Design Issues in Farmer-Managed Irrigation Systems: Three Case Studies in Gravity Irrigation in Maharashtra, India

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INTRODUCTION

FARMER-MANAGED IRRIGATION SYSTEMS are defined as systems where construction, operation, and maintenance activities are the responsibility of the beneficiaries. A caveat is added that in some such systems, the beneficiaries might have received external assistance for the construction phase. But the distinguishing characteristic of farmer-managed irrigation systems is that irrigators themselves carry out operation and maintenance of the systems. In general, these systems are designated as traditional, indigenous, communal, or people-managed systems.

However, there exists a subset where construction, operation, and maintenance of the system up to a designated point is farmer-managed while the management above this point is entrusted to the government-owned irrigation agency. This situation pertains to large irrigation projects (irrigating an area of 10,000 hectares [ha] or more) where because of technical and organizational complexities the total system management cannot be entrusted to the beneficiaries in the existing socioeconomic environmental setup. The large system is sectioned into smaller units where the management (of construction, and operation and maintenance) is entrusted to the beneficiaries. The irrigation agency is responsible for delivering the allocated volume of water (measured or left to the judgement of the agency) according to schedule at the head of the minor or distributary channel while leaving further operation, distribution, and maintenance of the downstream physical system to the beneficiaries. It stands to reason that the management above the designated point, which may be called "main system management," has to be entrusted to the irrigation agency. As these systems are now being experimented with in Southeast Asian countries they have to be included as farmer-managed irrigation systems. They also face design problems similar to those of the traditional, indigenous farmer-managed systems.

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That farmer-managed systems are superior to agency-managed systems (where the agency personnel deal directly with myriads of small farmers on an individual basis) in terms of cost and irrigation efficiencies is now well-acknowledged. Where farmer-managed systems have failed or weakened, the causes are traced to certain external factors such as degradation of storage and conveyance facilities, lack of knowledge of crop technology to suit the changing environment, the mismatch of water delivery to crop water needs, bureaucratic interference (laying down restrictions on crop patterns, fresh levies, etc.), and organizational decadence arising from social conflicts among the beneficiaries. Every failure needs to be studied individually and solutions found for restructuring the systems.

DESIGN ISSUES

In any farmer-managed irrigation system, either in the traditional small or medium size or in any segment of a major project, the following design issues need to be considered to ensure success:

1. Designs should be simple enough for the farmers to understand: the farmers should have a prior knowledge of when, how, and how often water is delivered to individual farms. This would help them make a reasonable estimate of reliability, predictability, and stability of water supply.
2. Size of the flow should be such as to be manageable by an individual or by a group of farmers. This would depend upon how water application is organized.
3. The frequency of water application should meet crop water requirements. If there is crop diversity, this factor should be taken into account at the design stage.
4. Principles for sharing water storage/surpluses should be clearly laid down. A minimum equity should be ensured among the farmers and groups of farmers.
5. Design should provide for the "Principle of Redundancy." Thus, if a system has high sensitivity to environmental accident or decay, certain redundancies, or slacks, have to be provided for shock absorption. In the case of irrigation systems, this would mean provision of en route or buffer, or night storage, or escapes in case there are probabilities of heavy rainfall or floods. Such safeguards promote the stability of the system.
6. In order to increase water-use efficiency, conjunctive use of groundwater and flow water has to be considered. Conjunctive use can ensure regularity in water supply despite irregularities in canal operation. It can be organized collectively, via water associations/societies or on an individual basis, stipulating that canal water would not be supplied at designated frequencies. How these issues were resolved in three farmer-managed irrigation systems in Maharashtra State, India, is discussed in this paper.

THE PHAD SYSTEM

Farmer-managed irrigation systems are not new to Maharashtra, especially in the northern districts of Nasik and Dhule. In the mid-seventeenth century, water from three rivers in these districts was regulated by building a series of weirs/bunds and diverting it through canals to the nearby croplands. Historical records are scanty on who constructed them but available evidence suggests that local leaders built them and then approached the rulers for hereditary rights as village heads. They were then made responsible for maintenance and distribution with the help of local farmers. These systems are locally known as phads.

