Integrated Snow and Water Harvesting and Low-Cost Irrigation

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Introduction

Precipitation in the form of rain or snow is a fundamental component of all mountain farming systems. Its management dictates the extent not only of crop yield and biomass cover, but also of the availability of drinking water for humans and livestock, irrigation patterns, flooding frequency, and soil quality.

Rationale and Relevance

Harvesting precipitation involves the collection, concentration and storage of both rain and snow from various sources. The harvesting of rainwater and snow can provide water for regions where other sources are far away or too costly to provide, or where other methods of water collection are impractical because of unfavourable geology or the high costs involved. Rain water and snow harvesting are possible in areas which receive as little as 50-80 millimetres (mm) of rainfall. In Afghanistan, rainfall varies from less than 100 mm to over 900 mm (FAO Country Profile, Afghanistan), with more than 50% of the territory in rain shadow areas receiving less than 300 mm of rain per annum. (Arid regions are regions with less than 250 mm of mean annual precipitation. Semi-arid regions, by the same general classification, receive 250-500 mm of annual rainfall). Harvesting all forms of precipitation is therefore crucial for a range of livelihood strategies especially requiring water, for example for irrigation purposes and for drinking water.

Because of its diverse topography, there are enormous differences in climate and precipitation levels within Afghanistan. The mountains provide a substantial proportion of the water necessary for agriculture, power, and human consumption throughout the country. The bulk of water originating from mountains derive from melt snow and its efficient management. This is a crucial component of farming systems, livelihood strategies, and disaster mitigation in Afghanistan. In the lower regions, higher amounts of rain occur, increasing the potential for the harvesting and utilising rainwater.

Available Technology Systems

This paper presents three precipitation management options: 1) rainwater harvesting and management, 2) snow harvesting, and 3) water-saving, low-cost micro-irrigation methods that can be adapted to different climatic conditions in the country.

Rain water harvesting and management

(Suitable for lower, rainfed regions)

Benefits of rainwater harvesting

- Improved availability of water for drinking and irrigation
- Increased water availability during the dry season
- Encouraging better sanitation through adequate supply and use of water, which translates to improved health
- As water is available near the house, reduction in time and drudgery in fetching water
- Reduced downstream flooding and downstream siltation

Method

A rain/runoff water harvesting system comprises the following sub-systems: a) catchment, b) conveyance, c) filtration, d) storage, and e) distribution (Figure 1).

a. Catchment sub-system

The roofs of houses are the most common catchments for rainwater. Therefore the selection of roofing materials should be done carefully to avoid lead and asbestos poisoning if collecting rainwater from roof for drinking purposes. Rainwater should also be intercepted before it reaches the ground to avoid contamination.

For irrigation purposes, catchment types like roads and landscape can be used for catching water either in its natural or treated state to increase run-off. Reshaping the soil surface, sealing the surface with chemicals, covering the surface with stones, and use of hydrophobic chemicals and water proof membranes are some of the examples of catchment treatment (FAO 1987).

