CHAPTER 8

Alternative Methods of Irrigation Application

THE NEED FOR ALTERNATIVES

Sprinkler, drip and trickle methods of field irrigation application are common alternatives to flood, furrow and border irrigation. They have the advantage of higher field application efficiency than the common alternatives mentioned. When irrigable land is abundant and the water supply is limited, a water conserving method of application may be the best option.

Frequently, however, it is the cost of accessing the irrigation supply rather than the quantity that is the determining factor in choosing the field application method. When diversion and delivery by gravity flow are prohibitively expensive to develop or maintain, or when the only available water source is at an elevation lower than the fields to be irrigated, the water must be pumped.

Energy expended for pumping is directly proportional to both the height and the discharge rate of the water pumped. There are situations where water can be pumped from rivers onto lowlying river terraces. The lift in such cases may be in the same range as pumping groundwater with comparable costs. In many cases, however, hilly and mountainous areas require higher lifts to reach irrigable areas with higher associated costs.

All forms of irrigation delivery have an associated cost and are often subsidized. However, the cost of energy for pumping is easily identified as an operating expense and national policies frequently require the irrigator to pay for all or a substantial part of this cost. A frequent outcome of the high energy cost for pumped irrigation is for farmers to abandon the irrigation system when the returns do not cover the costs. The design capacity of many lift irrigation schemes in Nepal and north India is underutilized for this reason. Unless the delivery cost is highly subsidized when water is pumped in mountainous areas, growing a water-intensive crop such as rice or a crop with low market value such as wheat, can seldom be justified. The alternatives are to turn to high-value crops and to find more efficient means for field application of water.

Sprinkler irrigation allows controlled water application to sloping fields. This overcomes the problem of erosion from water application by most surface methods which often require extensive and costly terracing. However, since the area irrigated in mountainous regions by sprinkler and alternative field application systems is small, little systematic research and development effort has been made by government agencies to improve the cost-effectiveness and reliability of these alternatives.

LIMITATIONS OF ALTERNATIVE IRRIGATION APPLICATION METHODS

Example 8.4 illustrates a typical problem that irrigation agencies face. A reliable water source was too low to be effectively utilized by diversion and gravity distribution. A lift scheme was implemented based on the expectation that a high-value citrus crop would be irrigated and that it would pay for the expensive irrigation water. When the citrus crop did not succeed, farmers turned to irrigating subsistence crops which cannot be economically justified. The dilemma for the irrigation agency is whether to abandon its investment of several million dollars or to continue to subsidize the use of the system for crops that do not pay the cost of operation.

When farmers have been subsistence-oriented for generations and have virtually no margin for error in making cropping decisions or taking risks with new ventures, moving to high-value cash crops is a slow process. Transportation and communication infrastructures must be in place but they are not sufficient prerequisites; a steady market and culturally acceptable conditions for interaction are equally important. The transition to high-value crops and efficient water-conserving methods of applying irrigation water to fields are most likely to happen under conditions where various components of the necessary changes can be implemented and tested separately.

Example 8.1 is a good illustration of incremental change. Gravity diversion and conveyance remain a part of the systems described in the examples, so pumping is not necessary. Traditional crops such as maize and alfalfa can be irrigated, though, with more frequent application and less water per irrigation. It is only the final distributions, pipe instead of open channels down the slope, and field application by sprinkler instead of flooding, that are changed. While success is still not assured in the community pilot scheme described, the potential clearly has the younger farmers in the community interested.

RESEARCH AND DEVELOPMENT NEEDED

Sprinkle, trickle and drip irrigation technologies are highly developed. Abundant literature is available about these technologies, including procedures for system design. However, it is the type of innovation illustrated by Example 8.1 that is lacking. Farmers with small holdings and whose land is often situated on the marginal slopes in the mountains often cannot afford available off-the-shelf technology. They want to start with the lowest possible cash expenditure until the technology is proven. Using a strainer fashioned from a milk tin (with perforations made using a nail) is a good example of using available low-cost local resources.

More work is needed to develop reliable, effective, low-cost drip and trickle emitter devices as was done for the sprinkler head described in Example 8.1. Low-cost methods are needed to overcome the problem of emitters clogging with physical, biological or chemical contaminants.

The pipe distribution system necessary to use sprinkler or drip systems is very similar to the rural drinking water systems being installed in many mountain communities. A great deal of effort has been put into developing handbooks on installation and maintenance and manuals for drinking water systems. This material needs to be adapted and made available to irrigators who could use the same technology and techniques.

In Nepal, the Agricultural Development Bank has promoted sprinkler irrigation development. Credit available through small farmer groups has been an important factor in the success of this undertaking. In addition to developing cost-effective hardware options, more effort is necessary for solving agronomic problems faced by small farmers who must modify their cropping pattern after they pipe minor sources of water to small plots of land.

Example 8.1

The Ccochawasi and Ccorao KARPAY Sprinkler Irrigation Systems, Cusco, Peru

Manuel Chavez,[62] Lino Chavez[63] and Alfons Broeks[64]

Goal: *To increase the application efficiency, in a region where water is very scarce, and to make it possible to use small springs for irrigation and to increase the land production potential.*

The Setting

This example describes an alternative-technology-based sprinkler irrigation system. It includes all elements of a physical irrigation system such as water capture, conveyance, distribution and field application. It is called "KARPAY" because that is the word used in the Quechua language for irrigation.

The innovative aspects of this example concern the water application sprinkler. It uses the hydraulic pressure of the height between the sprinkler head in the irrigated area and the distribution point where water enters the pressure pipe.

The reasons for developing the KARPAY System emerged from the general circumstances in large areas of the Andes of Peru:

- There is little water available to meet the high demand for irrigation.
- There are serious erosion problems with conventional irrigation conveyance and field application methods in areas with steep gradients, while population pressure pushes the agricultural frontier on to steeper mountain slopes.
- High production potential results from increasing irrigation frequencies from one or two heavy applications to frequent light applications.
- Sprinkler irrigation can be used to reduce frost as well as drought risk by increasing air humidity.
- Because credit and income levels are low, a cheap but effective system for irrigation delivery was needed.

The sprinkler head has been patented and is accepted in patent registers in the USA, Spain and Japan. Although production facilities are not optimized, the most important reason for seeking a patent was to protect the KARPAY sprinkler against low-quality copies that would cause loss of confidence of this approach to irrigation before it is proven.

In Ccochawasi, the sprinkler system replaced controlled flooding and furrow irrigation. Ccochawasi is a farm whose owner maintains relations with the neighboring indigenous farming community by exchanging animal traction, plows, labor, agricultural inputs and this new sprinkler technology. Ccorao is a pilot sprinkler irrigation project which is financed by the German-Peruvian Development Project Plan MERISS.