British rulers did not disturb the system. However, in view of the poor maintenance of the physical system they systematized the organization and management around the 1860s by imposing responsibilities on the groups and by giving powers to impose taxes/fees on the beneficiaries. Guidelines were framed for maintenance activities and water distribution and also for managing financial accounts and funds. The government did not take any responsibility except that of broad supervision.

Until 1960, about 70 small farmer-managed systems were in existence irrigating an area of about 4,800 ha. Today, only about 33 groups are functioning as the river flows are affected by catchment degradation and/or water-resource developments on the upstream side. The extinct groups are generally located on the downstream weirs where water availability in the post-monsoon season has become critical or nonexistent.

Physical System

The physical system consists of a weir, a canal, and then secondary and tertiary channels irrigating the fields. The group of beneficiaries on a given weir is responsible for maintenance, operation, and distribution. Depending on the topography, a weir commands an area of 50-400 ha. As the height of the weir is the concern of both the designated beneficiary village and of the beneficiaries of successive downstream weirs (as these are fed from the overflows of the upstream ones) no single group can tamper with it. A watch is kept and if any group tries to raise the height quick action is taken.

In most of the weirs there is only one canal. If the command is available on both sides, two canals are designed. However, to ensure equity between the two groups, sill levels of both canals are fixed to be equal so that in case of scarcity water is shared on an equitable basis.

The canals run for a distance of two to ten kilometers (km) through a ravine to the command area. Along its length, a few escapes are provided for diverting excess flows. These are also used for the disposal of silt during maintenance activities. The canal system is very elaborate, consisting of deep cuts, tunnels, and a number of aqueducts. Wherever topography is favorable, free catchment is tapped and integrated in the system. There are distributaries to the canal for feeding different sub-areas. However, distributaries have the same discharge capacity as the canal. Therefore, only one distributary carries the full canal water at a time. There is a masonry

structure at the head of the distributary and diversion of water is controlled by putting wooden planks or earthen temporary bunds across the canal.

As there are yearly variations in water availability, the command is divided into permanent and temporary irrigated areas. Only in good rainfall years does the temporary area get water. Generally this area is at the tail end.

One aspect of the canal and distributary design is worth noting, viz., existence of a large canal capacity in relation to irrigation requirements. The capacity of the canal is practically constant from the weir down to, and including the distributaries. Thus, the capacity factor increases from head to tail. This design provides greater flexibility for operation at the field level.

The command area is divided into blocks (phads, from which the system takes its name), ranging from 4 to 30 ha. Whatever may be the ownership in a given block (and there are up to 70 landholders in the block), only one crop is grown in the given block. The rotation sequence of crops in the block is decided by the managing committee at the beginning of the season and is binding on the members. This design avoids differences in requirements of water application.

The sequence of irrigation in the block is from head to tail. In this sequence the efficiency of water application is relatively better. When the upper farm is irrigated, any excess flow reaches the farm below but before the irrigation in the upper farm is completed. There is also no need for fine adjustments of flows in the distributaries to avoid wastage of water in the channel. The only care needed is to divert the water from the outlet in advance of the flow reaching the last segment of the tail field so that the water in the "pipeline" is not wasted.

This type of sequence requires high social discipline, ensured by two organizational innovations. In this system, water application is not performed by the landowner; it is an exclusive prerogative of the waterman appointed by the committee. Second, no second watering is allowed until the last tail end plot is irrigated. This ensures that water scarcity in any season or year is equally distributed.

Maintenance

As the whole system is managed and operated by the farmer groups, annual maintenance has to be organized collectively. The weirs do not need much maintenance and repair. But the canals and distribution system have to be cleaned at the start of each irrigation season. Two months ahead of the irrigation season a general meeting is held where all the irrigators are informed of the maintenance and repair needs. Each irrigator has to provide a pair of bullocks and three men for one day. Those who cannot provide these have to bear equivalent monetary charges. The work consists of cutting the bushes and weeds, removing silt, and cleaning with bullock-drawn scrapers. Bed stones are provided in the canal and distribution system to indicate the levels beyond which silt and other debris are not to be removed. The farm watercourses are maintained by individual irrigators. In addition, individuals have to maintain the channel length between the upstream offtake and their own farms.