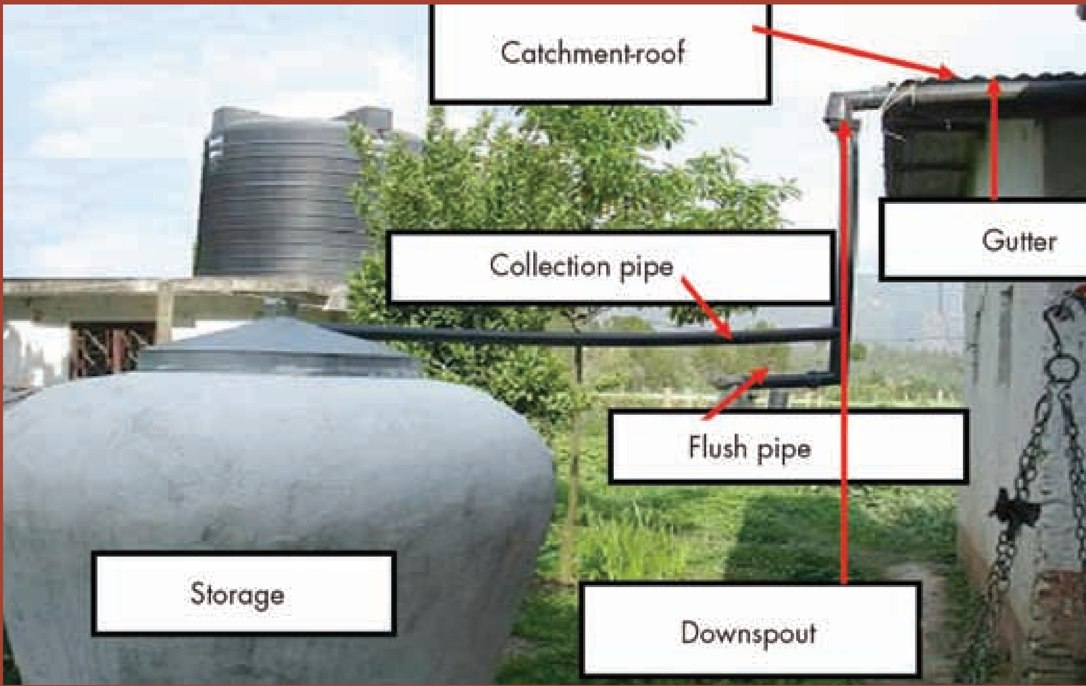
b. Conveyance sub-system

Simple improvised gutters, downspouts, and pipes are the conveyance systems for roof rainwater harvesting for drinking purposes. For irrigation, trenches lined with grass, stone, and cement can be used. They convey the runoff from catchment to storage sub-system.

c. Filtration sub-system

For household purposes, the first wash of water over the roof should be discarded because of their dirt, debris, leaves, and other contaminants that accumulate on the roofs. A simple net can be put

Figure 1: **Roof rainwater harvesting system in Nepal**



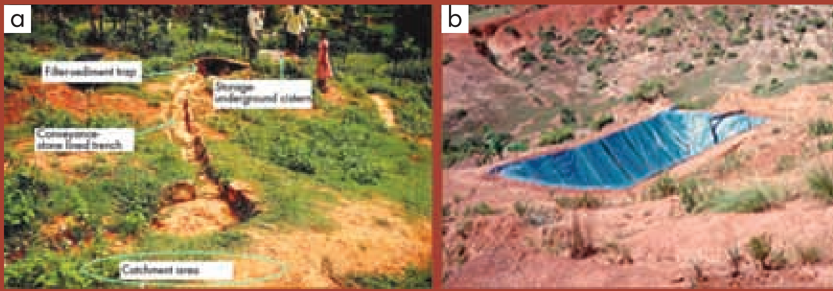
at the inlet of the storage to avoid the entry of insects. For irrigation purposes, pre-filter to keep out sediment build-up if the sediments cannot be easily removed from the storage sub-system. Sedimentation chambers before the storage can be made to filter sediments entering the storage.

d. Storage

For drinking water, any material can be used for storage. The water storage material should be air-tight, made of non-toxic material, and big enough to contain sufficient supply. Jars, barrels, tanks, or even drums can be used. The size of the storage should depend on the amount and frequency of rainfall, catchment available, as well as the demand for water. Cover the stored water to control evaporation and guard against contamination.

For irrigation purposes, structures like ponds, small earth dams, underground cisterns, and so forth, can be used as storage (Figures 2a and 2b). The size of storage should depend on the amount of rainfall/runoff amount and its frequency, the catchment available, as well as the demand for watering crops. Losses from evaporation and seepage should be considered when selecting the type of storage.

Figure 2: **Water storage in (a) an underground cistern, and (b) a plastic lined pond.**



Box 1: **Rain water harvesting with eyebrow pits**

Moisture stress is a major constraint for vegetation in drier sites. Eyebrow-pitting is an option for harvesting rainwater and improving infiltration, and hence improving soil moisture. Eyebrow pitting has been tested for rehabilitating degraded dry lands and the result has been very encouraging.

Eyebrow-pitting in degraded land in Nepal

Distribution

On a small household level, collected rainwater for drinking purposes is generally distributed through a tap. For irrigation purposes, collected water in any type of storage should be used efficiently.

