economical.*

## Section 7. Assumptions Made for the Analyses

*Specific Task # 7: Provide detailed assumptions made for these analyses.*

Very detailed explanations regarding each cost and yield assumed for the crops examined by the study team are provided in the footnotes to spreadsheets in Workbook 1 – Perennial Crop Budgets and Workbook 2 – Annual Crops Budgets. *The most important assumptions are:*

1. The irrigation efficiency of drip systems was taken as 95%, of ISI (including canal losses) 50% and of traditional flood irrigation 40%. This corresponds to international experience.
2. We could not find Afghan figures for total crop water requirements, so based on Quetta, Colorado, Washington State and other international arid-zone experience, we assumed for: grape and almond 600 mm/year; pomegranate mm/year; apricot 800 mm/year; apples 900 mm/year; tomato, potato, watermelon and maize 650 mm/year; cucumbers and eggplant 600

mm/year; okra 550 mm/year; peanuts and onion 500 mm/year; and wheat 475 mm/year. Lower water requirements would reduce the attractiveness of drip, and vice versa.

3. There is no Afghan experience on yields under drip for trees, no yield comparison in greenhouses between ISI and drip, and the figures we found on yield increases for drip in vegetables we do not consider reliable. Therefore, *based on international and personal experience, we have assumed that drip irrigation increases yields over ISI in tree crops by 15%, in vegetables by 25% and greenhouses by 30%. We consider that these assumptions are conservative; assuming higher yields would drastically increase the advantage of drip*.
4. The life of the drip equipment was assumed as five years – the minimum guaranteed by reputable manufacturers (in US practice such systems often last 10-20 years).

## Section 8. Analysis of Cultivation Practices Used on High-Value Crops

*Specific Task #6: Conduct analyses of the cultivation practices used on crops considered high potential for drip irrigation. Recommend modifications of the presently used cultural systems if necessary for improving efficient production under drip irrigation.*

### 8.1 Traditional Practices of Fruit and Grape Production

Until tree plantations bear fruit, the farmers usually practice intercropping (wheat, potatoes and other field crops, as well as vegetables). Small farmers are primarily concerned with producing their subsistence food. They regard fruit trees as a secondary crop and thus are reticent to make high investments such as trellises and drip systems. In certain areas farmers do not practice crop rotations, e.g. certain areas grow only wheat, although in the milder climate of Helmand and Kandahar farmers grow two and sometimes three crops per year. Afghan farmers have time-tested methods that produce what they consider acceptable yields, so are reluctant to risk new technologies. The majority of land holdings are small, no more than 1.0 Ha/family, and have very few fruit trees. Traditional farmers apply manure and some chemical fertilizers. They are slowly adopting new cultivation practices such as pruning, budding, grafting and pesticide spraying.

Farmers usually over-irrigate their crops, whether they use canals water or pump from tubewells.

Vines are normally grown in Kandahar/Helmand on mud trellises, which result in a lot of damaged and dirty fruit. With mud trellises, usually farmers do not intercrop.

The condition of the existing vineyards and orchards is such that except for some activities (better pest management, fertilizing, pruning) it is better to start new ones.

A major constraint to fruit production is the marketing system. Due to lack of cold storage, fruit are exported to Pakistan, then often re-imported to Afghanistan. RAMP is financing cold storage facilities and organizing farmers' associations around them. RAMP is also introducing improved farming techniques for fruit and vegetables as an alternative to poppy production. The farmers' adoption rate of new techniques is very low (less than 10% of all farms). The adoption rate is higher closer to the demonstration plots.

### 8.2 Modifications Being Introduced by Donor Organizations on High-Value Crops

**Roots of Peace:** For **grapes** it is introducing trellising (with concrete posts and wiring) in 150 farmers' plots, new improved varieties, a new type of raisin drying shed which improves quality and

shortens drying time, cold storage, packaging and marketing. It has nurseries to produce rooted cuttings and is encouraging private nurseries. For **almonds** it is doing extension work on production, is active in marketing, and has three processing plants in Afghanistan.
**IF Hope** carries out massive production of tree saplings, with extension to farmers and establishing demonstration centers, aiming to create 5000 ha of new plantations.
**CADG** carries out in Southern Afghanistan a massive program of extension and demo plots for improved practices in fruit trees, grapes, vegetables and field crops, including drip irrigation.
**ICARDA,** beside their programs for improvement of wheat and field crops (e.g. potatoes), concentrates on high-quality greenhouses. The yields are outstanding (the top 1/3 of greenhouses averaged 117 MT/ha in the spring and 108 MT/ha in the fall – the study team have verified one in the field). A farmer we visited in Bagram planted rose cuttings as a winter crop, tomato seedlings for sale to other farmers, and plans to buy 10 more greenhouses with his own cash.
**Mercy Corps** has started with medium-priced greenhouses, but are now building more robust ones.
**RAMP** has financed through its Implementing Partners many of the above improvements.
**The World Bank** is designing a three-year horticulture program in which they plan to introduce demonstration plots with drip irrigation.
**The UNDP Horticultural Feasibility Study (*op. cit.*)** recommends that **almond** seedlings should be grafted using local varieties, especially from in Northern Afghanistan. For **pomegranate,** pruning and the cleaning of flower remains on growing fruit can significantly improve productivity and quality. This is rarely done in Afghanistan. For **apricot,** local varieties have a good export potential and should be selected for multiplication in nurseries. Grafting on selected root stock can significantly improve crop performance. For **Grapes,** that study recommends trellises.
**CNFA** (Afghanistan Ag. Dev. Program) gives grants to agribusinessmen to install processing facilities. This includes some upstream investments with farmers, e.g. orchard establishment.

While it was not the brief of this study to evaluate the work of USAID contractors in fruit and vegetable development, *the general impression of the team is that all of those organizations are doing very good development work that should be continued in the future.* In particular:

- **IF HOPE** is remarkable for its work through the *shura* village councils and for the sheer size of its endeavor (nearly a million saplings to be distributed in 2006);
- **Roots of Peace** for its integrated approach, supporting both orchard development (vine trellises, improved varieties) and marketing (packing houses, cold storage, contacts abroad);
- **CADG** is doing massive extension work (over 600 demo plots) in the very difficult security conditions of Helmand and Kandahar;
- **ICARDA,** now followed by **Mercy Corps,** is introducing commercial greenhouses, which can materially increase farmers' income and security within a short period.