Both are located in the Ccorao Subbasin of the Vilcanota River near Pisaq, Department of Cusco, Inka Region, Peru. The altitude is about 3,500 m,

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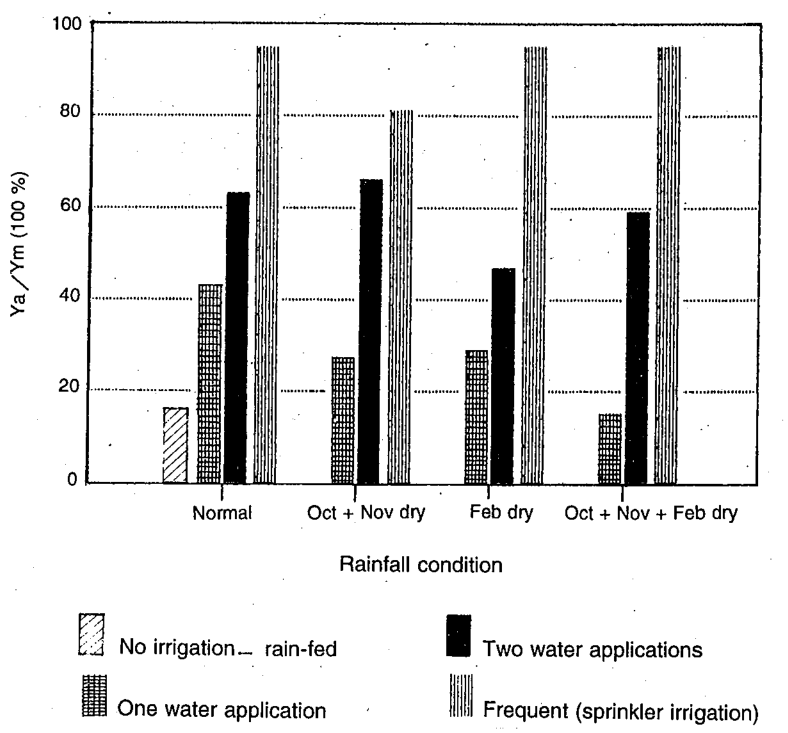
with a minimum temperature of -8° C and a maximum of 18° C. There are two clearly defined seasons. Summertime is from September to March with a medium rainfall of 750 mm: wintertime is from May to August without rain except for a few light showers. There are ten hours of sunshine per day in the winter with frequent frost at night. Rainfall is irregular within the year and also between years. Every three to five years there is a period of drought, which affects crop production.

The majority of the population are farmers with small landholdings of 0.5 to 2 ha. The farmers do not have property titles. The Farmer Community (Comunidad Campesina) is the legal proprietor of all resources in their territory. The Farmer Community Law was instituted to protect small indigenous farmers. In Ccorao, there are 200 farm families. Land parcels are allocated to the cultivator as if they were personal property. There is also communal land in Ccorao. Due to the low level of mechanization, labor availability is a limitation in working the communal land.

Figure 8.1.1. Yield response of maize to different irrigation treatments.



Due to the area's accessibility by asphalt road, part of the production is sold in the market of Cusco about 20 km away. Production for subsistence continues to be of fundamental importance but the sale of produce is also a significant part of the household economy.

The traditional irrigation practice is to provide one or two irrigations for land preparation. The first, in the period from May to July, and the next between August and November. This allows early maize planting so that the crop will mature and can be harvested before the frosts of May. Another important purpose of early irrigation is to enable the farmer to use his labor within these months. Without irrigation the soil is dry and hard, making it impossible to do land preparation.

All decisions about the crop schedule are made exclusively by the farm families. Potato, maize, and great bean are the crops planted and irrigated in the dry period. In the Ccorao Valley, maize is primarily grown in the valley bottom and is planted in August or September: potatoes are planted in September and October: the great bean is planted in July. Onion, barley, wheat and some potatoes are marketed.

Figure 8.1.1 illustrates the relationship of maize yield to different irrigation treatments: rain-fed without irrigation, traditional irrigation with one and/or two water applications, and yield with sprinkler irrigation. The treatments were repeated for the following four rainfall conditions: 1) normal precipitation, 2) a dry October and November and rest of the year normal, 3) a little rain in February and rest of the year normal, 4) both October-November and February dry. The beneficial effect of light but sustained sprinkler irrigation is evident.

The Ccochawasi Irrigation System

The Ccochawasi farm changed to sprinkler irrigation when its main water source was withdrawn by the neighboring communities when they improved their irrigation system. The farm is negotiating with these irrigation committees to maintain some access to their water. In the meantime, an agreement has been reached with the Kallarrayan community on the other side of the valley for the use of a spring with a discharge of 0.5 l/s. The Kallarrayan community uses the spring only in the month of August. With this water, about 1 ha of alfalfa or 2 ha of onion are grown in the dry period (Figure 8.1.2). In Ccochawasi, maintenance and irrigation are done by the landowner. Even his ten-year old children can operate the system because it is easy to manage.

The water source is a small permanent spring with a minimum discharge of 0.5 l/s. The discharge increases slightly in the rainy period. The spring is located on a rocky slope with a gradient of more than 100 percent. A small earthen canal leads the water to a simple inlet reservoir. A pipe connects to the reservoir and takes part of the water to the fields not irrigated by the primary pipe. The canal continues further down the valley to the point where the primary pressure pipe is connected. Heavy rains once caused breaching and serious erosion along this segment of canal.

Figure 8.1.2. Sprinkler-irrigated alfalfa field.

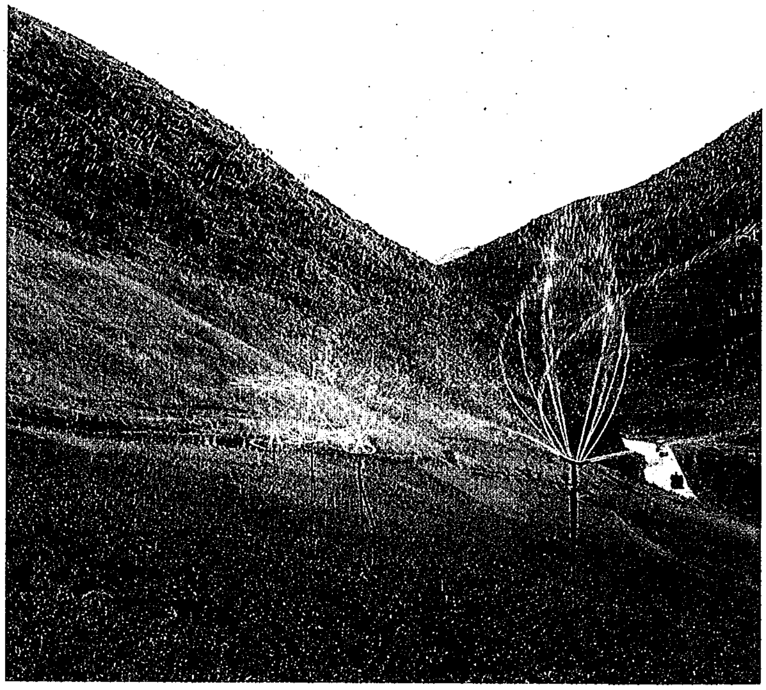


Photo by KARPAY Working Group.