Required resources

Construction material according to locally available materials (e.g. drums, plastic sheets, pipes, others)
Skilled labour

Snow management and harvesting in mountainous regions

Precipitation in the form of snow, as it falls, flows, and percolates through the soil, is as much a socio-political issue as it is an environmental, economic, and agricultural resource. Snow trapping is therefore not simply a physical intervention, but occurs in the context of broader land ownership issues, sustainable management, and productive need, and must incorporate in its implementation an appreciation for the various dimensions which exist between upper and lower catchments.

Box 2: **System of rice intensification as a potential option of water management**

The system of rice intensification (SRI) is a method of increasing the productivity of irrigated rice by changing the management of plants, soil, water, and nutrients. SRI practices contribute to both healthier soil and plants supported by greater root growth and the nurturing of soil microbial abundance and diversity.

In SRI management practices, rice seedlings are transplanted in the following way: very young - usually just 8-12 day-old seedlings, with only two small leaves carefully and quickly transplanted causing minimum disturbances to the root. Only one seedling per hill, instead of three to four together, is planted to avoid root competition. The seedlings are kept widely spaced for better root and canopy growth. They are transplanted in a square grid pattern, 25 x 25 cm or wider – 30 x 30 cm or 40 x 40 cm, even up to 50 x 50 cm with the best quality soil.

Soil is kept moist but well drained and is aerated to support increased biological activity. Water is applied in minimum quantity during the vegetative growth period; only a thin layer of water is maintained on the field during the flowering and grain filling stage. Better quality compost such as well-decomposed farmyard manure is applied to achieve additional yield increases. Since weeds become a problem in fields that are not kept flooded, weeding is necessary at least once or twice at the beginning, 10 to 12 days after transplanting, and preferably three or four times before the canopy closes.

SRI does not require additional inputs like new seeds, chemical fertiliser or pesticides, but does require skillful management of the factors of production and, at least initially, additional labour input of between 25-50%, particularly for careful transplanting and for weeding. As farmers gain skill and confidence in SRI methods, labour input decreases and can eventually become the same or even less compared with conventional rice-growing methods.

SRI farmer in Nepal reaping good harvest even with less water

What is it?

Snow harvesting and trapping structures represent the interface between people, water, the soil, sun, and vegetation. It is the process by which water in the form of snow is 'held' within or behind biological and physical structures in order to reduce evaporation, increase the time water has to percolate through the soil, and counter the erosive effects of flowing snow melt. The process is intended to aid in the creation of biological circumstances in which the rehabilitation of high mountain upper catchments and watersheds can occur.

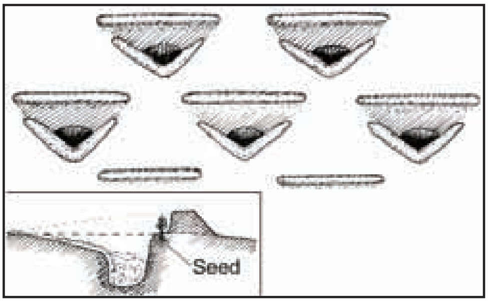
Benefits of snow management

- Snow management through snow harvesting is a tool for increasing soil moisture content and reducing erosion.
- It improves biomass cover, and
- Increases the amount of water available for agriculture and enables the off-season cultivation of crops.

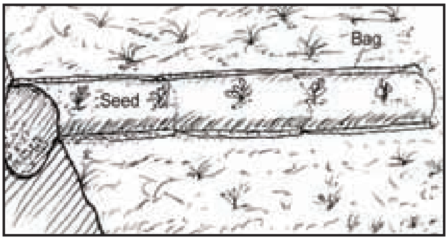
Method

A number of options for snow management are possible, both economically and physically, for the conditions of Afghanistan. These technologies are often simple adaptations of existing technologies to specific snow-bound environments, the characteristics of which include high rates of evaporation in response to sharp sunlight, shallow soil depths, high rates of rill erosion, heavy, compacted snow for extended periods, strong swirling winds, and cold temperatures.