### 8.3 Further Modifications Recommended by the Study Team

**1. Gravity-drip systems:** We recommend the use of drip irrigation in Afghanistan particularly with tubewells, for the reasons detailed in Sec. 3. In the present setup, the tubewell pump lifts the water to a ground-level storage tank, from which another pump drives it into the drip system. This requires an additional $1100 cost of the booster pump, plus annual operation costs of about $250 and maintenance of about $50/year. Instead, the tubewell pump could lift the water to a water tank placed on an earth mound about 1m high at the high edge of the irrigated 1-hectare area, from which water would flow *by gravity* into drip lines equipped with micro-drippers, which can operate at such low pressure. Annex C shows a sketch and details of this system. It calculates that the total investment for a vineyard will be about $3000/ha, comparable with a booster pump drip system

($1,100 for pump, $1,400 for lines, $500 for tank).  A similar concept is being used in the Roots of Peace Bagram nursery and the ICARDA greenhouses (albeit without use of micro-drippers, and not for *field* drip systems as we recommend here).  The advantages of a gravity-drip system are:

1. The $1100 cost of the booster pump (which must be replaced every five years) is eliminated;
2. The fuel costs for operating the booster pump ($250/year or more), as well as its maintenance costs which increase over the life of the pump, will be eliminated.  (The extra fuel cost for the tubewell pump to lift water into an elevated tank is negligible);
3. Gravity drip is particularly appropriate for small farmers who irrigate less than 1 ha, since it does not have the indivisible cost of the booster pump;
4. The water tank is necessary even with the present setup, so implies no extra costs;
5. Fertigation can be done very simply by dropping soluble fertilizer into the tank.

**2. External drippers:** The drip systems presently being introduced by ICARDA and CADG both have the drippers *inside* the irrigation pipe.  With these systems, if the drippers clog up seriously, little can be done except throw away the pipe.  We recommend instead the use of systems such as used by IF Hope, where the drippers are mounted onto the pipe (see photo).

**External Drippers for Tomatoes in Uzbekistan**

The advantages of this system are:

- The drippers can be mounted locally in a mini-workshop according to the spacing requirements of each farmer (this also creates some local employment);
- In case of clogging the drippers can be removed, cleaned and re-mounted very simply;
- The cost is competitive or cheaper than that of internal drippers;
- This system has a successful track record under similar conditions in Central Asia.

**3.** **Rollers for drip lines:** We have observed that the drip lines are stored off-season in a mess, forming kinks with will seriously shorten their useful lives. Simple metal rollers, which can be cheaply manufactured locally, should be supplied to the farmers together with the drip system.

**4.** **Promote hybrid seeds:** The team did not notice in CADG's program a focus on hybrid sees, and was informed by the CADG Helmand agricultural coordinator that for both maize and tomatoes the farmers use their own seed or bazaar seed of dubious origin. *Normally the introduction of hybrid seeds, were applicable, brings far more cost-effective and immediate returns than the introduction of drip irrigation*. Thus we recommend more stress on hybrid seeds.

## Section 9. Recommendations

*Specific Task #8: Provide recommendations based on the findings of this study.*

**1.** **Concentrate on tubewell areas:** Due to the problems of using drip with surface water and the sufficient availability of tubewells in Helmand, Kandahar, Nangarhar and other provinces, *at present drip irrigation should be used only where the water source is wells, karezes or piped water supply*. (This is the near-unanimous opinion of implementing organizations). The only exceptions are greenhouses, where even operating a drip system with canal water can be viable, as we have observed in Helmand.
**2.** **Install drip systems in greenhouses:** All market-oriented greenhouses installed with USAID assistance should include drip systems, even when the water source is a canal, since this low additional investment brings high and immediate returns, which motivates the farmers to take proper care of the systems.
**3.** **Concentrate on high-value crops:** Drip demonstrations on low-value field crops such as watermelon should be discontinued and the funds oriented to tree crops and high-value annual crops.
**4.** **Introduce gravity drip systems:** Install in several regions drip systems with micro-drippers fed by gravity from an elevated tank into which the tubewell pump discharges. *Such systems, pioneered by the company Ein-Tal, can significantly decrease drip system costs by eliminating the capital, fuel, maintenance and replacement costs of the booster pump*.
**5.** **External drippers:** Generalize the use of drip systems equipped with external drippers, which are easier to clean.

**Recommendations of Alternatives or Complements to Drip Irrigation:**

1. **Generalize the use of piping:** Irrigation efficiencies can be significantly improved and the irrigated areas expanded at minimal investments by simply replacing the canals from tubewells and karezes to fields, which have high losses to weeds and seepage, by PET pipes.
**2.** **Solar pumps:** Experiment with the use of solar pumps, as planned by **Roots of Peace**, to install drip irrigation in dry areas for permanent crops and lift the water from wells with solar pumps, which economize fuel.
**3.** **Trellises:** Promote the use of trellises for grapes, which are the most important tree crop.
**4.** **Nurseries:** Support (with other donors) both NGO-operated and private tree nurseries to the extent necessary to meet the foreseeable farmers' demand for saplings and rooted cuttings of imported and of good local varieties.

## Section 10. Follow-Up Actions

*Specific Task #9: Detail any follow-up actions required.*

Beside the actions discuss in the previous section, the study team recommends to:

1. **Establish demonstration plots:** ***Our most important recommendation is to establish with drip irrigation in regions of USAID interventions one vineyard, one orchard of the most important tree species, and one plot of another tree crop and/or high-value vegetables****, of about 1 ha each, to gain experience with yields and demonstrate the technology*. These should in general be on the fields of leading farmers, and may be on the same or on separate farms. (The entire investment cost per province would be less than that of one armored car).
2. **Encourage local input suppliers to stock spare parts for drip systems**, as e.g. IFDC is doing in Kyrgyzstan, by making the initial orders through them and signing supply contracts.
3. **Consider credit financing for establishing greenhouses with drip irrigation,** instead of the 80% subsidy on greenhouses currently provided to farmers by ICARDA (the farmer pays just 20%). This could be done through the organizations promoting greenhouses, with the greenhouse as collateral. This way the farmer could pay over 5 years the full cost of the greenhouse, and the funds rolled to provide greenhouses to other farmers. A similar USAID program in Uzbekistan is quite successful, with a 100% repayment rate.