From the main canal the water is piped across the valley to fill a night-storage reservoir (Figure 8.1.3). The difference in elevation between the inlet-reservoir and night-storage reservoir is about 16 m. The difference in elevation between the night-storage reservoir and the command area is about 20 m. This gives about 8 m of dynamic hydraulic pressure on the sprinklers during full-flow conditions. The primary pipe is completely buried in the ground. To cross the asphalt road, the pipe passes under a bridge.

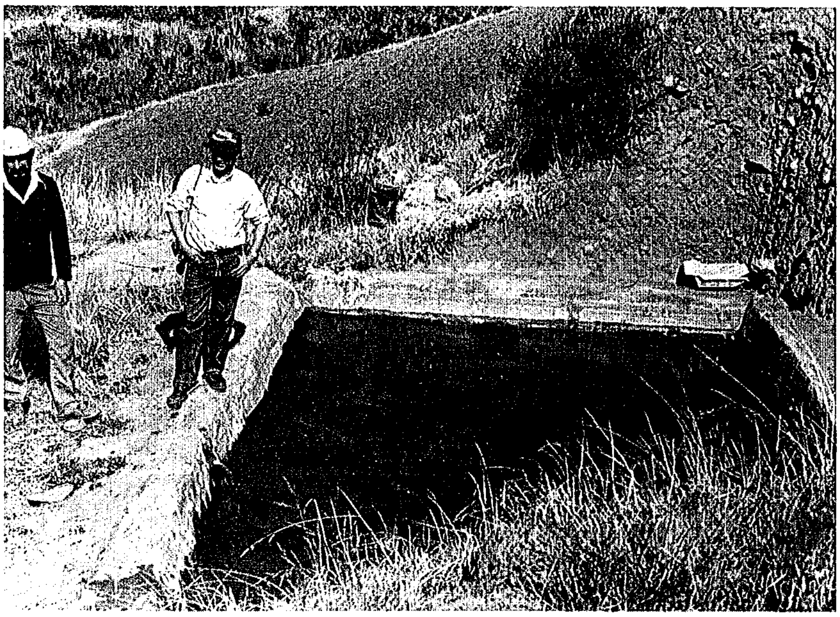


Photo by KARPAY Working Group.

Figure 8.1.3. The night-storage reservoir just above the command area.

The Ccorao Irrigation System

Ccorao was chosen for a pilot sprinkler project for the following reasons:

- Since it did not have a significant traditional irrigation culture, introduction of a new system would not disturb existing agricultural practices or water distribution rules.
- The inventor of the alternative sprinkler who is a Ccochawasi landholder and a member of the KARPAY working group, is also a part-time teacher at Ccorao Secondary School and he can provide advice and supervise the new system.
- In the community, the Mothers' Club and the secondary school pupils and teachers expressed interest in a pilot project on 10 ha of communal land.
- The Ccorao farmers and other farmers in the area had already seen the excellent results of the sprinkling technique in the Ccochawasi farm.

While some communities have well-established irrigation committees, others do not and they do not have practical knowledge about irrigation techniques. The existence of an irrigation culture depends on the availability of irrigation water.

The native residents of Ccorao had practiced only rain-fed agriculture until a small group of newcomers, who had irrigation experience, married women of Ccorao. They initiated land-preparation irrigation on about 20 ha of land. In the period from August through October, about 1 l/s irrigation is sufficient for preparing a 5 ha area for planting. With a minimum of about a 10 l/s irrigation supply available, no formal agreements among the small group of Ccorao irrigators are necessary to coordinate their turns for irrigation.

Water for this community is diverted from a mountain river flowing into the Ccorao River valley. The river diversion is made of stones and sealed with grass. In the rainy season, heavy discharge and bed load often destroy the diversion and the first section of the canal. A 14 km long earthen canal conveys the water along a steep mountain slope to four indigenous communities. A 5,000 m^3 reservoir was constructed 12 km from the diversion to compensate for the temporary interruption of water delivery from the headworks. However, the reservoir is not used since no one has taken responsibility for its management.

Ccorao has an irrigation committee as do the other three communities using the canal. However, the Ccorao committee is not active. The irrigation committees were organized to build the 5,000 m^3 irrigation reservoir. The labor of the farmers for this work was paid for by assistance by way of food from the government. The reservoir has never been used. The other three communities have a long tradition of irrigation practice.

Outlets from the main canal have in the past caused minor erosion and, in a few cases, serious damage to the mountain slope. No structures were built to protect the outlets. The command area is located in the valley bottom that is wide and

Figure 8.1.4. Ten-meter section of lined canal at the intake and the pipe inlet box.

Photo by KARPAY Working Group.

almost flat like a small "pampa." Conveying irrigation water to the command area by open channels is difficult since the gradient is so steep. The elevation difference between the canal and the command area is approximately 30 m in a distance of just 200 m.

The communal land of Ccorao was divided into three parts with the Mothers' Club in charge of 1.8 ha, the community itself 2.3 ha, and the Secondary School 3.6 ha. The Secondary School is responsible for the management of the system and the administration of water turns.

Figure 8.1.5. Pipe inlet box showing the pipe filter and waste pipe.

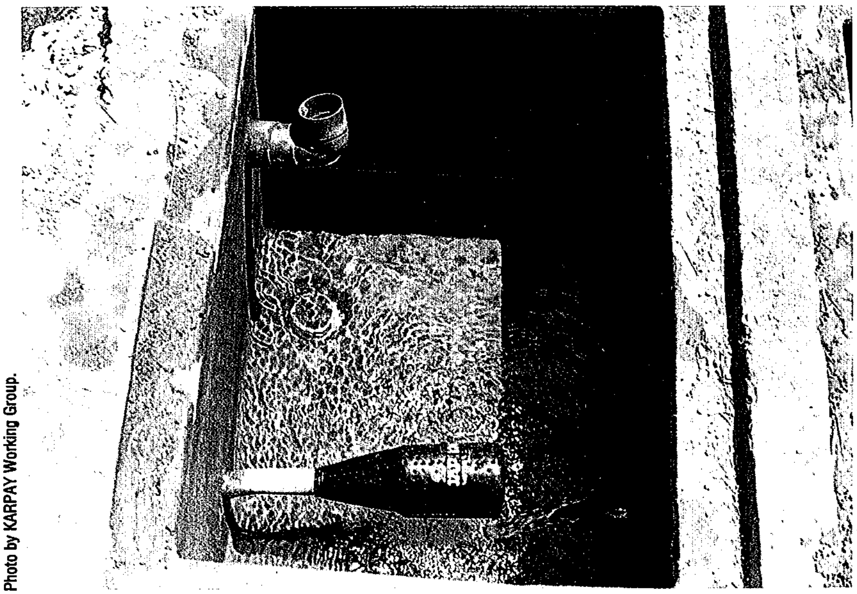


Photo by KARPAY Working Group.

