CHAPTER 9

Some Lessons from the Examples

The 44 examples presented in the preceding four chapters indicate the main lines of thinking and of actual experience among a group of practitioners who are well-versed in the realities of irrigation operations in mountainous terrain. Among them, the group who assembled for the Kathmandu Workshop had seen a great range of variants of structural designs, some successful, others not. In these closing pages we attempt to identify the major recurring themes which, according to this group's experiences, seem to have special importance, in distinguishing mountain irrigation facilities from their plains counterparts, or in making mountain irrigation systems increase their levels of success and sustainability.

SUSTAINING THE ORGANIZATION

Among the many factors, other than topography itself, which make mountain irrigation different, uncertainty and variability may be most significant. In systems that are installed in flat alluvial plains beside large rivers, high levels of order and predictability can be achieved. High predictability and homogeneity of water and land resources can make possible high levels of uniformity in irrigation practices and in institutional controls. Mountain irrigation can never be organized like that. Uncertainties of the hydrological system, specific local events like landslides, and difficulties in communications with the external world, all mean that flexibility and self-reliance are essential characteristics of mountain systems.

Flexibility, in turn, means the capacity to take and implement decisions quickly, in order to seize opportunities or to avert calamities. So the requirements for flexibility and self-reliance mean a requirement for effective organizations in which all farmers participate willingly. Everyone has a stake in sustaining the organization, and so fairness and transparency in the organization are treated as high values. Many of the designs presented in this book have shown how these social considerations of equity and transparency may override more technological considerations such as efficient hydraulic control.

As Bellekens (Example 7.4) tells us, "equitable sharing is an important condition for maintaining harmony ... conflicts would threaten sustainability of the irrigation institution," and for this reason the leaders of the Balinese *subak* demanded that new installations that were technically more modern should be removed, in favour of traditional ones.

Spare (Example 7.6) emphasizes similarly the essential need for transparency: "the widths of opening are displayed in a public place, and any member can check the openings at any time they desire."

The paramount need to sustain an effective organization and to define each individual's relationship to that organization can produce some outcomes that are much less familiar to those who are experienced in irrigation on the plains. For example, it may readily be supposed that a design that reduces labor requirements for annual maintenance is quite desirable; but Bellekens (Example 5.3) and Ambler (Example 5.5) show cases where the reduction of these personal labor inputs have impaired organizational cohesion. Such inputs may be likened to the payment of an annual subscription; and in a remote location where labor that is "saved" cannot be sold to an employer, such new structures provided by governments may break an essential organizational bond, even if they are provided with good intentions of making farmers' lives a little easier.

The idea that the details of design of an irrigation structure are intimately connected with the sustainability of the local organization, and are therefore not governed simply by the customary engineering criteria of effectiveness and cost, is perhaps an unfamiliar idea to engineers more accustomed to plains irrigation systems.

WATER RIGHTS

Many of the authors who have contributed design examples of structures for water acquisition or water distribution have stressed the significance of understanding both existing and future water rights. Hierarchies and priorities in rights to water access are common, both within user groups and between different user groups. These include rights derived from primacy of use, or from settlement of past disputes; they also include differential rights based on location within the system, or on local soil conditions. Rights may be in terms of water quantities, sequence of access to water, preferential access at certain seasons, and so on. The subtle combinations of all these factors that mountain communities have developed, each reflecting the particularities of their own situation, seem to be infinite. As Ambler (Example 7.3) records in Sumatra, "no farmer could remember the sizing of the *paraku* ever being adjusted, and they considered the present system a priceless inheritance from their forefathers."

Two kinds of problems, derived from these strong traditional systems, are identified by the authors. One of these is the need for constant revalidation of rights; the other is that the introduction of new users may be difficult.

In regard to the first, Valcárcel and van Driel (Example 5.7) report typically from southern Peru: "Water rights are clearly established by tradition. Monetary payment is not practiced. Rather, a 'seasonal payment' to reclaim one's water right is made by one's own labor for maintenance, and in the form of food and drink during the communal labor mobilizations for maintenance."