**Table 2.1: Farmgate Prices of Fruits, Nuts, Vegetables and Field Crops in Afghanistan**

## PART I: FRUIT AND NUTS ($/MT)

| Product | Source 1 (Hort. Assessment Survey) | Source 2 (RAMP Cost of Production) | Source 3 (CADG Lashkar Gah) | Source 4 (UC Davis Afghan Fruit & Nuts) | Source 5 (UNDP – Raphy Favre Study) | Source 6 (Study Team Observations) | Source 7 (Competitiveness Study) | Source 8 (IF Hope, Jalalabad) |
|---|---|---|---|---|---|---|---|---|
| Apple, Golden Delicious | 750 | | | | 200 | | | |
| Apple, Red Delicious | 625 | 200 | | | 295 | | | 432 to 967 |
| Apricot | | 343 | | | 320 t 360 | | | 330 to 700 |
| Grape | | | | | 240 to 350 | Kandarhar 300 Bagram 200 to 700 | 100 to 200 | |
| Lemon | 750 | | | | | | | |
| Mulberry | 240 | | | | | IFHope Jalalabad dried fruit 4000 | | |
| **Orange** | 200 | | | | | | | |
| Peach | | 340 | | | 200 to 320 | | | 356 to 833 |
| Pear | 375 | | | | | | | |
| Plum | | 480 | | | 230 | | | |
| Pomegranate | | | | | 85 to 220 | | | |
| Raisins | | | | Medium roud green = 91 Medium long green= 287 High Shunduka n= 667 | | **Kandarhar**: sundried = 50 Green high = 2600 Green medium =930 Green low = 550 **Bagram** Black = 400 Green = 857 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sweet Cherry | | 760 | | | | | | |
| Almond | | | | | 2000 to 2220 | Mercy Corps = 1714 IFHope = 4000 to 5000 | | |
| Pistachio | | 2860 | | 700 to 750 | 2860 to 5500 | | | |
| Walnut | | 851 | | | 550 to 600 | | 3000 | |

## PART II: VEGETABLES ($/MT)

| Product | Source 1 (Hort. Assessment Survey) | Source 2 (RAMP Cost of Production) | Source 3 (CADG Lashkar Gah) | Source 4 (UC Davis Afghan Fruit & Nuts) | Source 5 (UNDP – Raphy Favre Study) | Source 6 (Study Team Observations) | Source 7 (Competitiveness Study) | Source 8 (IF Hope, Jalalabad) |
|---|---|---|---|---|---|---|---|---|
| Bell Pepper | 625 | | | | | | | |
| Broccoli | 375 | | | | | | | |
| Carrots | 125 | 85 | | | 270 | | | |
| Cabbage | $ 0.20/piece | 65 | | | | | | |
| Cauliflower | $ 0.175/piece | 85 | | | | | | |
| **Coriander** | 100 | | | | | | | |
| Cucumber | $ 0.075/piece | | | | | Greenhouse ICARDA Charikar 440 | | |
| Eggplant | 250 | 58 | 100 | | | | | |
| Garlic | 625 | 290 | | | | | | |
| Hot Pepper (chili) | 125 | 380 | | | | | | |
| Leek | 175 | | | | | | | |
| Lettuce | 300 | | | | | | | |
| Melon | | 65 | | | 60 | | | |
| Mint | 750 | | | | | | | |
| Okra | | 100 | 160 | | | Jalalabad 190 to 476 | | 181 to 1128 |
| Onion | 250 | 122 | | | 110 | | | 109 to 201 |
| Potato | 250 | 102 | | | 115 | | | 122 t0 204 |
| Spinach | 100 | 75 | | | | | | |
| Summer Squash | 375 | | | | | | | |
| Tomato | 250 | 100 | 140 | | 250 | CADG 60 to 120 | | 126 to 564 |
| **Turnip** | 75 | | | | | | | |
| White Raddish | 50 | | | | | | | |
| **Watermelon** | | 55 | 80 | | 60 | Kandahar 50 | | |

## PART III: FIELD CROPS ($/MT)

| Product | Source 1 (Hort. Assessment Survey) | Source 2 (RAMP Cost of Production) | Source 3 (CADG Lashkar Gah) | Source 4 (UC Davis Afghan Fruit & Nuts) | Source 5 (UNDP – Raphy Favre Study) | Source 6 (Study Team Observations) | Source 7 (Competitiveness Study) | Source 8 (IF Hope, Jalalabad) |
|---|---|---|---|---|---|---|---|---|
| **Alfalfa** | | 43 | | | | | | |
| Barley | | G = 115<br>S = 80 | | | | | | |
| Chickpea | | G = 250<br>S = 80 | | | | | | |
| Cotton | | | 280 | | | | | |
| Cowpea | | G = 325<br>S = 80 | | | | | | |
| Cumin | | 1200 | | | | | | |
| Maize | | G = 130<br>S= 35 | | | | CADG Lashkar Gah = 130 to 220 | | |
| Mungbean | | G = 235<br>S = 90 | | | | | | |
| Peanuts | | G = 510<br>S = 20 | 610 | | | | | |
| Red Bean | | G = 265<br>S = 90 | | | | | | |
| Rice | | G = 285 to 320<br>S = 20 | | | | | | |
| Sesame | | G = 610<br>S = 30 | | | | | | |
| Sunflower | | | 690 | | | | | |
| Wheat | | G = 125<br>S = 80 | | | | Jalalabad<br>G = 190<br>S = 25 | | 129 to 282 |

**Source 1: "A Preliminary Assessment Survey of Horticultural Crop Production and Marketing in Afghanistan" by Nasir A. Sardy, Jan. 2003**
**Source 2: RAMP – Cost-of-Production Tables**
**Source 3: CADG - Lashkar Gah**
**Source 4: ALP/S - UC Davis - Afghan Fruit and Nut Analyses**
**Source 5: "Market Sector Assessment in Horticulture – Phase 2-3, Feasibility Studies and Business Plans", Annex I, by Raphy Favre et al, UNDP**
**Source 6: Prices quoted to the study team by farmers during field visits**
**Source 7: "Competiveness for Afghanistan's Fruits, Nuts and Vegetables" by Dr. Kennth Swanberg, RAMP/Chemonics/USAID, Oct. – Dec. 2004**
**Source 8: IF Hope, Jalalabad**

Table 2.2: RAMP Vegetable Production Costs, Yield, Price, Gross and Net Income per Ha in Afghanistan

| Crop | Cost/Ha ($) | Yield (MT/Ha) | Price ($/MT) | Gross Income ($/Ha) | Net Income ($/Ha) |
|---|---|---|---|---|---|
| 1. Cabbage | 1,417.00 | 20 | 65 | 1,300.00 | (117.00) |
| 2. Carrot | 1,535.00 | 35 | 85 | 2,975.00 | 1,436.00 |
| 3. Cauliflower | 1,117.00 | 20 | 85 | 1,700.00 | 523.00 |
| 4. Chilli | 919.00 | 4 | 380 | 1,520.00 | 601.00 |
| 5. Cucumber | 923.00 | 10 | 102 | 1,020.00 | 97.00 |
| 6. Eggplant | 1,201.00 | 18 | 58 | 1,044.00 | (157.00) |
| 7. Garlic | 1,930.00 | 6 | 290 | 1,740.00 | (190.00) |
| 8. Melon Irrigated | 643.00 | 20 | 65 | 1,300.00 | 657.00 |
| 9. Okra | 1,737.00 | 18 | 100 | 1,800.00 | 63.00 |
| 10. Onion | 1,315.00 | 18 | 122 | 2,196.00 | 881.00 |
| 11. Spinach | 1,085.00 | 15 | 75 | 1,125.00 | 40.00 |
| 12. Tomato | 3,259.00 | 40 | 100 | 4,000.00 | 750.00 |
| 13. Watermelon, irrig. | 783.00 | 18 | 55 | 990.00 | 207.00 |
| 14. Potato | 1,798.00 | 25 | 102 | 2,550.00 | 752.00 |