Each of the three user groups is responsible for the distribution of water to its field. The distribution scheme is based on the days of the week as decided by the Community Assembly with direction from the Secondary School. The idea of giving an important role to the school and its pupils was based on the importance of guaranteeing the participation of the younger generation in learning to manage this new technology.

In Ccorao, the pipe intake (at the end of a 14 km long canal) for the sprinkler system is built in an earthen canal of 50 l/s capacity (Figure 8.1.4). Ten meters of the canal at the intake location are lined with concrete. The waste outlet and connection pipe to the sprinkler system enter directly into the masonry intake box (Figure 8.1.5). A simple filter, a milk tin perforated with a nail, is used on the inlet pipe. The filter has holes of 1 mm diameter which keeps most particles out of the system. It is fixed in place by pushing it over the inlet pipe. There have been no serious problems with the filter.

A few meters below the inlet, the delivery pipe has a T-piece connected to a ventilation tube. This allows air in the pipe to escape when water enters the empty pipe. The open end of this ventilation tube is maintained at canal level so that no water is lost through this opening.

The pipe leading to the sprinkler system in Ccorao is buried 0.8 m deep as it drops down the slope to the 6.35 ha command area. The ditch dug to bury the pipe is stabilized with masonry "shoes" at 5 m intervals. The pipe must be pressure-tested for leaks before it is buried.

The development agency paid for two local construction technicians and provided an engineer to supervise the work. The work of digging the trench for burying the pipe was divided equally among community members.

The maintenance of the sprinkler part of the system is simple. The masonry intake box must be cleaned periodically. This task takes one person about half a day. Every three months, the scour valve located in the lowest part of the main pipe must be opened to wash particles out of the pipe. The sprinklers will pass fine particles but silt is avoided as much as possible.

The Sprinkler Head

The development and testing of the alternative sprinkler took place over a period of six years. The goals were good performance in distributing the water and durability over long periods of use.

The main delivery pipe from the canal is 2 inches (5.08 cm) in diameter and 650 m long. The basic parameter in designing the pipe diameter was a maximum conveyance velocity of 3 m/s. The delivery pipe has eight hydrant offtake points in the command area. An 80 m long mobile field pipe is connected to the hydrant. Each field pipe can support six sprinklers although five are recommended. With a dynamic hydraulic head of a little less than 20 m, one mobile pipe delivering 1.25 l/s and operating for 9 hours irrigates about 4,500 m^2 to a depth of 9 mm.

The alternative sprinkler head functions well at hydraulic pressures between 5 and 50 m. With a dynamic hydraulic water pressure of 20 m and the sprinkler head 1.60 m above field level, the sprinkler wets an effective circle of 17.8 to 19.5 m diameter. Under these conditions the alternative sprinkler head will deliver about 0.35 l/s or about 6 mm/hour depth of water on the effective circle. In Ccochawasi, 97 percent of total irrigation efficiency was achieved. In Ccorao, engineers of Plan MERISS evaluated a 92 percent efficiency.

The sprinkler head is made entirely of good quality PVC plastic. The sprinkler consists of a rotating element made of a 0.5 inch (1.27 cm) diameter tube with T-pieces of the same diameter at its ends. Short pieces of perforated pipe sections are connected to the T-pieces. The outer ends of these arms are closed. The perforated pipe arms are angled upward at about 45° to maximize the wetted circle. The first prototype was 1 m in diameter. Testing and development continue but at present a diameter of 53 cm seems to work acceptably.

The sprinkler heads have a one-year or a 2,000 working-hour guarantee. Practice shows that repair is needed after about 4,000 working hours. After internal wear reduces its effectiveness, repair of the sprinkler is simple, and after repair, it could be guaranteed for another 2,000 working hours.

The sprinkler head is fixed to a wooden or metal stake and connected by a good quality hose to the mobile field tube. The field tube is connected to one of several water offtake points of the buried primary tube network. The required water pressure and application intensity are very flexible.

Uniformity in water distribution is excellent requiring only small overlaps between sprinkler positions. Application uniformity was measured with empty food tins placed at different distances from the sprinkler to the edge of the wetted perimeter. With 13 to 16 water jets spraying from the two arms, the distribution uniformity was 90 percent.

Four years after developing the prototype, a farmer 100 km from Ccochawasi purchased a sprinkler setup for his farm. He is managing intensive sprinkler irrigation on his 10 hectares successfully. Six years after development of the prototype, farmers from a community near Ccochawasi bought several sprinklers and connected them to the drinking water system. While the system works as planned, there is a conflict over water use for drinking. They continue to use the sprinklers but under some restrictions.

The 0.5 l/s discharge available to Ccochawasi was found to be sufficient to irrigate 1 ha of alfalfa or 2 ha of onion in the dry period. This was arrived at empirically after first adjusting the area based on evapotranspiration. Sprinkling during the night proved to be more efficient because there is less wind and lower evaporation. Since the water in Ccochawasi contains calcium, evaporation of the sprinkled water from the leaves, leaves a visual residue on the leaves. This is reduced with night irrigation.

The KARPAY sprinkler technology is very easy to use when compared with controlled flooding and furrow irrigation or even with conventional sprinkling equipment. A sprinkler system of up to 10 ha can easily be managed by one person.

By connecting the sprinklers to the mobile field pipe with a hose (flexible reinforced rubber pipe), three sprinkler positions can be reached before moving it to another offtake point from the secondary or primary conveyance pipe. This decreases the field work since moving the sprinkler with the hose attached does not require much effort. All connections for the sprinkler tube arms and for the field pipe elements are friction fits (one pipe warmed and slightly enlarged so the other will slide into it) needing only hand pressure. Bends in the field pipe are made by using pieces of reinforced rubber hose.

In the Ccorao System, two field pipes are used simultaneously, one for the community and one for the school. The Mothers' Club shares the field pipe with the community. The entire area can be irrigated in 7 days. Continuous sprinkling delivers irrigation at the rate of 40 mm per month. This is sufficient for the climate of Ccorao at 3,500 m above sea level.

Training is necessary for the Ccorao irrigators and for future users of sprinkler irrigation. The most important issues that need to be covered include:

- Differences between traditional and intensive irrigation, i.e., the value of frequent water application.

- Necessity of frequent sprinkling to avoid frost damage.
- Proper operation of valves (open and close slowly) to prevent water hammer.
- Improved uniformity in irrigation delivery by varying the location of the sprinkler position with each application.
- Regular cleaning of primary pipe by opening the scour valves.

The greatest problem with the sprinklers, breaking or tearing of the tube, is caused by improper handling. Of the thousand sprinklers sold in a three-month period, a few came back broken due to improper handling. The guarantee does not cover handling. If a sprinkler system is installed, it is wise to have some sprinkler heads in reserve. While repair is simple, it requires qualified expertise. Until a training program prepares technicians to carry out the repair work, all sprinkler repairs are done by the KARPAY consultancy.

The flexible rubber hose connection between the sprinkler and mobile field pipes must also be handled properly. When pulling it to a new position, it is recommended that the hose be pulled straight rather than in a bent position to avoid breaking of the hose. After 5 years, the reinforced hoses used in Ccochawasi are still functioning without defect.