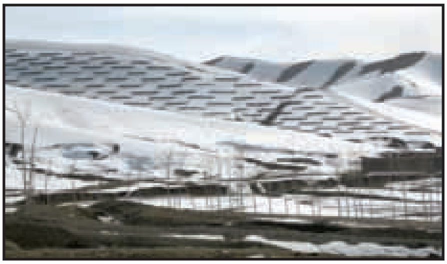
Bird bunds (Bundee parinda). These earthen structures are large pits up to a metre and a half deep topped with berms (mounds of earth usually engineered by humans to serve a specific purpose) leading to V-shaped bunds in a downward slope facing direction. The earth leading to the pit is removed to ever increasing depths so that snow can be collected in the structures' wings, and melting snow is directed to the pit. The bund and berm can then be seeded. The type of species should dictate where the seed is located.



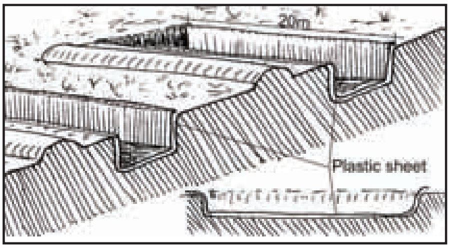
The structure in its entirety attempts both to trap snow, as well as provide shadow to the pit in the early months of spring in order to reduce evaporation. These structures are suitable for moderate slopes (5-8%).



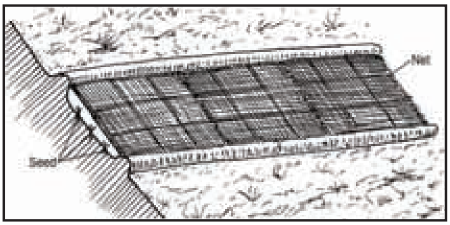
"Hesion bag bunds". This technology combines a number of elements. A trench 50-70 cm in depth running up to 20 m in length is dug along a moderate slope. The soil and gravel extracted from the trench is placed inside hesion bags and then placed back in the trench side by side. The filled bags act both as a bund reducing the flow of water and soil and increasing water percolation. The hesion bags retain moisture when the land around has become dry, thereby allowing seeds which can be placed inside, to germinate.


Snow trapping using contour trenches

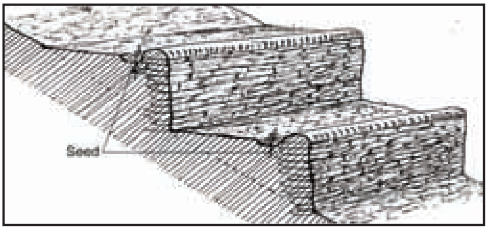
Earthen and stone V-shaped bunds. A direct derivation of the traditional bunds found in the lowlands, these structures are intended to check the movement of soil and gravel through the downward movement of melting snow and to increase the time available for water to percolate through the soil. Such bunds are usable for steep areas and are shaped into a 'V' to cushion the snow's weight as it rests across a smaller surface area. 'V' bunds also reduce the danger of uneven water settlement in the bunds that do not correspond to contours. They are a combination of the v-shaped bunds (bird bunds) and normal straight earthen and stone bunds.



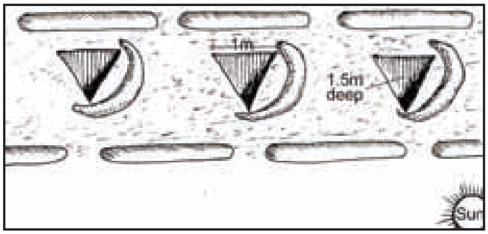
Plastic lined and non-plastic lined pits. Referred to as percolation ponds, these structures trap snow in large pits. Unlined pits or ponds facilitate the percolation of larger amounts of water through the soil though, depending on the size of the pit or pond, their surface area is such that they experience higher rates of evaporation than smaller structures. Plastic lined pits and ponds are lined with plastic to trap water and not allow it to seep through the soil. As the temperature increases, farmers are able to use the water trapped in the pit or pond for irrigation, drinking water, or for feeding livestock.