Management Aspects

For overall management and supervision of the system, a committee is elected by the assembly of irrigators to hold office for three years. The committee appoints irrigation staff (supervisors, watermen, and watchmen) every year, hears complaints from the irrigators and the staff, and is responsible for policy decisions on water allocation and maintenance. For a command of about 150 ha, there are 2 supervisors, 6 watermen, and 6 watchmen. Supervisors and watermen are responsible for flows in the canals and distributaries and water application in the field. Watchmen are responsible for crop protection, particularly in the harvest season. Generally, the staff is paid in kind by the irrigators. If the crop is a cash crop like sugarcane payment is made in cash. This method of payment does away with keeping accounts at the committee level, besides providing incentives to the staff for careful tending of the crops at different growth stages, as they get a share in kind. The share is fixed in terms of crop rows in the field or some percentage of the total produce.

Financial accounting is kept to a minimum as it is confined only to collection of fines in case of defaults.

Finally, two more organizational innovations aimed at resolving conflicts may be noted. The command is demarcated on the basis of average annual flows. It is only in good rainfall years that the temporary irrigation tract receives water. The farmers in this area know by October whether they will or will not get water and plan their crops accordingly. In low-rainfall years, average water flows are not available. To the extent this is predictable early in the season, the cropping plan and the area in the permanent irrigation tract are suitably adjusted in consultation with the irrigators. As most of the irrigators in a given system reside in one village, this type of consultation poses no difficulty. If the scarcity is noticed late in the season water is rationed by extending the irrigation interval.

Second, in most of these systems there is an idle length of the canal between the weir and the command. As this length sometimes passes near an upstream village, the villagers are likely to divert water for unauthorized use. Therefore, a convention is arrived at whereby a day or a half day in a week is allowed to the upstream village. This is a very practical solution for avoiding potential conflict.

In conclusion, it may be said that this 350-year-old farmer-managed irrigation system meets all the design criteria of equity and efficiency, considering the "state of the art" available then. That it has survived until now demonstrates the inherent strength of the organizational and technical design.

SAMVATSAR WATER DISTRIBUTION SOCIETY

With the advent of British rule in the 19th century the administration created large-scale irrigation facilities in the latter part of the 19th century, building large dams and reservoirs commanding over thousands of hectares in the arid areas of eastern parts of Maharashtra. These systems were

not only government-designed and -owned but were operated and managed by the bureaucracy right down to the farm level. The government agency fixes the crop pattern, decides water distribution frequencies and water allocation, maintains the physical system down to the farm gate, and deals directly with individual irrigators. Though not anarchical, the system as it developed was inequitable, water wasting, and prone to manipulations in the hands of influential irrigators and self-serving government employees, especially at the lower levels.

The state government prepared plans for the active involvement of the farmers in the large irrigation systems but most of these plans remained on paper. In isolated cases, some local farmers took the initiative to form small groups for water management. One such group was formed in the 1930s in Samvatsar village in Ahmednager District.

Genesis

In 1912, a large dam was built in Nasik District on the Darna River, a tributary of the mighty Godavari River. The dam has a potential of irrigating 25,000 ha in Nasik and Ahmednagar districts. Samvatsar village is located on the tail-end distributary of the left bank of the Godavari canal. Though the dam is on the tributary, canals take off beyond the confluence and hence, the canals are named after the Godavari River.

The genesis of the Samvatsar Big Bagayatdar Cooperative Society, a water-management group, is rather interesting. On commissioning of the canals in 1912, it was found that there was no demand, as the local farmers did not have the necessary technical background or the financial ability to employ irrigated agriculture. A few Mali families (a progressive agricultural community) migrated to the area from the nearby Pune District and took lands on lease or by outright purchase for sugarcane cultivation. As the joint-stock sugar companies were in the vicinity marketing was not a problem. However, these companies also secured lands on long lease for sugarcane cultivation and executed agreements with the irrigation agency for supply of canal water on a volumetric basis. Due to state politics, the Malis were concerned that they might lose land to the companies. They were advised to form a cooperative society for obtaining water on a volumetric basis and then distribute to the members for sugarcane cultivation.