The hydrant, a discharge pipe with a valve, through which the mobile field pipes are connected to the underground primary or secondary distribution pipe is perhaps the most delicate part of the system. It is housed in a concrete box with a concrete cover. If necessary, the box can be locked. Careful construction of the hydrant and concrete box can prevent many problems.

The Ccorao System irrigating 6.35 ha had a total installation cost of US$4,900 or US$770/ha. This included the cost of 200 person-days labor by the Ccorao farmers for burying the pipe. The cost for a conventional system is in the range of US$1,000 to US$2,000 per hectare. The price of an alternative sprinkler head is about 10 percent to 20 percent of the price of a conventional metal sprinkler and requires less maintenance.

Constructing a sprinkler system is easier than constructing a gravity channel. There is no need for sophisticated topographical measuring equipment. With the pipe system, the height may vary a bit if kept below the critical level. Digging the ditches for burying the pipes in the hilly terrain is easier than digging a much wider canal. Lower quantities of heavy materials such as sand, lime, stones and cement are required. The pipe is light and the effort required for transporting materials is much less. Construction of the sprinkler system is rapid with the user group doing a great part of the work.

An advantage of a sprinkler or, in general, any closed conveyance system, is that "water theft" by authorized users can be rapidly detected. Sprinklers will not function properly if an unauthorized user opens his valve when there is insufficient capacity.

The capacity for future expansion depends upon water availability. In Ccorao, there is capacity for expansion. The flexibility of expansion of a sprinkler system is limited by the diameter of the conveyance pipe between the inlet and expansion point. In many situations in Peru and probably in other mountainous regions, it will be more convenient to construct separate sprinkler systems, or secondary distribution systems than to expand existing systems. These can be managed in a decentralized way that adapts to the particular physical, socioeconomic and organizational setting of each subsystem.

The capture and use of small springs is easy with sprinkler irrigation technology. This is important in areas where the program objective is to optimize the use of small water sources.

In Ccorao there have been serious operational problems that are being resolved slowly. Coordination of system management was put in the hands of the secondary school where a Ccochawasi landholder and inventor of the system is a part-time teacher. He plays the role of an adviser in managing the system. A five-month national strike of all the primary and secondary education personnel restricted the normal development of the pilot project. Children from 22 neighboring communities in the Ccorao river basin attend the school. Without the institutional support of the school, children of other communities did not come to operate the system because their parents feared that the Ccorao community would get all the benefits.

The community did not respond actively because they felt that the school was responsible for operation. In spite of the widely known excellent results of the Ccochawasi experimental farm located at the same altitude, there were doubts about the feasibility of a second crop in the dry period. This was partly because of the danger of frost.

Once the strike was resolved, the school managed its 3.2 ha area. Two groups have emerged within the community: a group of young farmers who are interested and use the equipment and a group of older people who are not interested in understanding the system. To achieve farmer management, the role of the younger group of farmers is vital.

In the three months after the inauguration of the Ccorao System on 15 February 1991, there were three incidents of vandalism resulting in two broken valves and a hole in the main delivery pipe. These were repaired immediately by farmers with help from Plan MERISS. It was determined that persons involved in the school strike were responsible for the damage.

While the problematic beginning of the Ccorao Pilot Project cannot be considered representative of future projects in other communities, some of the lessons learned are that:

- Introduction of sprinklers into an existing open-channel system requires good methods for implementing the new practice.
- Collective activities to maintain the headworks and the conveyance network with field equipment owned by users (as personal property) make maintenance easy.
- Interest of farmers, water scarcity, and water demand can be used as criteria for selection of farmer groups who apply for a sprinkler system.

While the Ccorao Pilot Project has had some serious, specific problems, the system is actually used by school pupils and some community farmers in the total area of 6.35 ha. Meanwhile, farmers of neighboring communities and even other provinces of Cusco are buying sprinklers to use with the drinking water system of their community or village. The need for fewer organizational agreements and the opportunity to save time seem to be the most important reasons for people opting to use sprinklers. It is important to develop extension services to maximize the profits of this technology and to minimize conflicts and social incompatibilities caused by the use of drinking water systems. The KARPAY Working Group is monitoring the experience.

Example 8.2

Sprinkler Irrigation Systems in Benguet Province, the Philippines

Borromeo P. Melchor[65]

Goal: To irrigate a hillslope command area, from a lower river source, by pumping water to a set of small on-farm tanks which in turn supply sprinklers under gravity.

The Setting

This example describes the Ampilet and Pawai Community Irrigation Systems. The two systems are adjacent to each other and share the same source of water. They are sprinkler systems installed in the hilly Benguet Province primarily for growing vegetable crops.

Figures 8.2.1, 8.2.2 and 8.2.3 show the rolling topography of the command areas. Some of the irrigable area is relatively flat but most of the fields are on rolling hills. Fields on steeper slopes are terraced. The soil types in the irrigable area are sandy loam and silty clay.

The average monthly rainfall is given in Figure 8.2.4. Most of the rain falls in the monsoon season from May through October. There is little variation in temperature over the entire year. The lowest mean monthly temperature on record is 20 °C in the month of December. The average monthly temperature ranges from 23 °C in December/January to 26 °C in April/May.

Figure 8.2.1. Topography of the command area, Benguet, the Philippines.

Photo by B. Melchor.

Figure 8.2.2. Irrigated command area, Benguet, the Philippines.

Photo by B. Melchor.

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The Irrigation Systems

Figure 8.2.3. Profile of a terraced slope and series of irrigation sprinklers.

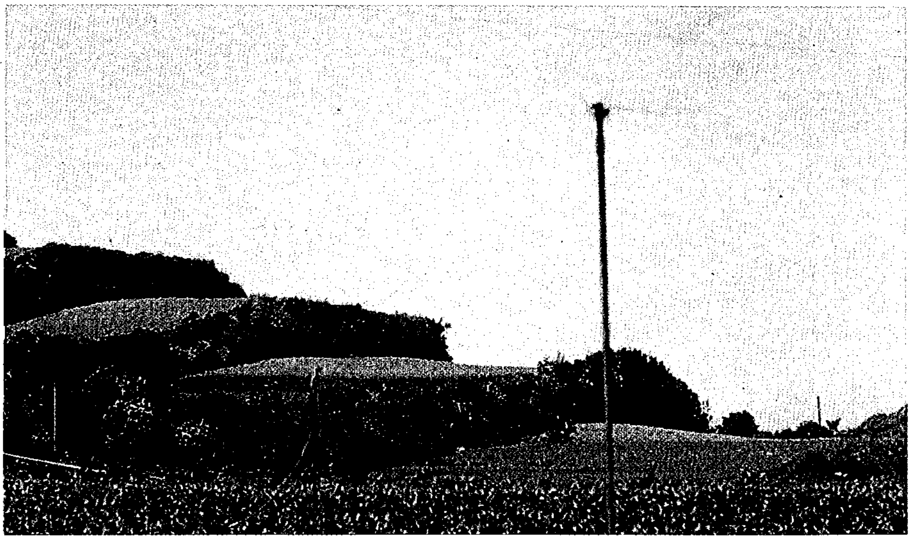


Photo by B. Melchor.