**Source: RAMP - Vegetables, Cost of Production**

Table 2.3: RAMP and UNDP Fruit and Nut Production Costs, Yield, Price, Gross and Net Income per Ha in Afghanistan

| Crop | Cost/Ha ($) | Yield (MT/Ha) | Price ($/MT) | Gross Income ($/Ha) | Net Income ($/Ha) |
|---|---|---|---|---|---|
| 1. Almond (13 to 18 yrs) | 1,413.30 | 2.1* | 2,000* | 4,200.00 | 2,786.70 |
| 2. Walnut (4 to 8 yrs) | 1,088.10 | 8 | 857 | 6,856.00 | 5,767.90 |
| 3. Pistacho | | 1.45 (Iran)* | 2,860* | 4,147.00 | |
| 4. Grape (9 to 15 yrs) | 2,246.37 | 25* | 260* | 6,500.00 | 4,253.63 |
| 5. Grape (1 yr nursery) | 303.52 | 0 | 0 | 0.00 | (303.52) |
| 6. Pomegranate (5 to 10 yrs) | 1,969.95 | 18.5* | 220* | 4,107.00 | 2,37.05 |
| 7. Apricot Ghorband (7 to 12 yrs) | 2,206.28 | 18 | 343 | 6,174.00 | 3,967.72 |
| 8. Apricot (1 to 3 yrs nursey) | 303.34 | 0 | 343 | 0.00 | (303.34) |
| 9. Apricot Samangan (7 to 12 yrs) | 1,636.94 | 13.5 | 343 | 4,630.50 | 2,993.56 |
| 10. Cumin intercropped | 470.50 | 0.75 | 1200 | 900.00 | 429.50 |
| 11. Apple (12 to 22 yrs) | 2,306.52 | 16 | 200 | 3,200.00 | 893.48 |
| 12. Sweet Cherry (9 to 13 yrs) | 1,751.93 | 7 | 760 | 5,320.00 | 3,568.07 |
| 13. Mulberry (7 to 12 yrs) | 2,191.10 | 14 | 240 | 3,360.00 | 1,168.90 |
| 14. Plum Ghazni (7 to 12 yrs) | 1,395.34 | 7.5 | 480 | 3,600.00 | 2,204.66 |
| 15. Peach | | 7 to 20*<br>Av. 13.5 | 340* | 4,590.00 | |

*UNDP Horticultural Feasibility Study.

**Check on source

**Source: RAMP - Fruit and Nuts, Cost of Production**

**Table 2.4: RAMP Field Crop Production Costs, Yield, Price, Gross and Net Income per Ha**

| Crop | Cost/Ha ($) | Yield (MT/Ha) | Price ($/MT) | Gross Income ($/Ha) | Net Income ($/Ha) |
|---|---|---|---|---|---|
| 1. Alfalfa | 1,094.00 | 26.4 | 42.90 | 1,132.56 | 40.56 |
| 2. Barley | 622.70 | Grain 1.5<br>Straw 2.5 | Grain 115.00<br>Straw 880.00 | Grain 173.25<br>Straw 200.00 | (250.20) |
| 3. Red beans, irrigated | 761.04 | Grain 1.5<br>Straw 2.0 | Grain 265.00<br>Straw 180.00 | Grain 397.50<br>Straw 180.00 | (183.54) |
| 4. Chickpea, rainfed | 272.70 | G 1.6<br>S 2.0 | G 250.00<br>S 80.00 | G 375.00<br>S 160.00 | 262.30 |
| 5. Cowpea, rainfed | 174.60 | G 1.5<br>S 1.5 | G 325.00<br>S 80.00 | G 422.50<br>S 120.00 | 367.89 |
| 6. Maize (corn) | 601.92 | G 2.98<br>S 8 | G 130.00<br>S 35.00 | G 387.40<br>S 280.00 | 65.48 |
| 7. Mung Bean, irrigated | 612.89 | G 1.2<br>S 2 | G 235.00<br>S 90.00 | G 282.00<br>S 180.00 | (150.89) |
| 8. Peanut, irrigated | 436.17 | G 1.2<br>S 0.5 | G 510.00<br>S 20.00 | G 612.00<br>S 10.00 | 185.83 |
| 9. Rice, improved variety | 1,496.00 | G 3.5<br>S 5 | G 320.00<br>S 20.00 | G 1,120.00<br>S 100.00 | (276.05) |
| 10. Rice, local variety | 1,260.70 | G 3.0<br>S 5.1 | S 285.00<br>G 102.00 | G 855.00<br>S 102.00 | (303.70) |
| 11. Sesame, irrigated | 475.13 | G 1.5<br>S 0.5 | G 610.00<br>S 30.00 | G 915.00<br>S 15.00 | 454.87 |
| 12. Wheat | 760.40 | G 2.85<br>S 4.28 | G 125.00<br>S 80.00 | G 356.30<br>S 342.40 | (61.70) |

**Source: RAMP - Field Crops, Cost of Production**

## 4 Table 2.5: Mercy Corps Yields and Farmgate Prices for Some Fruit and Vegetables

| Crop | Yield (MT/Ha) | Price ($/MT) |
|---|---|---|
| Pomegranates | 9 to 10 | 220 to 880 |
| Raisins | - | 230 |
| Apple local | - | 420 |
| Apple Pakistan | - | 250 |
| Apple local | - | 370 |
| Tomato (polyhouse demo plot) | 80?? | 225 |
| Tomato local | 13.5 | 185 to 225 |
| Cauliflower | - | 140 |
| Onions | 6.4 to 9.0 | - |
| Egg plant | - | 200 |
| Marrows | - | 120 |
| Okra | - | 330 |
| Sunflower | 0.9 to 1.5 | - |
| Poppy, opium | 0.07 to 0.09 | 1,700 |