The society was formed in 1936, with 11 members (now 45) having an area of 160 ha, lying at the tail end of the canal. The society command is not continuous, as there are patches of land belonging to local farmers in between, who are denied membership. To date, only Malis are members. In this sense it is a closed group.

Agreement with the Irrigation Agency

An agreement was signed with the irrigation agency for water supplies. The terms and conditions are: 1) The agency shall supply water on a volumetric basis to a maximum area of 40 ha for sugarcane cultivation; other crops can be irrigated, and be assessed on a volumetric basis. 2) Water allocation is calculated at 280-centimeter (cm) depth for sugarcane, at the minor heads.

Measuring devices would be installed. 3)Water bills are to be paid by the society. 4) Rotation frequencies and timings would be fixed by the agency. The society shall indent for water for every rotation, 15 days in advance.

A managing committee elected by the members looks after the delivery and further distribution. The committee has appointed a secretary and gaugeman-cum-waterman.

Management of Water Distribution

Before the start of the season, the society invites water indents from the members. These are consolidated and sent to the irrigation agency. The agreed-upon quota is then proportionately divided by rotations and the agency informed accordingly. The discharge at each of the three supply points is six cubic meters per second (cusecs) and this is measured jointly. The society's waterman then controls this discharge and delivers water to the farm gates of the members by sectioning it among four to six outlets. Water application in the field is the responsibility of the members, with the help of the waterman. From experience it is found that one hectare can be irrigated in 3.75 hours with a flow of six cusecs. Within this time allocation, the depth in the field per rotation is quite high (18 cm) and water is wasted. It appears that the society has not paid much attention to field-irrigation efficiency.

Water management at the field level is a bit complex because of the plots within the command area owned by nonsociety members, and because of different water charges for sugarcane and other food crops. Though the agreement provides for volumetric charging, over the years convention has established that a volumetric rate is charged only for sugarcane whereas the grain crops are charged on a crop-area basis. This system is in the interest of the society, as the volumetric rate is higher than the crop-area rate in respect to grain crops because of the concessions given for raising food crops. When water is released in the minor channels the society's area is irrigated first and records of water deliveries are kept. The allocation of water between sugarcane and other crops is only judgmental and the agency accepts the version offered by the society.

The society has worked satisfactorily for the past 55 years and has declared dividends. Of late, however, some problems have arisen. The agency has not been in a position to supply the guaranteed allocation in view of the rising nonagricultural demand for dam water. Agricultural yields have been adversely affected. To overcome the water shortage, members have dug wells. The well waters are not managed nor monitored by the society and the society has no intention of integrating well waters with the variable canal flows.

Maintenance of the parts of the physical system is primarily the responsibility of the concerned members, with the society having a supervisory role. In view of the family relations among the members, this work is executed smoothly and no conflicts are reported. Further, the physical system is quite small compared to the phad system.

The technical design of the system was determined prior to the formation of the society. The group had to adapt its performance to the given design. Not enough attention has been given to build up slack in the form of en route or buffer storage. The need for this is urgent in view of the variable canal supplies and the fact that the command is situated at the tail end, which affects reliability adversely. There is also no provision in the design for conjunctive use of groundwater.

It appears that the society is now at the crossroads. It requires guidance on buffer storage, water-application methods, crop technology, and irrigation efficiency. Crop pattern may also need a drastic change in view of the shortage of canal waters. It also appears that by sectioning the command of major irrigation systems, it is possible to involve the farmers in water management. What is needed is a strong legal and technical framework. Discussions with the society members show that they would never abandon their group management as it has benefited them over the last 50 years. However, they expect assurance from the government agency of reliability and delivery of agreed-upon water supplies. Alternatively, they want to change the crop pattern stated in the agreement. There is no need for changing the organizational design as the group is coherent and compact. However, for achieving the wider goal of social integration and for operational efficiency, non-Mali irrigators should be included in the society.

DATTA COOPERATIVE WATER DISTRIBUTION SOCIETY

The third case does not refer to any established water group but to the attempts made so far to establish one by the farmers. The society became operational only from July 1989 and more experience has to be gained. This case is included here as it highlights the problems that have to be faced and resolved for establishing farmer management for large irrigation systems.