The command area of the Ampilet System is just under 70 ha and that of Pawai about 70 ha. There are 23 families who benefit from the Ampilet System and 68 families who benefit from the Pawai System. Both are community-managed irrigation systems.

Figure 8.2.4 shows the average monthly discharge in the creek available for irrigation. Water availability is one of the factors limiting the selection of crops. The main irrigated crops are cabbage, potato and sweet pea.

Three 6 hp pump units are used to lift water from the creek to small reservoir tanks in the Ampilet System (Figure 8.2.5). The Pawai System has a single 15 hp pump. The pumps are operated about 12 hours each day. There are a series of small tanks or reservoirs scattered throughout the command area. The reservoirs vary in size from about 6 m^3 to 285 m^3. Water is pumped from the creek to a reservoir and then released through the pipe distribution system that feeds the sprinklers. Figure 8.2.6 shows the layout of the Ampilet Irrigation System

In the Pawai System, the irrigators are organized into 4 groups of 17 members each. Two groups use the system on Monday, Wednesday and Friday and the other two groups on Tuesday, Thursday and Saturday. The pumps are not operated on Sunday. Each farmer is given two hours to fill his tank. The fuel and oil for operating the pumps are provided by the users each day. The 15 hp pump consumes about 18 liters of fuel and 1 liter of oil in 12 hours of operation.

The length of the throw from the two-arm sprinklers depends on the dynamic hydraulic head. This is fixed by the elevation of the tank relative to the field, the size of the delivery pipe and the discharge rate. Typically, the sprinklers are set on a 12 mm diameter riser pipe about 1.4 m high. The

Figure 8.2.4. Average monthly rainfall and discharge in the Makines Creek available for irrigation.

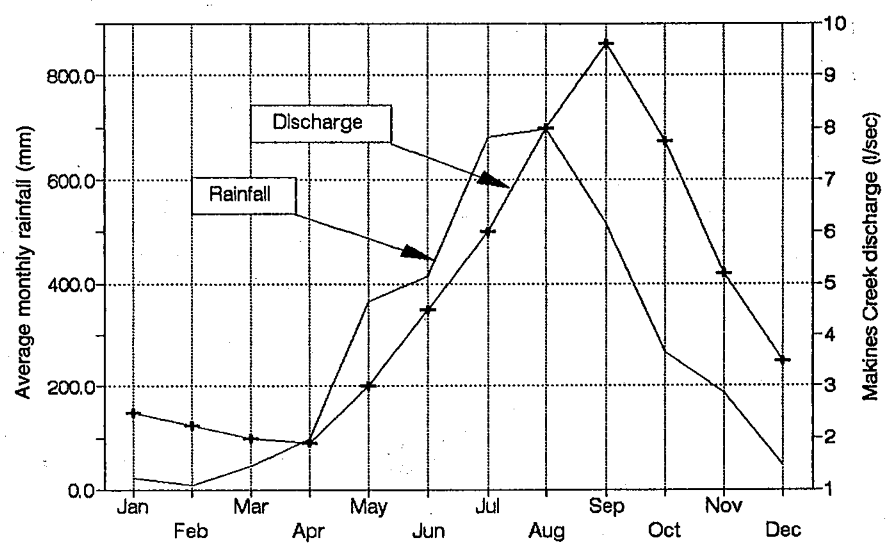


Figure 8.2.5. Irrigated command area showing three reservoir tanks.

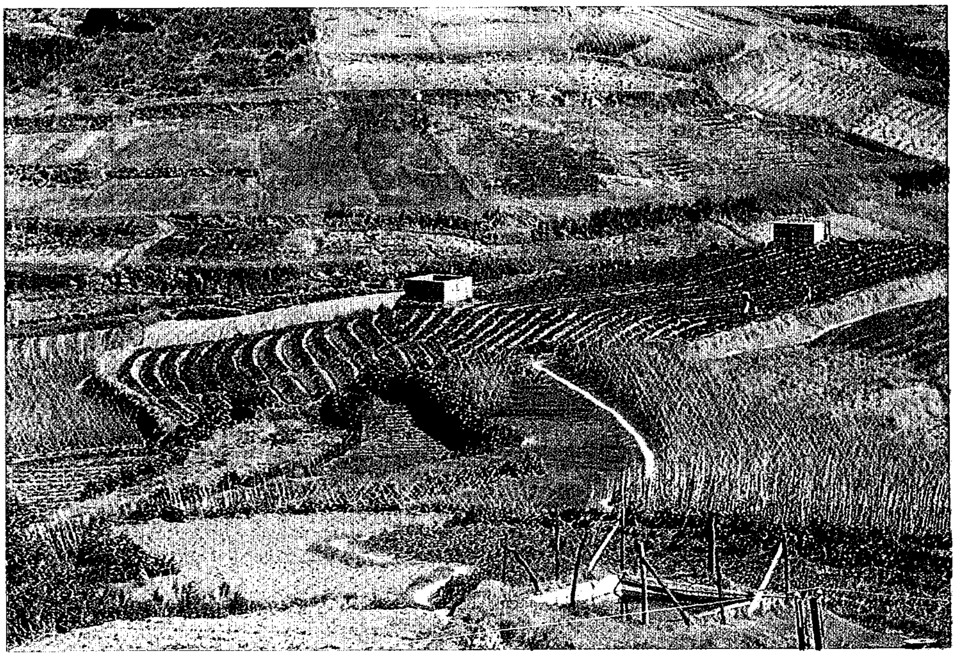


Photo by B. Melchor.

average throw is about 15 m and the area irrigated by one sprinkler in a day is about 800 m^2.