Source: Technical Consultancy of Paul D. Smith and Keith H. Morris, CAZS Natural Resources, University of Wales, Bangor, to Mercy Corps Afghanistan, Nov. 888-24, 2005

## Table 2.6: CADG Crop Yields and Farmgate Prices

| Crop | Average Price ($/Kg) | Drip Irrigation with Improved Practices (Kg/Ha) | Furrow Irrigation with Improved Practices (Kg/Ha) | Traditional Farmers' Cultivation Practices (Kg/Ha) |
|---|---|---|---|---|
| Tomatoes | 0.14 | Hav.*17,890<br>Av.**11,140 | Hav.17,060<br>Av.15,282 | Av.12,500 |
| Okra | 0.16 | Hav.23,150<br>Av.18,299 | Hav.17,550<br>Av.15,883 | Av.11,148 |
| Eggplant | 0.10 | Hav.38,760<br>Av.26,355<br>Low 14,00 | Hav.21,200<br>Av.17,410 | Av.10.000 |
| Watermelon | 0.08 | Hav.35,250<br>Av.30,675 | Hav.30,667<br>Av.26,483 | Hav.22,863<br>Av.21,000 |
| Peanuts | 0.61 | Hav.4,100<br>Av.3,721 | Hav.3,750<br>Av.3,344 | Hav.3,750<br>Av.3,344 |
| Sunflower | 0.69 | Hav.1,750<br>Av.1,350 | Hav.1450<br>Av.1,350 | Av.1,000 |
| Cotton | 0.28 | Hav.4,500<br>Av.4,152 | Hav.4,050<br>Av.3,711 | Av.2,690 |

* Hav. = High average – top 1/3 of the plots (those farmers who followed recommendations)
** Av. = Average

**Source: CADG Lashkar Gah**

**Table 5.1: Yield Increases and Water Savings from Drip Irrigation in India**

| Crop | % Increase in Yield (Drip over Surface Irrigation) | % Water Saving |
|---|---|---|
| Eggplant | 18 | 44 |
| Cabbage | 34 | 46 |
| Cauliflower | 44 | 20 |
| Chili | 10 | 68 |
| Okra | 27 | 15 |
| Potato | 20 | 40 |
| Tomato | 25 | 40 |
| Pomegranate | 21 | 51 |
| Cotton | 40 to 47 | 5 to 33 |
| Simple average | 27% | 38% |

**Source: Progress Report 201, National Committee on Plasticulture Applications, MOA, India**

**Table 5.2: Increased Yields and Water Savings with Drip Irrigation in India**

| Crop | % Increase in Yield | % Water Increase in Saving |
|---|---|---|
| Grapes | 23 | 48 |
| Pomegranates | 98 | 45 |
| Tomatoes | 50 | 39 |
| Watermelon | 88 | 36 |
| Cotton | 27 | 53 |

**Source: "Success of Drip in India: An Example to the Third World" by S.K. Suryawanshi**

**Table 5.3: Water Conservation in Mediterranean Countries**

| Country | Jordan | Morocco | Turkey | Egypt | Tunisia |
|---|---|---|---|---|---|
| Type of irrigation | Drip | Laser-leveled basin irrigation | Drip, sprinkler and California system | Modernized lined mesq | Drip, sprinkler and modernized surface irrigation |
| **Reported water savings (%)** | 20 to 50 | 20 | 34 | - | 25 |
| **Reported crop yield increase (%)** | 15% to 20% (Cucumber, tomato) | 30% (Cereals) | - | 10% (cereals, cotton) | - |
| **Derived increase of water use efficiency. (%)** | 44% to 100% | 62% | 51% | 10% | 33% |

**Section 11. Source: Water Conservation, GRID Issue 17, February 2001**

## Table 5.4: Comparing the Economics of Drip and Surface Irrigation in Pomegranates, Grapes and Tomatoes in India

| N° | Particulars | Pomegranates | | Grapes | | Tomatoes | |
|---|---|---|---|---|---|---|---|
| | | Drip | Surface | Drip | Surface | 5 Drip | Surface |
| 1 | Plant spacing (m) | 4.2 x 4.2 | 4.2 x 4.2 | 3.0 x 1.8 | 3.0 x 1.8 | 1.65 x 0.45 | 0.9 x 0.6 |
| 2 | Cost of drip system ($/Ha) | 600.00 | - | 875.00 | - | 600.00 | - |
| | a) Life 5 yrs for lateral / dripper and 10 yrs for main, sub-main and filter.<br>b) Depreciation ($/Ha)<br>c) Interest 13% ($/Ha)<br>d) Repair and Maintenance ($/Ha)<br>e) Total ($/Ha) | 102.00<br>36.00<br>30.00<br>168.00 | | 148.75<br>52.50<br>43.75<br>245.00 | | 102.00<br>36.00<br>30.00<br>168.00 | |
| 3 | Cultivation cost ($/Ha) | 800.00 | 1,000.00 | 2,500.00 | 3,250.00 | 1,400.00 | 1.600.00 |
| 4 | Total seasonal cost (3+2e) ($/Ha) | 968.00 | 1,000.00 | 2,745.00 | 3,250.00 | 1,568.00 | 1,600.00 |
| 5 | Water used (Lt/day/plant) | 15 | 17.5 | 20 | 40 | 5 | 10 |
| 6 | Yield (MT/Ha) | 23 | 17.5 | 45 | 30 | 75 | 50 |
| 7 | Selling price ($/MT) | 200.00 | 160.00 | 180.00 | 160.00 | 40.00 | 40.00 |
| 8 | Gross income (6x7) ($/Ha) | 4,600.00 | 2,800.00 | 8,100.00 | 4,800.00 | 3,000.00 | 2,000.00 |
| 9 | Net seasonal income (8-4) ($/Ha) | 3,632.00 | 1,800.00 | 5,355.00 | 1,550.00 | 1,432.00 | 400.00 |
| 10 | Additional area cultivated due to water saving (Ha) | 1 | - | 1 | - | 1 | - |
| 11 | Additional expenditure due to additional area (4x10) ($/Ha) | 968.00 | - | 2,745.00 | - | 1,568.00 | - |
| 12 | Additional income due to additional area (8x10) ($/Ha) | 4,600.00 | - | 8,100.00 | - | 3,000.00 | - |
| 13 | Additional net income (12-11) ($/Ha) | 3,632.00 | - | 5,355.00 | - | 1,432.00 | - |
| 14 | Gross cost of production (4+11)/2 ($/Ha) | 968.00 | 1,000.00 | 2,745.00 | 3,250.00 | 1,568.00 | 1,600.00 |
| 15 | Gross income (8+12)/2 ($/Ha) | 4,600.00 | 2,800.00 | 8,100.00 | 4,800.00 | 3,000.00 | 2,000.00 |
| 16 | Benefit: Cost ratio (15/14) | 4.75 | 2.8 | 2.95 | 1.48 | 1.91 | 1.25 |
| 17 | Net extra income due to drip over surface irrigation.<br>[(13+9Drip) - 9 surf) ($/Ha) | 5,464.00 | 1,800.00 | 9,160.00 | 1,550.00 | 2,464.00 | - |