Labor input is often a factor also in establishing new rights. Spare (Example 7.6) has described, from a new system in Nepal, how "persons ..... who want to participate in the benefits of irrigation may purchase 'water shares' by their labor during construction or by monetary transaction."

Rehabilitating or altering existing structures may enable them to capture more water. Ambler (Example 5.5) describes a characteristic situation: "leakage (of the traditional weir) is intentional, as it allows a significant portion of the stream flow to move downstream to other canals that need it ... during the dry season, the enhanced acquisition capabilities of the (new) permanent weir allow it to capture more water than its traditional share, to the dismay of farmers in downstream canals." Both Ambler and Bellekens (Example 5.6) describe how, because of this pressure from downstream people, new structures could not be used in the manner intended by their designers; so resources used for their installation had been, to some degree, wasted.

Equitable rights to water do not simply mean a system of area-based shares. In the traditional system studied by Ambler in West Sumatra (Example 7.3), shares had been adjusted long ago, so that variations in seepage loss were taken into account, with the result that "only 42 percent of the total variance in water share could be accounted for by share of land."

For the designers of new projects or rehabilitations, the lessons of such examples are that it is essential to spend time, before the design, on understanding the existing patterns of water rights. Structures that cannot be operated in a manner conforming to water rights risk being attacked, destroyed, or (at best) misused. Rehabilitations that eliminate the communal labor element of annual maintenance may weaken organizational bonds and obscure the patterns of water rights.

There can be reasons nevertheless where these things may have to be done; for example, we may not be able to rely on communal labor in circumstances where the attractions of alternative economic activities are depleting the local labor resources. Even in these cases, the impact of new structures must be thoroughly discussed in advance with the holders of existing and potential future water rights, in order to ensure general acceptance of changes.

Khan (Example 6.16) provides an excellent example of these consultative processes from northern Pakistan. Three existing irrigators' organizations agreed to collaborate in constructing a new channel that would make a large block of additional land available to them jointly, drawing its water from an already existing canal. They could not, however, agree to abstract water from the place which the engineers chose as technically optimal; instead, they chose a lower location which commanded less land. The external engineers cooperated in implementing the group's preferences, and now "the three village organizations have fully internalized the new irrigation structure. They are responsible for management, maintenance and repairs."

LOCAL HYDROLOGY

The authors of several of the examples, especially about water acquisition structures, describe problems arising from the hydrological characteristics of the rivers they were trying to use. A major problem in this area is the deficiencies of data. From the viewpoint of the design engineer, special programs of flow measurement are expensive but of only limited value if the variability of the stream is great, because a measurement campaign of a year or two does not define the flow statistics very well.

There are two usual requirements, which are to estimate the low and the high flows. The statistics of low flows determine how much land the source can irrigate, and the statistics of high flows determine the security of the structure against flood damage. Information in both these areas is commonly deficient, so the designer should use certain kinds of precautions.

At the high-flow extreme, there is the need to allow for flood flows that are in excess of the structure's normal capacity. Pande (Example 5.2) and Williamson (Example 5.11) describe doing this in water-capture structures, with a short "fuse" or "breach" section which will collapse first when high flows come, and thus will ensure that most of the diversion structure remains intact. In the case described by Williamson in Sulawesi, however, the farmers did not understand the principle and therefore declined to install it. Bellekens (Example 5.1) describes a structure that is expendable, but capable of rapid repair with available materials, several times a year. Smout, van Bentun and Dorji (Example 5.8) describe the use in Bhutan of an orifice-inlet that will prevent very large flows from entering the canal.

Excessive sediment is also a probable feature of very large flows. Singh (Example 5.9) and Gurung (Example 5.10) describe, respectively, side and bottom intakes in Nepal, whose aim is to abstract water without taking too much sediment with it.

