Hill Irrigation in Himachal Pradesh, India

Under the Hill Area Lands and Water Development (HALWD) Project in Himachal Pradesh, 150 gravity flow and lift irrigation schemes will be constructed to irrigate 15,000 hectares. The seven year project, which began in 1984, calls for turnover of the systems from the Department of Irrigation and Public Health (IPH) which will construct them, to the farmer communities. So far, however, this turnover process has not happened.

The reasons for the disappointing response from farmers are complex, but a major factor is the design of the systems themselves. To promote farmer participation, the system design must increase farmers' ability to match irrigation water deliveries to crop water requirements. The designs must also maintain existing water rights.

BACKGROUND

The state of Himachal Pradesh straddles the transition zone between the Gangetic river plain of northern India and the Himalayan mountains; elevations range from 400 to 7000 meters. Typical landforms are small narrow valleys, and steep hillsides, with intensive terracing for agriculture. Population pressure on the small areas of arable land is high, and landholding sizes small.

Water for irrigation is usually obtained by surface diversion from small mountain streams, and in limited cases by lifting from major rivers or (in the southwest plains) from groundwater. Average annual rainfall is over 1100 mm, with 75% of the rain occurring during the summer monsoon (June to October). The principal summer crop is maize with some paddy. The main winter crop is wheat, with secondary crops of barley, pulses and oilseeds.

A GRAVITY FLOW SYSTEM

An irrigation system along the Rai khud (stream) 20 km northeast of Rampur city provides an example of the design options facing the HALWD project engineers. The diversion weir for the irrigation system was completed in February 1987. It was of gabion construction, with loose stones held together by steel wire. Following general design practice, no flow regulation structure was provided at the intake to the main canal, which had a design discharge of 60 litres/second. The first storm in August 1987 broke the weir and the nearby section of the main canal.

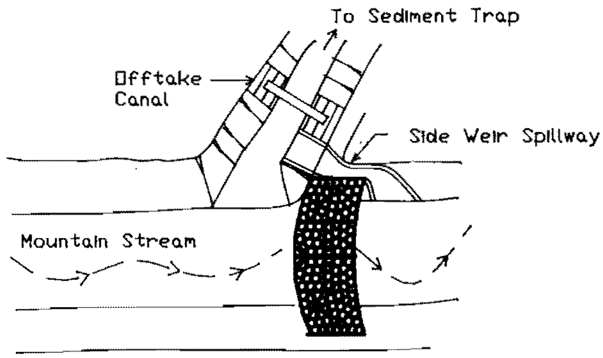

Figure 1A. Suggested design for surface diversion from mountain streams.

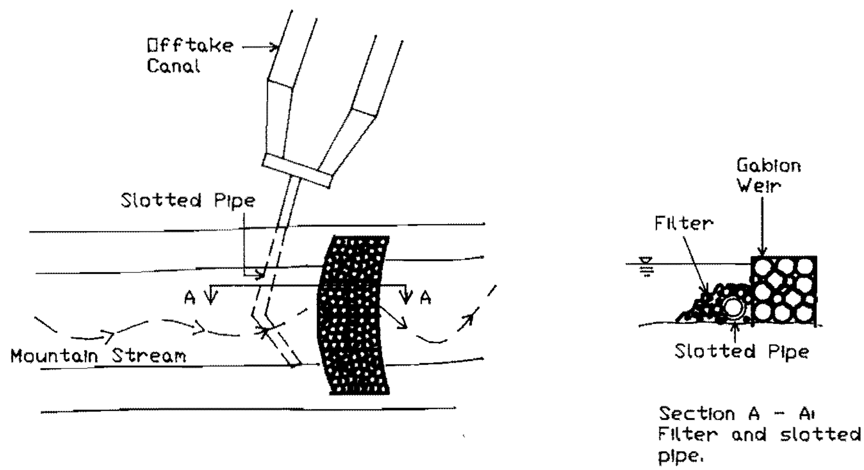

Figure 1B. Suggested design for sub-surface diversion from mountain streams.