**Source: "On-Farm Increased Production, Income and Water Use Efficiency Through Micro Irrigation in India", S.M. Taley, R.S. Patode and A.N. Mankar**

## Table 5.5: Comparison of Drip and Surface Irrigation Yields in India

| 6 Crop | Surface Irrigation (MT/Ha) | Drip Irrigation (MT/Ha) | Increase, % |
|---|---|---|---|
| Pomegranates | 7.5 | 10.9 | 45% |
| Grapes | 26.6 | 32.5 | 22% |
| Radish | 16.3 | 26.8 | 64% |
| Tomatoes | 32.0 | 48.0 | 50% |
| Onions | 9.3 | 11.2 | 20% |
| Potatoes | 32.0<br>23.6 | 48.0<br>34.4 | 50%<br>46% |
| Maize (corn) | 1.56 | 1.81 | 16% |
| Peanuts | 2.68 | 3.2 | 19% |

**Source: "Drip Irrigation in India", United Nations Environmental Programme, Division of Technology, Industry and Economics**

## Table 5.6: CADG Report of 6-Ha Drip System, Compared with Traditional Irrigation

Location – Zhare Dasht District, Kandahar Province
Type of irrigation – a tubewell and 6 hectares of drip irrigation for tomato & okra

| Item | Drip System Costs, $ | Improved Furrow Irrigation Costs, $ | Traditional Irrigation Costs, $ |
|---|---|---|---|
| **Gross revenue** | | | |
| Yield, MT/ha | 25 | 20 | 12 |
| Price, $/kg | $0.12 | $0.12 | $0.12 |
| **Gross revenue per hectare** | **$3,000** | **$2,400** | **$1,440** |
| | | | |
| **Investment costs** | | | |
| Tubewell, pump & motor | $4,000 | $4,000 | $4,000 |
| Drip system costs (6 ha @ 1761/ha) | $10,565 | – | – |
| **Total investment cost** | **$14,565** | **$4,000** | **$4,000** |
| **Area irrigated (a)** | **6 ha** | **3.16 ha** | **2.53 ha** |
| | | | |
| **Production costs (tomatoes, 1 ha)** | | | |
| Tomato seed (same for both, 0.5-1.2 kg/ha) (b) | $70 | $70 | $25 |
| Weeding (1 time with drip, 3 times traditionally) | $64 | $192 | $192 |
| Fertilizer (c) | $155 | 155 | $105 |
| Fuel for pump (d) | $227 | $227 | $227 |
| Land preparation (e) | $100 | $200 | $100 |
| Pesticide | $100 | $100 | $35 |
| **Total production costs per hectare** | **$ 716.00** | **$ 944.00** | **$ 684.00** |
| | | | |
| **Net revenue per hectare (before repayment of investment)** | **$2,284** | **$1,456** | **$756** |
| Net revenue for the total irrigated area (before repayment) | $13,704 | $4,601 | $1,913 |
| **Payback period on the investment, years** | **1.06** | **0.87** | **2.09** |

(a) Assumed drip system 95% irrigation efficiency, improved furrow 50% irrigation efficiency, traditional system 40% irrigation efficiency, so if the tubewell suffices for 6 ha with drip irrigation, it can irrigate 6x50%/95% = 3.16 ha with improved furrow and 2.53 ha traditionally.
(b) Assumed 1 kg tomato seed/ha, improved seed @ $70/kg, traditional @ $25/kg.
(c) Drip & improved furrow – 5 bags urea @ $11 and 5 bags DAP @ $20. Traditional – 5 bags urea and 2.5 bags DAP.
(d) Tubewell pump assumed directly connected to drip system, so no booster pump is required.
(e) For improved furrow, land leveling is required.

# Annex A: Farm Size Distribution In Afghanistan

The table below shows that land distribution in Afghanistan is quite skewed. On the one hand, it is characterized by small holdings – Farms with irrigated land manage an average of 3.24 Ha under irrigation. Nearly 70% of the farms have less than 5 hectares and typically control 1.14 hectares of irrigated land and 0.5 hectares of rain-fed land. On the other hand, there is a significant concentration of land in the larger farm-size groups. A mere 6.5% of the farms, with area over 20 hectares of arable land, control about 33% of the irrigated land. *29% of the farms have 5 ha or more of irrigated land, and these farms control fully 70% of the irrigated land in Afghanistan.* Such farms have sufficient land to install 1 ha or more of orchards. These are the potential early adopters of drip irrigation, and later smaller farmers will follow their example.

**Table A.1: Distribution of Irrigated Land in Afghanistan**

| Farm Size, ha | % of Farms | % of land |
|---|---|---|
| 50+ | 1% | 15% |
| 20-49.9 | 5% | 19% |
| 10-19.9 | 9% | 18% |
| 5-9.99 | 14% | 18% |
| 2-4.99 | 26% | 19% |
| 1-1.99 | 19% | 7% |
| 0.50-0.99 | 12% | 2% |
| Below 0.50 | 14% | 2% |
| Total | 100% | 100% |
| Total, over 5 ha | 29% | 70% |

Source: "Agriculture and Food Production in post-war Afghanistan", a report of the Winter Agricultural Surveys 2003, by Hector Maletta and Raphy Favre

## Annex B: Methodology Of The Feasibility Analysis

For an investment in a drip irrigation system, which normally takes several years to recuperate, the most appropriate method of economic analysis is the *Internal Rate of Return (IRR)*, for the reasons discussed in the following.

Various methods exist to measure the economic feasibility of investment, notably:

1. **The Benefit/Cost Ratio (B/C ratio):** The total revenue is divided by the total cost to yield a ratio, for example 2:1. This method is most effective for investments that are consumed within one year, such as seeds, fertilizers and pesticides. A benefit/cost ratio of 2:1 means that for each extra dollar spent on fertilizer, the farmer will get two extra dollars of revenue. When the costs and benefits occur over several years, they are reduced (discounted) to year 1 by using a *discount factor*, which represents the value of capital in the economy.