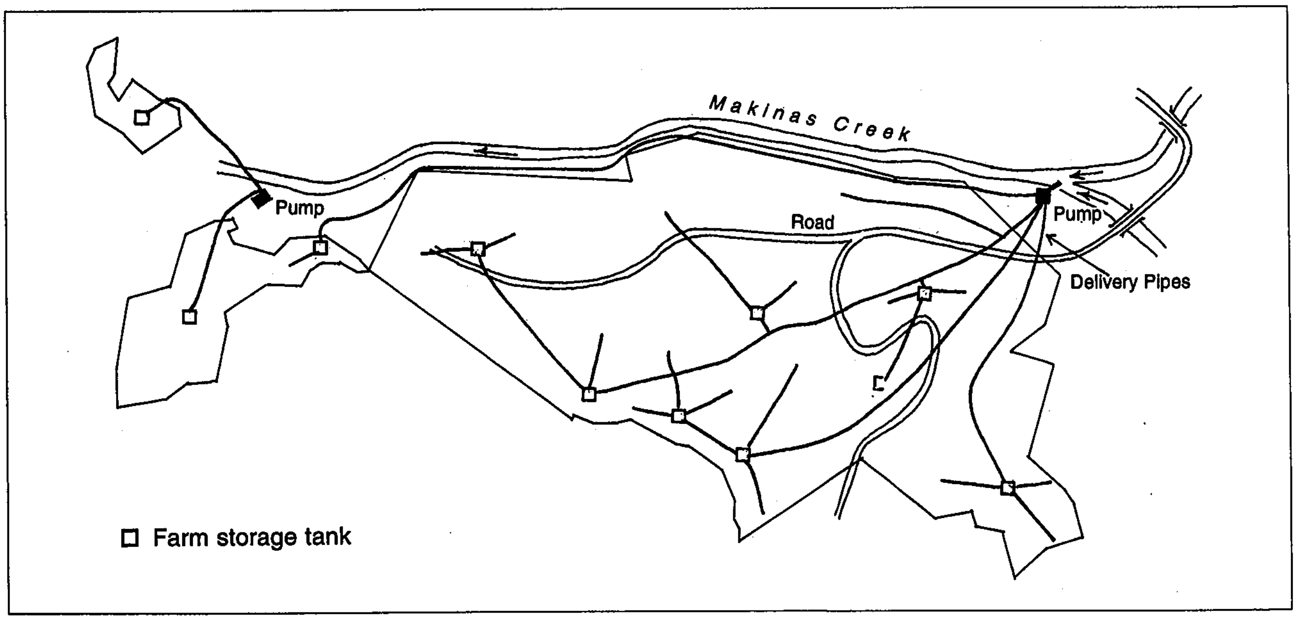
The Ampilet System was constructed in two phases. The second was completed in 1988. The total cost of the system was P 835,488 (about US$89,000). The Pawai System was completed in 1984 at a total cost of about P 358,502 (about US$45,000). Table 8.2.1 shows production information collected from the systems in 1991. Examining only the minimum value as computed from the lowest annual price, the value of production is 2.5 to 3 times the production cost for each of the crops.

Table 8.2.1. Production, production value, and cost in 1991.

Crop planted	Production cost (P/ha)	Average yield (kg/ha)	Price (P/kg)	Minimum value (P)
Cabbage	60,000	20,000	10-20	200,000
Potato	65,000	16,000	10-25	160,000
Sweet Pea	20,000	4,000	15-45	60,000

US$1.0 = P 26.0 in 1991

Figure 8.2.6. Layout of the Ampilet Community Irrigation System.



Example 8.3

Drip Irrigation System in Benguet Province, the Philippines

Borromeo P. Melchor[66]

Goal: *To irrigate tree crops with precise amounts of water and fertilizer, and to minimize energy costs in lifting water from a river to a mountain-slope command. The system uses drip irrigation equipment, fed under gravity from a tank to which water is lifted from the river.*

Photo by B. Melchor.

Figure 8.3.1. Citrus trees in the rolling topography irrigated by the drip irrigation system.

The Setting

This example describes the Bayacsan-Bayadjeng Drip Irrigation System. The system is located in the hilly Benguet Province and irrigates an orchard. Figure 8.3.1 shows the rolling topography of the command areas. The soil type in the irrigable area is clay loam. The temperature and rainfall patterns are similar to those described for the sprinkler systems in Benguet Province in Example 8.2.

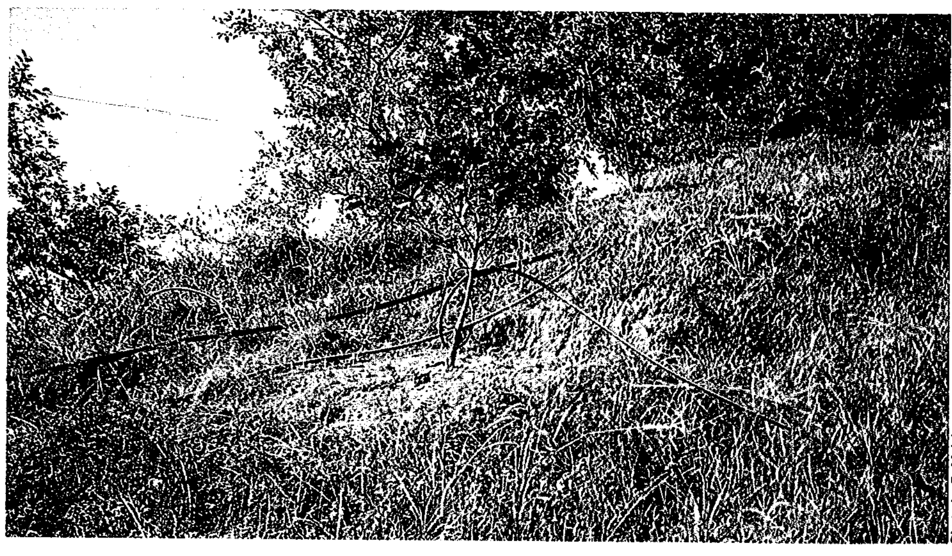


Photo by B. Melchor.

Figure 8.3.2. Sub-main and lateral pipes.

66 Provincial Irrigation Officer II, Benguet Provincial Irrigation Office, National Irrigation Administration Region I, the Philippines.

Figure 8.3.3. Pressure regulator valve and fertilizer injector.

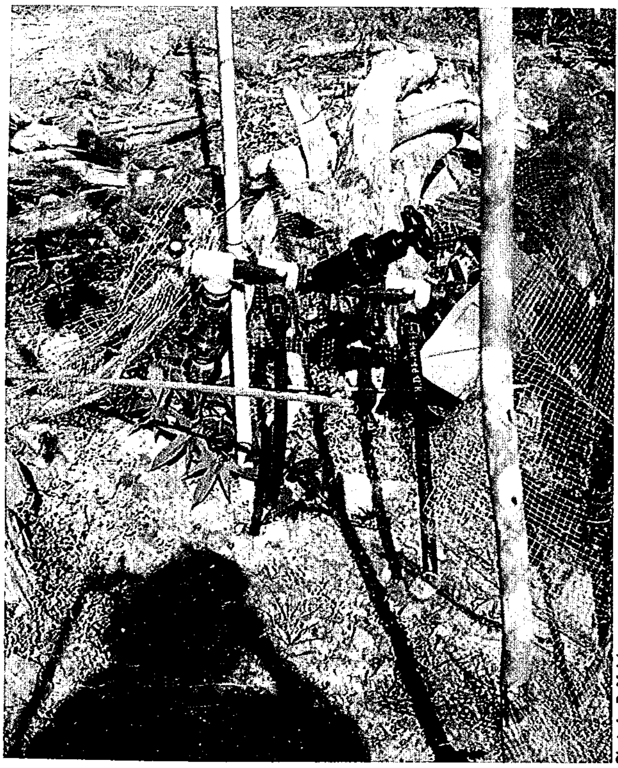


Photo by B. Melchor.