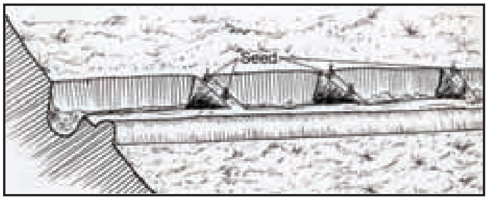
Hesion net. Seeds are sown horizontally along a slope. A series of hesion bags opened along their edges are then sewn together to form a larger net type structure and is placed over the seeds. An earthen bund is created above and below the structure to ensure that water does not pass directly under the net to wash the seeds away.



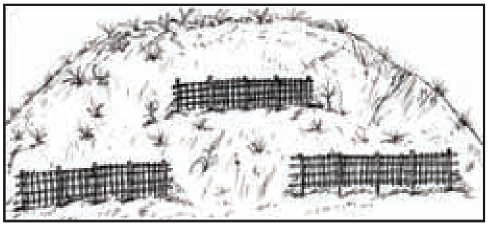
Earthen and stone bunds. These structures are found across a broad spectrum of topographical ranges where the angle of slope permits. Often proceeded particularly when trapping and harvesting snow, by a trench of corresponding length, bunds, earthen, and stone, retard the downward flow of water and increases the rates of water percolation through the soil.



Triangular pit. A triangular pit attempts to reduce the evaporative effects of the sun and wind. The pit, being triangular, exposes less of the snow trapped in the structure to evaporative elements. The shape also reduces the possibility of pit wall collapse which, depending on the soil, can characterise other pits formed in a circular or square fashion. Earth is piled on the sunny side of the structure forming a bund with a berm or mound type structure in which seeds can be placed. This structure provides further shade to trapped snow, reducing evaporation and increasing the amount of water percolation.



Compartmentalised and open trenches. The weight of snow, especially over a period of up to six months, can exert great pressure on bunds, particularly straight bunds. Excessive weight of snow can break bunds, concentrating the flow of water in specific areas and leading to further degrading the soil. To reduce the chances of this happening, earthen compartments or bunds within bunds can be added to the structure, directing the snow in sections and reducing the pressure across the length of the bund.



Brush wood structures. Made in sections one metre in length, willow branches are horizontally woven through three thick willow stems or trunks two metres high. The metre-long sections are joined to another by a one metre woven willow structure, forming a two-metre structure. The stems/ trunks are then anchored one metre to one metre and a half in the soil. (Soil type and slope angle should be carefully considered at this point as well as the amount of expected snow). This anchoring is crucial to structural stability. The structure is ideal for steep areas where other structures are not viable. They are used at the top of the watershed. The weight of snow tends to break these structures after two years if the willow stems/trunks have not started to grow in the soil. Seeds can be placed behind the structures to add both to the stability of the structure and increase biomass cover in the area. A metal mesh can also be added to the structure to give it additional strength.

When working with snow harvesting structures, a number of key elements are important to consider.

- If you trap too much water on an unstable slope you can increase the chances of a landslide and/or a land slip.
- Bunds and other similar structures must respect contours. If bunds are not straight and do not run along contours, water can form in the corners of the bund, putting pressure on the structure and increasing the chances of collapse.
- Local people know their slopes, their soil types, the flow and melt of water, and the weather patterns of their area. Their participation in the planning process is absolutely essential. No amount of hydrological data and watershed management experience can compensate for the absence of community-based ideas and understanding.
- Snow harvesting/trapping structures can be implemented anywhere in a watershed, but they are most crucial in the upper catchments. In Afghanistan, most communities live close to valley floors and are therefore far from areas where snow trapping occurs.
- Land ownership patterns must be considered. The current situation in landownership in Afghanistan is both complex and dynamic. Snow is a common resource and its harvesting and trapping and the benefits that can be derive from it must be seen as a common good for all communities in a watershed.
- While most snow harvesting/trapping structures are found in the upper catchment, they often benefit the lower catchments. It is crucial to ensure that the entire watershed is involved in the process and that issues of upper and lower catchments are discussed, understood, and agreed upon by the communities before work commences.
- Snow harvesting/ trapping can be an expensive business and, more often than not, requires much labour. It therefore involves a high investment for communities. Issues of management beyond the time of the project must be dealt with before work even starts.