The B/C ratio is the best method for calculating the profitability of an investment which is consumed in one year or less. Its disadvantage for multi-annual investments is that it can be easily manipulated by advocates of a particular investment to hoodwink people unfamiliar with economic analysis; it creates the impression that any investment with a cost-benefit ratio larger than 1:1 is profitable and should be undertaken. Furthermore it can make almost any investment seem profitable, by assuming a sufficiently low discount factor and hiding that assumption.

2. **The Payback Period:** This method calculates the number of years necessary to recuperate the investment. For example, if an investment of $25,000 yields an additional net income of $10,000 per year (including the first year), then the payback period is 25,000/10,000 = 2.5 years.

This is a rough-and-ready measure, easily comprehended by businessmen who are not used to economic analysis. Its disadvantage is that *it does not measure the value of time:* a revenue of $10,000 in year 3 is worth less than a revenue of $10,000 in year 1. Thus *this method always under-estimates the true payback period, by an unknown amount.* At best, it gives a quick intuitive idea of whether a proposed investment is worth analyzing by more accurate methods.

3. **The Return on Investment (ROI):** Suppose an initial investment of $100,000 gives in a certain year a net revenue of $20,000; then the ROI in that year is 20%.

   This is a useful measure for annual reports, to inform investors of how profitable was their investment *in that year*. It is also appropriate e.g. to show return on installing a new machine or computer, *if the benefits start immediately and are equal in all years*. However it is not appropriate calculating e.g. the profitability of an orchard, where the benefits start only after several years and have dissimilar values in different years.

4. **The Net Present Value (NPV):** In this method, the net revenues in various years *(the revenue stream)* are reduced *(discounted)* to the first year by use of a *discount factor*, which is chosen to represent the value of capital in the country's economy. For example, if the *discount factor* is chosen as 15%, then a revenue of $1000 in year 2 is worth only $1000/(1+0.15) = $870 in year 1; a revenue of $1000 in year 3 is worth only $1000/(1+0.15)^2 = $756 in year 1; and so on. If the investment costs occur over several years, they are similarly discounted to the first year.

One disadvantage of the NPV is that *the resulting value critically depends on the choice of the discount factor*. In practice, this choice is rather arbitrary. As a real example, RAMP calculated the NPV of 1 ha of apricots to be $6,405 at a discount factor of 15%. *At a discount factor of 30%, the NPV of this investment is actually negative – minus $451.*

The major disadvantage of the NPV method is that it results in a *number*, not a *ratio*. In the above example, at a discount factor of 15% the NPV of an apricot orchard was calculated to be $6,405. We have *no* idea whether an NPV of $6,405 is good or poor – not even if we compare it with the NPVs of other investment opportunities, since they would likely require different amounts of investment, and of course the larger the investment, the larger the NPV.

5. **The Internal Rate of Return (IRR):** In this method, we calculate the *net revenue* of the investment in every year (gross revenue minus expenses and investment), to get the *revenue stream* for the useful life of the investment. The investment in the first year or years is entered as negative revenue. Thus the revenue stream is typically negative in the first few years and positive later. Next, we apply different discount factors until we find by trial and error *the discount factor which makes the present value of the revenue stream equal to zero. This is the internal rate of return.*

   The advantage of the IRR is that *it does not depend on the application of an arbitrary discount factor – it is "internal" to that particular investment.* The second advantage is that it gives us an immediate appreciation of the profitability of that investment, without comparing it with other opportunities: for example, an IRR of 70% represents a spectacular investment.

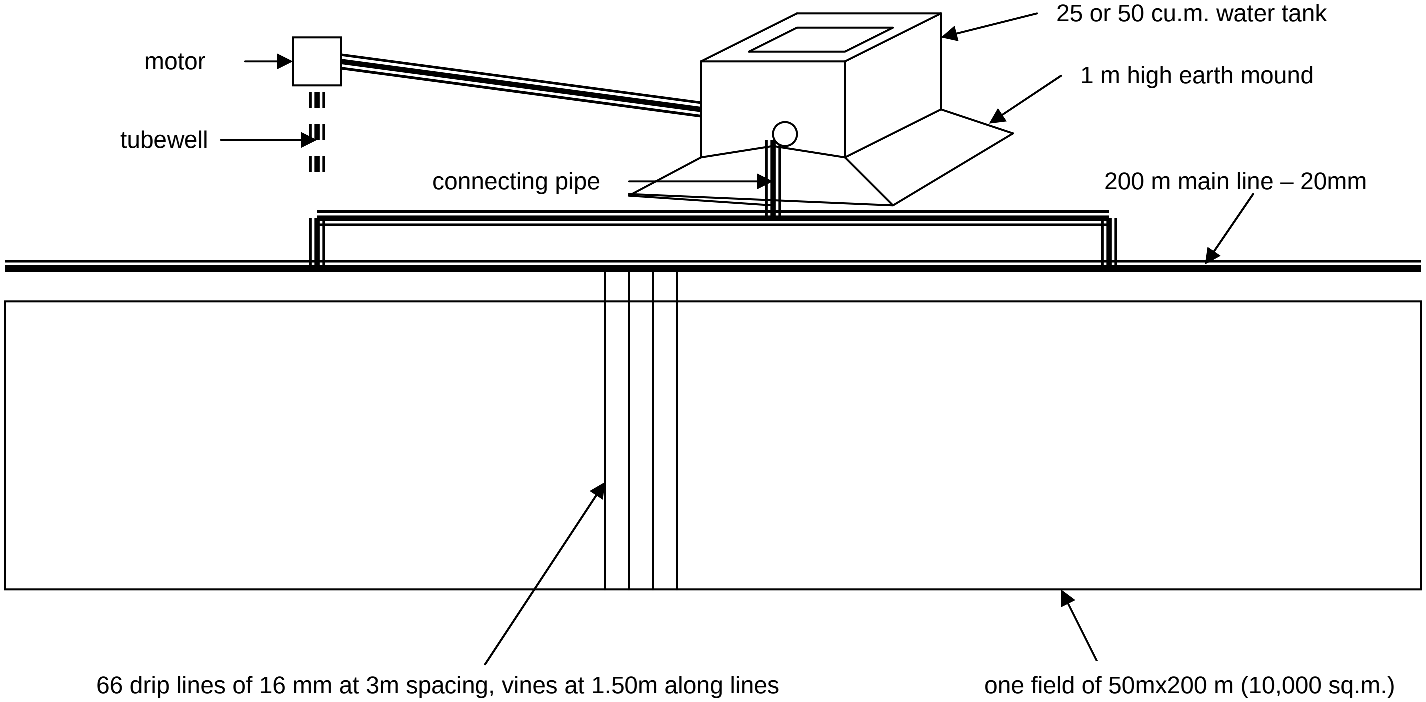
   Therefore the IRR is the best method for evaluating the profitability of a multi-annual investment, which is the reason it is extensively used by the World Bank and regional development banks, as well as by venture capital firms. By definition, it is not applicable for an investment which is consumed in less than one year – in that case we use the Benefit/Cost Ratio or the Payback Period.