The Irrigation Systems

The command area of the Bayacsan-Bayadjeng System is 2.6 ha. The system was built in a two-week period in 1991. The water source for the system is the Dipanay Creek. It has a minimum discharge in the month of February of about 7 l/s and a maximum discharge in the wet season of about 38 l/s.

Water is pumped to a storage tank at an elevation of about 384 m. Water is then distributed by gravity through four sub-main high density polyethylene (HDPE) pipes of 25 mm diameter. The lowest elevation in the command area is about 368 m.

Each tree is served by a "woodpecker" self-compensated dripper. The dripper flow rate is 4.2 l/hour. The system is operated about 10 hours each day. All the laterals are buried 20 cm deep.

Figure 8.3.2 shows the 25 mm diameter sub-main and the 12 mm diameter lateral pipes. Figure 8.3.3. shows the arrangement used to inject fertilizer into the irrigation water and the pressure regulator. Figure 8.3.4 shows the drip tube for an individual tree.

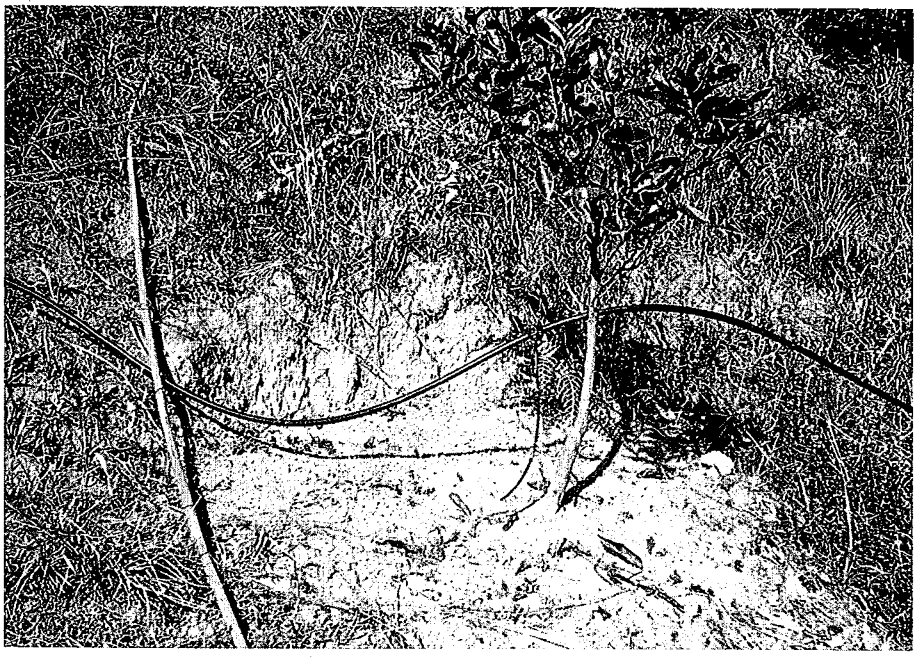


Photo by B. Melchor.

Figure 8.3.4. Lateral and dripper for individual tree.

Example 8.4

Pumped Spring Water for Gravity Distribution from Storage Reservoir in Indonesia

Yves Bellekens[67]

Goal: *To irrigate tree crops under lift irrigation, by pumping water up 65 m from a spring source to a single storage tank and feeding it from there to a 550 ha irrigated command through a buried-pipe distribution network under gravity. The scheme has proved unsuccessful financially because the farmers were not consulted or organized in advance, and now do not grow the planned crops nor pay for the system's high operating costs.*

The Setting

A spring located about 50 m from the sea is discharging 320 l/s on a sustained basis. The spring is located at the foot of poorly cultivated and forested hills. The mountain range prevents most of the rain from coming to this side of the island. The climate though monsoonal is rather dry because of the mountain barrier. The annual rainfall is 1,200 mm, concentrated mostly over 5 months with the rest of the year receiving only 200 mm of rainfall. For the months of August and September there is a minimum average rainfall of 5 mm. A large spring in an otherwise dry area has attracted people from the local community. A water temple has been built near the spring. More recently, a beach resort has been established at the spring along with a swimming pool and fish ponds which are supplied from the spring.

The Irrigation System

A few years ago, the government initiated a scheme with foreign assistance for diverting up to 300 l/s of the spring water to three electrically driven pumps. The water is pumped 65 m up the hill to a reinforced concrete reservoir of 1,500 m^3 capacity. The reservoir provides more flexibility for irrigation than direct pumping which would require more sophisticated controls or continuous manual operation with a communication system between users and operators. The reservoir provides a reliable pressure head for water distribution and storage against frequent interruptions in power supply.

Water is released into a pipe network to irrigate 550 ha. Part of this area was formerly uncultivated and part was terraced for rain-fed cultivation. There was a plan to plant highly remunerative citrus trees. Proximity to cities and tourist resorts, a good port, and an adequate road network provided the necessary infrastructure for marketing the produce. The expected benefits from the citrus crop was used to justify the high initial capital cost for installing the system and to cover expenses for operation and maintenance. Electricity was imported from a nearby island. The investment costs, expressed in 1986 terms, were about US$3,500 per ha and the annual electricity costs as much as US$370 per ha.

An incurable disease killed the citrus trees before the system was completely constructed. However, the government continued the construction and established nurseries for progressive replanting of the trees hoping the disease would disappear by the time construction was completed. Currently, grapes are irrigated in basins on rather light soils in part of the command area. The expensive electrically pumped water is used to irrigate the grapes. Water is applied in abundance and free of charge to mostly benefit large owners. Other areas are planted with

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67 Senior Evaluation Specialist, Asian Development Bank, Manila, the Philippines. The views expressed in this paper are those of the writer and not necessarily of the Asian Development Bank.

traditional crops, particularly corn, which is also irrigated freely with expensive pumped water.

The scheme costed about US$2.2 million to complete. Electricity consumption alone to essentially irrigate subsistence crops like corn costs about US$250,000 annually which corresponds to more than one-third of the district's budget for agriculture. The scheme is neither economical nor sustainable since irrigators cannot pay for even a fraction of the O&M costs. It is also not equitable since it concentrates too high a percentage of the district budget expenditures on a small area and disproportionately benefits a few land owners who profitably grow grapes but refuse to pay for the water they use.

Maintenance costs are also high and must be added to the expenditure for electricity. Problems have also been experienced with the PVC pipes used throughout the scheme for conveying water. The pipe bends are particularly susceptible to breakage. They are also broken by falling stones on steep slopes. Crossing the natural drains has also been a source of maintenance problems. As a result of the problems experienced, the PVC pipes in particularly vulnerable sections have been replaced by galvanized iron pipes. These pipes are heavy and farmers are not able to transport or handle them alone. The iron pipes have not been damaged in the two years since installation and they also do not leak.

Most farmers continue to earn low incomes. They are reluctant to accept any responsibility or ownership of a scheme which they recognize as too costly to operate and maintain with only their own resources. They feel no ownership toward the system because it was designed without their input and continues to be maintained without their assistance.