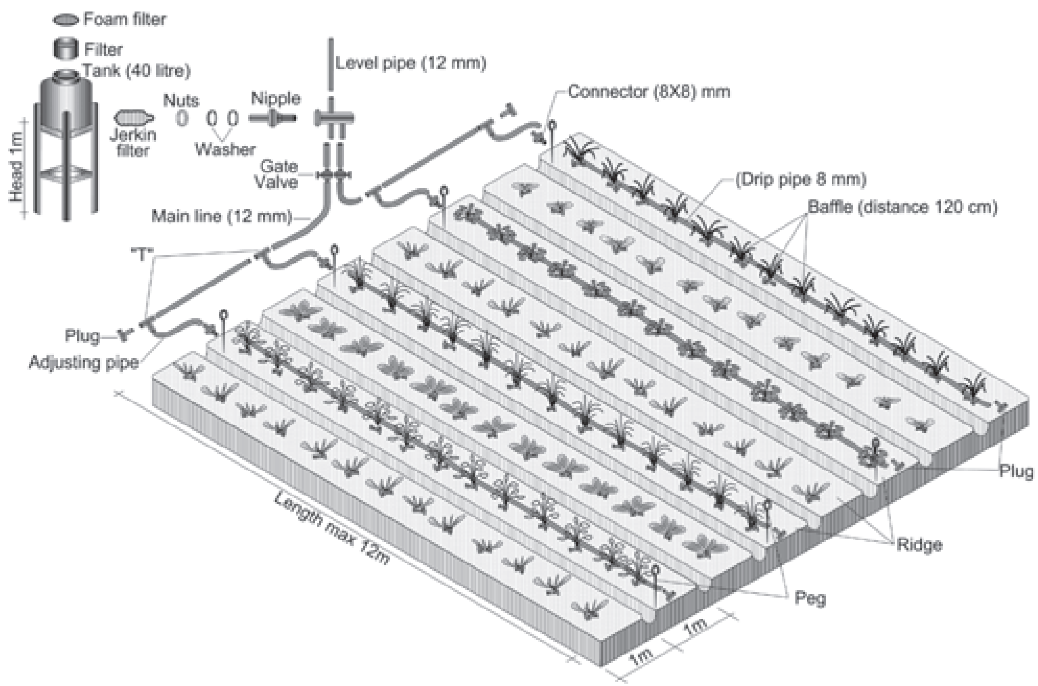
Required resources

- Skilled labour
- Snow
- Willow/poplar trees
- An understanding of resource dynamics
- Local seeds
- Hesion bags
- Metal wire

Technologies for efficient use of harvested water

Irrigation is practiced at all altitudes in Afghanistan. Various traditional technologies exist deriving water from rainwater and snow melt. Some of these technologies, however, can be enhanced using the following techniques including low-cost micro irrigation systems.

Figure 3: **Sketch of a drip irrigation system**



IDE Nepal promoted low-cost drip irrigation systems in Nepa

Drip irrigation

Drip irrigation, also known as trickle irrigation, is an irrigation method that applies water slowly to the roots of plants by depositing the water either on the soil's surface, or directly to the plant's root zone through a network of valves, pipes, tubings, and emitters (Figure 3).

Benefits of drip irrigation

- Delivers water slowly and precisely to the plant
- Enhances photosynthesis by maintaining consistent moisture in the soil
- Reduces water losses caused by evaporation, percolation, and distribution

- Saves considerable amount of water and labour compared to bucket irrigation
- Enables early fruiting and production of seasonal and off-season vegetables, thus enabling farmers to fetch better prices for these early or off-season agricultural products
- Provides opportunities for cultivating fallow land in water scarce areas
- Reduces disease in crops due to reduced water contact with crop leaves, stems, and fruits. Less weeds grow in drip plots because only the plants and not the surrounding areas are watered
- Water-soluble fertilisers can be applied more efficiently with drip irrigation

Limitations of drip irrigation

- May not function well in areas with sediment-loaded water
- Requires frequent cleaning of blockages in areas

Methods

There are generally two types of drip irrigation systems: surface and sub-surface. When a drip tube is laid on the soil's surface, this is called surface drip irrigation; if drip tube is buried below the soil's surface it is called sub-surface drip irrigation.