   There are two situations – both encountered in the present study – where the IRR cannot be calculated. One is when the revenue stream is positive in all years – i.e. the investment pays for itself in the first year and keeps on yielding benefits later. This is clearly a very good investment, and the inverse of the Payback Period shows how many times the investment pays for itself in the first year alone. The second situation is when the revenue stream is negative in all years, or its sum over the useful life of the investment is negative. Such an investment opportunity is clearly a "black hole for money" and from an economic point of view should not be undertaken.

Nevertheless, the disadvantage of *any* purely economic method of calculating profitability is that it unduly underestimates long-term benefits. There *are* classes of investors that are interested in long-term benefits rather than immediate gain. For example, parents are often interested in "leaving something" for their children rather than in immediate benefits, and thus often plant fruit trees of which only their children may benefit. In fact, *the very word for "investment" in Arabic and Farsi is "istismâr", meaning "planting fruit trees".*

# Annex C: Proposed Gravity-Drip System For A 1-Ha Vineyard

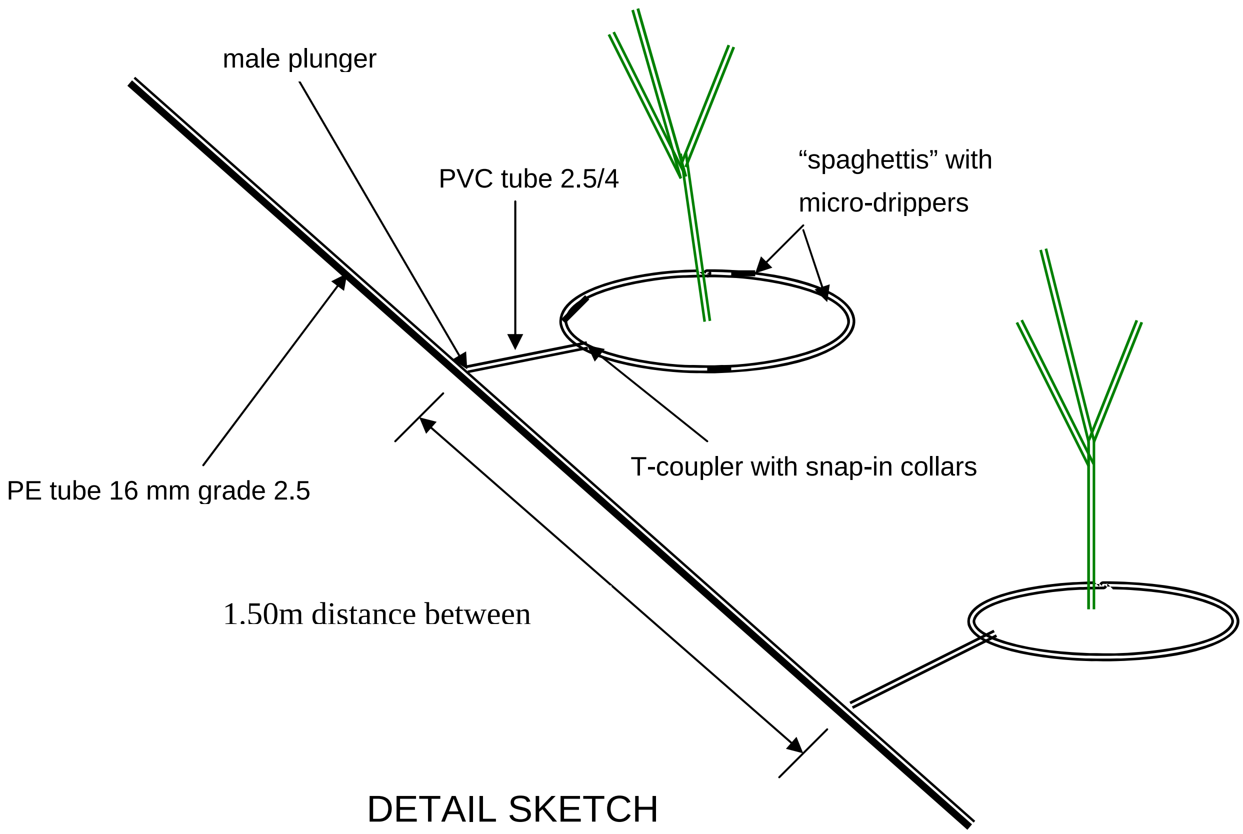
(not to scale)




## PRICE LIST

**For 1 Hectare**

| | Quantity | | Unit Price | Total | Year 1 | Year 3 | Year 5 |
|---|---|---|---|---|---|---|---|
| 25 cu.m. tank (cement blocks) | 1 | unit | | $500.00 | $500.00 | | |
| 7x7x1m earth mound (50 cu.m.) | 50 | cu.m. | $4.00 | $200.00 | $200.00 | | |
| Compaction of 50 cu.m. | 50 | cu.m. | $2.00 | $100.00 | $100.00 | | |
| Gravity Super Disk Filter | 1 | unit | $18.00 | $18.00 | $18.00 | | |
| Main valve | 2 | unit | $4.00 | $8.00 | $8.00 | | |
| PE tube 20 mm | 320 | m | $0.14 | $44.80 | $44.80 | | |
| PE tube 16 mm grade 2.5 | 3,350 | m | $0.11 | $368.50 | $368.50 | | |
| Tooth coupler T 20X16 mm | 130 | units | $0.18 | $23.40 | $23.40 | | |
| Elbow tooth coupler 20X16 mm | 3 | units | $0.18 | $0.54 | $0.54 | | |
| Spaghetti w/dripper , 2220 x 6 | 13,320 | units | $0.09 | $1198.80 | $599.40 | $399.60 | $199.80 |
| P.E Tube 3/4 | 0 | m | $0.04 | $0.00 | $0.00 | | |
| male plunger | 2,220 | units | $0.02 | $44.40 | $44.40 | | |
| T connector | 2,220 | units | $0.09 | $199.80 | $199.80 | | |
| PVC tube, 2.5/4 | 2,220 | m | $0.05 | $111.00 | $111.00 | | |
| snap-in collar | 4,440 | units | $0.04 | $177.60 | $177.60 | | |
| saddle coupler | 0 | units | $0.05 | $0.00 | $0.00 | | |
| **Total** | | | | **$2994.84** | **$2396.44** | **$399.60** | **$199.80** |




DETAIL SKETCH