After the water has entered the canal, protection against possible excess and bank over-topping is still an important design consideration. The principle of a deliberately weak point, where a stock of repair materials can be retained and repairs can be quickly completed, is again found, as in Bhattarai's example (Example 6.7). Efficient escape structures along the canal are also needed. In some cases, these guard also against the possibility of localized raising of water level by deposits of rocks or sediments.

In examples like those of Liu, Chen and Wang (Example 6.8) or Smout, van Bentum and Dorji (Example 6.3) there is a double problem: the low flows at the intake are not sufficient, so efforts have to be made to capture the water of several transverse streams which the canal crosses along its way to the irrigated command. However, the addition of water from those streams can increase the risk of breaching by high flows. The Chinese example, suitable for a quite large canal, uses a series of self-priming siphons as escapes to remove excess water; the one from Bhutan uses a level crossing so that transverse flows are accepted by the canal only if the resulting total flow in the canal is less than its capacity.

CHOICE OF MATERIALS

Construction sites among mountainous terrain impose a different logic, in regard to the choice of construction materials, from that which is customary in the plains. Transport of heavy items can involve large costs and severe practical difficulties, in the absence of roads. There is a clear advantage in using materials that are locally obtained, and materials that are light in weight. It has to be anticipated that virtually every structure located in the mountains will require maintenance and repairs, so it is essential that the material should be of a kind that can be obtained, handled and installed, within the scope of the community's labour and equipment resources.

These considerations do not necessarily mean that timber structures are a good solution. Many mountain communities that would have relied on wood in the past are now quite aware of the impact of deforestation. In the Nepali system described by Gurung (Example 5.10), on the "Mad" River with very high velocities, a traditional system of annual renewal of the intake structure became unsustainable because "each year, about 300 bundles of bushes and trees were required, causing deforestation in the watershed." Spare (Example 6.5), giving the reasons for introducing the ferrocement channel in Nepal, says "originally a flume carved out of a large log was used to close the ravine ... however, large trees are no longer readily available and have become very expensive."

The search for materials that are available, transportable, workable and replaceable is therefore a continuing part of the design process. Perhaps it focuses especially on the conveyance structures: they are numerous, and delays in repairing them can be disastrous to the community.

The ferrocement flume reported by Spare (Example 6.5), the high density polyethylene pipe for a small ravine crossing reported by Yoder (Example 6.6), the use of oil drums to constitute a conduit for rapid emergency repairs after landslides as reported by Bellekens (Example 6.9), the plastic sheets for canal linings to prevent saturation-induced landslips, reported by Singh and Bastola (Example 6.15), are all examples of non-indigenous materials that seem to have performed well and proved their appropriateness. There are other cases, where the imported materials presented specific management difficulties, such as the concrete pipe reported by Yoder (Example 6.10) which could not easily be unblocked after sedimentation, or the soil-cement canal lining reported by Spare (Example 6.14), which the farmers are reluctant to accept because they deem it "a second-rate technology."

In some cases, the imported materials clearly have not been successful. Such an example is the PVC pipe, "particularly susceptible to breakage" which Bellenkes (Example 8.4) reports from Indonesia. This is one of several reasons why the farmers "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."

In this matter of choice of appropriate materials, as in the questions of equitable water-dividing structures and of the supply of communal maintenance labor, we can see how the aim of sustaining a viable organization is one of the keys of physical design, and that purely technical considerations may have to give way if they seem likely to compromise this vital factor.

RELATIONSHIPS WITH GOVERNMENT

Example 8.4, where investment costs were US$3,500 per hectare and annual energy costs to pump water are US$370 per hectare, and farmers "feel no ownership toward the system because it was designed without their input and continues to be maintained without their assistance," is a vivid instance of the question of ensuring successful relationships between farmers and government in mountain irrigation schemes. Governments, in recent times, have been developing more projects of rehabilitation or of new installations in mountain areas; some of these give satisfaction, some do not. The governments, generally, do not want to find that they must carry continuing responsibility for operation or maintenance. The typical government project is one where certain capital inputs are made, but subsequent management and responsibility for recurrent costs are supposed to be accepted by the users as a group.