The surface drip irrigation system designed by the International Development Enterprise (IDE) in Nepal includes a plastic container and weather-proof lateral pipes with discharge holes or emitters at certain intervals.

- Each hole is supplied with baffles to ensure regular water dripping to the root zone of the plants
- Lateral pipes are connected to the container with joint pipes
- Water is dripped to the root zone from emitters at low rates of 2.5 litre/hr.

How to set up drip irrigation systems

- Drip irrigation sets are installed while the fields are being prepared by ploughing, levelling, and ridging, if necessary.
- Twelve metre (12 m) long lateral pipes are laid 1.5 m apart. At the same time a wooden platform (minimum 1 m height) with a storage tank is installed and connected to the lateral pipes.
- After the lateral pipes are laid out, planting holes are dug and spaced to coincide with the drip holes. These holes are usually set every 0.6 or 1.2 m along the pipes and depend on the crop type.
- Fertiliser and farmyard manure are placed in each pit and mixed with the soil.
- Vegetable seedlings are then planted in each hole and daily drip watering begins.

The set is available in different capacities as illustrated in table 1.

Table 1: **Size, capacity, and cost of drip irrigation system**

Size	Irrigation area	Number of lateral lines	Number of drippers	Cost (in US$ in 2006)
Small	125 m^2	4	80	17
Medium	250 m^2	8	160	30
Large	500 m^2	16	320	57

Drip irrigation is advisable or ideal in conditions where:

- water is scarce or expensive
- the soil is porous or too impervious or impenetrable for gravity irrigation, flood or furrow
- it is too windy for sprinkler irrigation
- irrigation labour is expensive or not available

This system can be used mainly on level ground to grow most kinds of crops that are not closely cropped.

Required resources

- Drip set and skilled labour to set it up
- Micro-credit facilities for poor farmers to be able to afford the technology

Pitcher irrigation

Pitcher irrigation is a traditional water saving and efficient irrigation system. The technology allows agricultural and horticulture development in areas where climatic conditions, the quality of the soils, and water scarcity have prevented the use of conventional irrigation methods.

The technology is suitable in arid and semi-arid regions, and for small-scale agricultural projects in areas affected by periodic drought. In its simplest form, pitcher irrigation entails burying an unglazed, porous clay pot next to a seedling. Water is poured into pots, and then seeps slowly into the soil, feeding the seedling's roots with a steady supply of moisture (Figure 4).

Benefits of pitcher irrigation

- A simple, low-cost, labour-saving, and easy to operate and maintain technology
- Reduces infiltration and evaporation losses through the pitcher
- Reduces fertiliser use by allowing application to defined, cultivated areas
- The technology reduces soil erosion

Figure 4: **Pitcher irrigation and pitcher filled with water.**

Source: Pakissan, http://www.pakissan.com

Methods

Pitcher irrigation consists, in its simplest form, of unglazed baked earthen pitchers, buried to their neck in the soil and filled with water. The water gradually seeps out through the porous walls into the root zone under hydrostatic pressure and/or suction to maintain plant growth around the pitchers.

In sandy soils there is the risk that the water will drain out of the pitcher very rapidly. Adaptive methods have to be used to cover the inner pitcher layer with cotton.

Required resources

- Earthen pitcher, cotton layer if applicable

Sprinkler irrigation

Micro-sprinkler irrigation is an efficient alternative method of watering cash crops if water is readily available. In Afghanistan, they are most suitable for cultivating vegetables in greenhouses.

For further reading

FAO (1987) 'Soil and water conservation in semi arid areas' in *FAO Soils Bulletins*, page 57

FAO (2008) 'Country profile and mapping information system for Afghanistan' http://www.fao.org/countryprofiles/Maps/AFG/06/pp/index.html.

Kerr, J; Pangare, G (2001) *Water harvesting and watershed management*, http://www.ifpri.org/2020/focus/focus09/focus09_09.htm.