Basic Calculations for Hybrid Systems Based on Handpumps

Since the most common water source for new hybrid systems in rural areas of developing countries are likely to be obtained from the installation of village hand pumps, it is useful to make some initial basic calculations integrating projected water needs both for drip irrigated cash crop gardens and domestic use, and pumping capacity of typical hand pumps.

Handpumps Where the Water Source is in the Suction Range

There are some 500 million people in the gangetic delta areas of Bangladesh, eastern India, and the tarai of Nepal alone, most of whom live in areas where groundwater is available in the suction range.

For handpumps lifting water from a depth of 7 meters or less can be considered to be in the suction range. Extensive experience with Treadle Pumps lifting from a depth of 5 meters indicates that they are capable of producing one liter per second, or 60 liters per minute. Because pumping with a walking motion uses the body's muscles more efficiently, a levered handpump like a # 6 UNICEF handpump is likely to produce less than a Treadle Pump, probably more in the range of 0.6 liters per second, or 36 liters a minute.

Let us assume that a typical #6 pump in a rural area serves six households within a radius of 300 meters, five of whom carry the water by bucket to their homes. Let us also assume that each of these six households carries water to a 100 square meter drip irrigated gravity flow plot of vegetables and other cash crops.

Assumptions

1. each household uses 100 liters of water a day for domestic use
2. the drip irrigated plot in a dry time of year uses 5 liters/square meter a day, or 500 liters of water a day for a 100 square meter plot. (if it rains, or if there is moisture in the soil at the time of the dry season, or if it is a cloudy day, the water requirements would be less. If the plants are mature, and the climate is hot, dry, and sunny, the requirement would be more.

Pumping Requirements

Based on these assumptions, a #6 UNICEF cast iron handpump or a Treadle Pump would need to produce 3,000 liters of water a day to irrigate six one hundred square meter plots, and 600 liters of water a day for household use, for a total of 3600 liters of water a day.

At one liter per second, the treadle pump would produce 3600 liters of water in one hour (60 liters per minute x 60 minutes).

The UNICEF #6 pump would produce 3600 liters of water in one hour and forty minutes.

Since six households would take turns operating the pump, each household would only need to pump for ten minutes each day in the case of the treadle pump, and less than twenty minutes a day in the case of the cast iron UNICEF pump. But the majority of the labor requirements would be in carrying water from the pump to the household and to the drip irrigated plot. A wheelbarrow type carrying device would reduce the labor requirements for carrying water.

7-30 Meter Depth Pumps and Drip Irrigation Systems
Some ten to twenty percent of the population in river delta areas are in locations where groundwater is deeper than the suction range, and in the majority of these locations, clean water is available at a depth less than 30 meters. There are also significant populations in China, westerns and southern India, Latin America, and Africa with access to clean groundwater at depths of 7-30 meters below the surface.

According to Henk Holtstag, who has more than ten years experience with rope and washer pumps in Nicaragua, a rope and washer pump operated by hand by a single operator can deliver 40 liters a minute from a 10 meter depth, and 10 liters a minute from a 35 meter depth. Comparable water delivery rates have been reported for the Jibon pump, a low cost handpump capable of delivering water from depths of 8- 25 meters, developed in Bangladesh by IDE in collaboration with SDC.

Assumptions
If we assume that there are six families using water for household use and for 100 square meter plots within a 400 meter radius of the rope and washer pump, as in the example of water users pumping from a lesser depth in the suction range case, then the six households will have identical water requirements as in the earlier case, that is 600 liters of water a day for a total of 3600 liters.

Pumping Requirements
At a depth of ten meters, the rope and washer pump would need to be operated for one and a half hours by the six families, taking turns to produce 3600 liters of water.

From a depth of 30 or so meters, however, the rope and washer pump would need to be operated for six hours, or one hour for each family, to produce sufficient water to meet both domestic water needs and the water requirements of the 100 square meter cash crop plot.

The labor requirements for carrying the water from the pump to the household and to the drip irrigated plot would be the same as for the earlier suction range handpump case.

Economics of Village Hybrid Systems

Income Potential
Based on experience with more than 30,000 installed small plot affordable drip kits, each 100 square meter plot should be capable of producing a net return of $100 a year from

two crops, in addition to an improved diet for the household. Assuming that 30 percent of the cash return from the drip irrigated plot can be applied to pay of a loan for the installation of handpump and for the drip system, a total of $180 could reasonably be assumed to be available to make payments on a loan to cover the installation cost of the pump and the drip systems. If we assume that each household would be willing to pay and additional amount of ten dollars a year for access to clean household water, an additional 60 dollars a year would be available, for a total of $240 a year. If repairs and maintenance costs $30 a year, with labor provided by villagers, there would be $210 available for loan payments.

Suction Range Pumps and Drip Irrigation Systems
Assuming that the community, or water users group, buys both the pump for both and the drip systems would require a total investment of $145, obtained through a loan. A #6 cast iron handpump or a treadle pump costs approximately $25 installed on a tubewell in Bangladesh or India, and a 100 square meter drip system costs $20). The $145 loan could easily be repaid in one year.

7-30 Meters Pumps and Drip Irrigation Systems
While a rope and washer pump can be purchased for less than a hundred dollars in Nicaragua, the cost for the well on which it is installed is more. Assuming that the installation cost of both the rope and washer pump and the well is $300, total cost for both the pump on a well and the drip systems would be $420. With projected income of $210 available for loan payments, it should be possible to retire a loan for the installation of the hybrid system in three years, including interest costs.

Village Hybrid Systems Using a Water Source Deeper than 30 Meters
These calculations suggest that village hybrid systems pumping water from depths below 30 meters are not likely to produce enough water through human power to meet the needs for both cash crop drip irrigated plots and domestic use.

Where electricity is available, the added expense of an electric pump could generate enough income to retire a 3- 5 year loan for the system if the size of the cash crop plots is expanded to 500 square meters, providing that there is sufficient water in the well to sustainably drip irrigate 3,000 square meters of cash crops (estimated water requirement 15 cubic meters of water a day for irrigation.)

The potential use of diesel or photovoltaic pumping mechanisms would need to be subjected to careful site specific analysis to determine economic and environmental sustainability on a case by case basis.