Weir design. Gabion construction works satisfactorily under low velocity conditions, but in high velocities, the stones tend to cut the wire. A simple modification to increase the stability of a gabion type diversion dam in high velocity conditions is to bind the stones together by cement grouting. The grouted dam will be a rigid structure, and its stability can be further improved by giving the dam profile an arch (see Figure 1).

The offtake works should include a control gate to regulate the discharge that enters the main canal (Figure 1a). After the gate, it is good practice to provide a canal spillway in the form of a side overflow weir or a self-priming siphon. Sediment traps are necessary for removing large sized soil particles from the irrigation water.

Another way to regulate flow into the canal and to exclude sediment is to divert the stream water into an infiltration gallery which consists of a perforated pipe placed in an envelope of filter material (Figure 1b). However, clogging of the filter material can be a problem if the filter is not designed and maintained properly.

The watershed. Any suggestions for improved diversion works in unstable mountain streams will have limited value without proper management of the stream catchment areas. Stable diversion works in mountain streams are difficult and expensive because of the extremely high flood flow compared to the base flow. The stream hydrograph must be stabilized to reduce the peak flow.

The land surface in the catchment areas should be covered with grass and an effective tree cover must be developed. The local people have traditional rights to timber cutting and grazing in the catchment areas. The Forest Department and the IPH need to work jointly with the people living in the catchment areas to reduce surface runoff and soil erosion

Presently, the local people take their animals for watering to the river, using the gullies as a walkway. Gullies are also used to slide down logs. The use of gullies for transportation prevents the Forest Department from terracing and stabilizing them. Local sources of water for animals could be provided by constructing small ponds which would also check surface runoff. These ponds would be very effective in reducing peak runoff and associated soil erosion.

Water distribution. The lateral distribution lines have a steep slope (about 40 degrees) in the Rai Khud irrigation system. Water from the main canal is delivered through concrete pipelines, along which small on-line storage tanks have been constructed. Each tank serves one landholding of about 0.5 hectares. The original design envisaged that the water level in all the tanks would rise simultaneously, allowing farmers to irrigate using siphon tubes. However, because of the large number of tanks on a single line (between 50-100 tanks), the lack of control valves, and organizational problems, farmers whose lands are down slope either do not get any water, or it flows to them via their upslope neighbors.

An alternate design would be a set of contour channels oriented parallel to each other down slope. The parallel channels could receive water from the main canal by means of a chute, buried pipeline, or through a natural stream or depression. Farmers could then irrigate from the channels using flexible rubber pipes.

A distribution system consisting of two or three parallel contour channels divides the overall command area into small channel commands, thus simplifying the management of rotational water distributions. Physical structures would be simple (open channels) and could be maintained by the farmers without continuous external help. From the funding point of view, this approach is cheaper than the tank pipeline system. Also, irrigation water is more efficiently used, since the lower channels would pick up a significant portion of the surface and subsurface flow from the higher lands.

A LIFT IRRIGATION SYSTEM

A lift irrigation system, planned for the Beas river valley in Hamirpur district, serves as an example of the design options for this type of system.

Water is to be lifted 40 meters to irrigate 100 hectares. The river water level fluctuates about 6 meters between the low and high stages, and the water carries a heavy sediment load. Intake structures using floating rafts, pumps mounted on trolleys, and wet wells are the major options, yet none has shown much success.

Such expensive intake structures are hard to justify economically for each small irrigation system. The cost of making a wet well intake structure

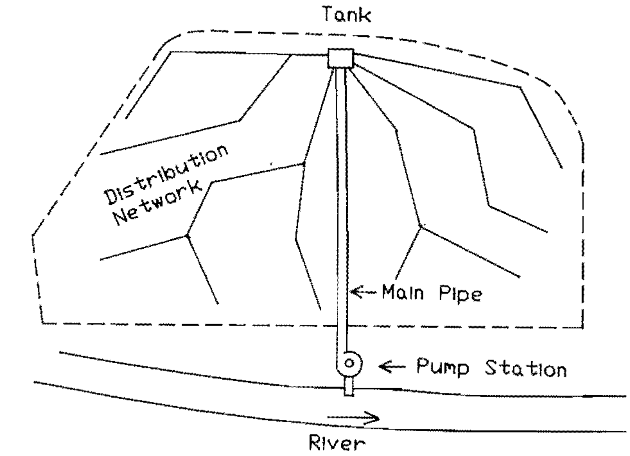

Figure 2A. Existing design of water distribution system for lift irrigation schemes.