The examples contain many lessons about the interactions between design and management in this area. The specific design elements in the system will influence the farmers' decisions as to whether they agree to assume responsibility for it. If they do not, governments may then discover that (in the case of a rehabilitation project) they have transformed a formerly viable farmers' group into one that is now financially dependent upon continuing government expenditure to keep the new system in operation.

The case described by Bellekens (Example 5.3) is an illustration of this design/management interaction. "The reinforced concrete weir cannot be compared with the earlier structures that it has replaced ... it was built without any input from the irrigators ... the improved structures resulted in very little, if any, production increase ... there has been a reduction in the system operation and maintenance labor required from the farmers [but this] is not cash income to the farmers and they remain unwilling to make payments to the government for system operation and maintenance."

Probably the most usual cause of this kind of problem is the application by government agencies of design standards that are too elaborate or costly. The example cited by Bellekens (Example 8.4) is an extreme one, although not rare. Ambler (Example 5.5) and Pande (Example 6.1) tell essentially similar things.

Pande's example shows another aspect: the government engineers are bound by departmental rules and standards, evolved for other circumstances, but applied with some rigidity even in conditions where they are inappropriate. Mountain soils often have high infiltration rates, and mountain streams often have variable flow rates. Therefore, farmers like to have canals with a substantially higher flow rate per hectare of command area, than might be needed elsewhere. The application of departmental standards of design produces canals that they consider are too small: "frequently, the canals are damaged because farmers have tried to operate them above their design capacity."

The lesson here is that success is much more likely, and the complete hand-over of the system to the farmers is more likely to be accepted, if the farmers' organization is consulted before the project and at each stage during its implementation.

MANAGEMENT ARRANGEMENTS

The most consistent message that is conveyed by almost all of the examples is that the designer should take account of the expected subsequent management arrangements, and should ensure that the structures designed are capable of being used and maintained by the operating organization, which generally means the users themselves, although in some cases like those in China it means a branch of local government.

As far as possible, these management arrangements should be in place before, not after, new projects are undertaken, so that those who will manage the new or revised system can influence the principles and the details of its construction. Their agreement to the design should not be passive; practical inputs by them consolidate the sense that it is a joint enterprise, as in Asencio's case (Example 6.11) in the Philippines where "the Irrigators' Association's contribution towards the construction of the project is in the form of labor and materials which are considered as equity generated by it."

A case that presents special difficulties is where the addition of new structures involves joining two or more existing systems together to share a common water source. Valcárcel and van Driel (Example 5.7) say, from their experiences in Peru, that "joining existing systems must definitely be avoided where there is an alternative, even if initial costs may be higher." They attribute the difficulties mainly to the problems of re-allocating water rights and maintenance responsibilities, and find that "although verbal agreements on these issues may be obtained, conflicts very often persist after the new construction." Something similar has been described by Yoder (1994) on a Nepali system where amalgamation was done under government pressure, reluctantly and with some residue of mistrust. But the experience described by Khan (Example 6.16) in Pakistan seems better, where representatives of three older organizations "formed a committee to manage the [joint] irrigation system. The committee also solves disputes related to the use of the new facility."

Generally, the examples presented in this book confirm that in mountainous environments, more even than in other classes of irrigation systems, designs and structures must be in harmony with the management capacity that exists. Organizations that will maintain and protect the installations are essential to their survival, so the organizations themselves must be sustained. Every water-delivery structure is a potential source of conflict; likewise, every contribution of labor to canal maintenance can be a source of consolidation or of discontent, according to the perceptions of the individual and of the group. The examples show repeatedly that designs which are done in collaboration with their ultimate users have a much greater prospect of success and sustainability, than those which neglect the complexity of rights, obligations, relationships and capacities within the user society.

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