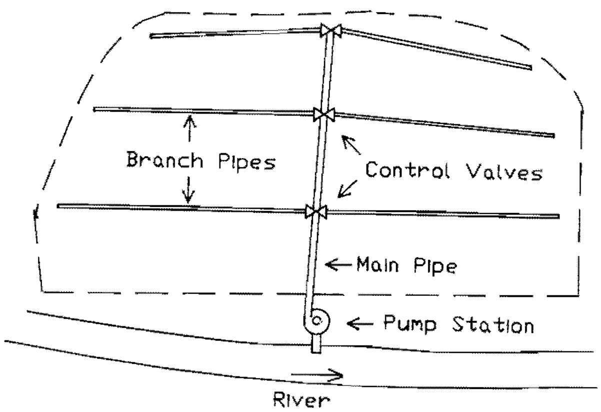

Figure 2B. Suggested water distribution system design.

and installing pumps was estimated to be about US$ 900/ha. This is roughly 25% of the total development cost including farm development. The benefit/cost ratio calculated was 1.1, a value which is only marginally acceptable according to project selection criteria. However, the high total cost, estimated at about US$ 4000/ha was higher than the project limit of $2500/ha.

A possible option for irrigation water development in the Beas river basin may be to use ground water. The topography of the valley is gentle with deep soils of loamy texture. Near the river banks, many farmers dig shallow wells and irrigate small patches of land for vegetables. The water level in these wells varied from 10 meters near the river to about 18 meters 2 kms away. However, to obtain larger discharges, deeper aquifers would need to be tapped.

Water distribution. The command area in lift irrigation systems is usually an inclined plane sloping towards the river. The normal design practice for water distribution is to lift all required water to a single point at the top of the command area. A distribution tank is constructed at the highest point, and water is distributed to all farmers from this tank (Figure 2a).

This design approach results in long distribution lines with many farmers on each line, some of whom are quite far from the water source (the distribution tank). Not only is it very difficult for farmers to organize a distribution pattern, but the design also results in high energy costs, since all water is raised to the highest point.

A better design for effective farmer participation and management would be to disaggregate the command area into smaller distribution units. To accomplish this, branch pipes could take water at suitable intervals from the main riser pipe. Each branch pipe delivers water to one distribution unit with a control valve at the intake point (Figure 2b).

In addition to simplifying water distribution, the design can decrease the energy costs for pump operation. Only 1/3 of the total water supply is lifted to the highest point. Another 1/3 of the water is lifted 2/3 of the way, and the final 1/3 of the water is lifted only 1/3 of the total height.

The reason for the existing design (Figure 2a) is the incorrect belief that pumps can only operate at one head, so all water must be lifted to one point. In fact, a pump designed for a certain head can be operated efficiently to deliver water at variable-heads. The pump speed can be changed by using variable speed motors or by installing variable frequency drives on the electric motors. The variable frequency drives change the motor speed by changing the electric cycles.

CONCLUSIONS

The dilemma of irrigation development in Himachal Pradesh is similar to that in many other Asian regions: How can the government provide assistance to farmers without eroding local initiative for managing irrigation? This article suggests that the engineering designs themselves are critical for providing a basis for farmer management.

In designing irrigation systems, engineers should seek information from the local people on stream flows, canal alignment, and the location and type of outlet structures. The canal alignment directly affects some farmers' landholdings. Farmers must be involved in these decisions; otherwise conflicts will arise during the construction phase. The location of outlet structures requires farmer involvement, since the design determines the farmer groups that must share water and maintain a common watercourse.

[Editor's note: This article has been adapted from a longer paper by the author entitled, "Irrigation Design and System Management: The Case of Irrigation in Hill Areas of India." Copies of this paper are available upon request. Please contact Shaul Manor at IIMI if you would like a copy.]

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Ramchand Oad
Assistant Professor
Dept. of Agricultural and Chemical Engineering
Colorado State University
Fort Collins, CO 80523 USA.