Physical System

In the late 1960s, the State Government built a major dam on the Mula River, another tributary of the Godavari, waters of which were to benefit 80,000 ha in 149 drought-prone villages. The service area was demarcated on the basis of a design pattern with only five percent of the area for perennial crops (mostly sugarcane), the rest being allocated to seasonal monsoon, winter, and hot-weather crops. The system became operational in 1972-73. Water management, distribution, and maintenance were entrusted to bureaucracy, as was the practice in government-owned systems. The system has not irrigated more than 40,000 ha in any year. In addition, the bureaucratic management was prone to several abuses, and in general, farmers were not happy.

In early 1986 the Center of Applied Systems Analysis in Development approached the farmers in the command of Mula Minor 7 with a suggestion that they form a water users' association for managing distribution in the command by taking deliveries at the minor head. The response from the farmers was enthusiastic but they wanted help in organizational design and for sorting out technical details with the irrigation agency which was not amenable to their entreaties.

Minor 7, with a discharge capacity of 450 liters per second, is located 40 km from the dam site and draws water directly from the main canal. The service area is fixed at 500 ha. The number of farmers is around 250. With a length of 2.2 km, Minor 7 feeds 13 outlets, each with a 30 liters/second discharge capacity. The physical system was designed according to government norms,

with no consultations with the farmers. The system is not well-maintained; management of distribution is with the agency and the agency deals directly with every irrigator. There is considerable dissatisfaction with the present management practices.

Organization

The farmers decided to form a cooperative water users' association. It took almost two years, as the concerned department created many obstacles. It was necessary to finalize a Memorandum of Understanding between the society and the irrigation agency, which is controlled by the government. It took two years to finalize the Memorandum of Understanding in which the agency allocated an annual quota of 1,775,000 cubic meters (m^3) of water to the society to be distributed in the proportions of 31, 55, and 14 in the monsoon, winter, and summer seasons, respectively. The society would be charged specific rates based on volume delivered in each season, and all restrictions on crop pattern were removed. The irrigation agency agreed to carry over the unutilized quota from winter to hot weather under certain conditions. Finally, the society was given total responsibility for maintenance of the physical system, for which the government agreed to give an ad hoc grant.

Though theses terms emerged after protracted discussions, the members felt a bit disappointed on the quantum of allocation. They expected that the allotted water would be in the same proportion to the society's service area as the ratio of water availability in the reservoir to the total service area of the project. In fact, the allocation was only two-thirds of the proportion.

Tasks for the Future

The tasks before the society now include designing an operational plan for water distribution among the members, upgrading and maintaining the physical system in the command, developing rules and sanctions for efficient water use, introducing innovative crop technology, and providing en route storage for canal-water supplies as well as integrating the canal water with groundwater supplies.

RECOMMENDATIONS

This brief description of three gravity irrigation systems leads to some affirmative conclusions for accelerating the process of establishing farmer management on small and large irrigation projects.

1. The water group must not be too large nor too small. The range should be 150 to 300 farmers with a command not exceeding 500/600 ha. In the major systems, the command should be sectioned on the basis of topography, hydrology, social cohesion, and harmony, with one or two delivery points.
2. There is a need for providing a legal, financial, and organizational framework defining the action arena and the roles of the government agency, the group/association, and individual members. Experience shows that the irrigators are willing to come together provided they feel that their interests are better served. The organizational design should be such that the group is close to the problems of each irrigator and is in a position to provide reliable, stable, and predictable service. It should be emphasized that water delivery is only part of the solution; the group also has to work for the introduction of crop technology.

   The design of the physical system should be settled in consultation with the group and members. Where a system is already built, further modifications should be discussed with the farmers. Cost aspects need to be discussed and formulas for sharing costs determined.
3. Main system management should be held responsible for regular, agreed-upon supplies and penalties should be provided for nonperformance. Today, whatever agreements and memorandums of understanding that have been drafted are lopsided in the sense that penalties are provided only for the groups/farmers and not for the agency, for nonperformance of the tasks.
4. The crop pattern is controlled and regulated by the bureaucracy. Once water is allocated on a quota basis, groups should be left to decide their own cropping patterns. Maintenance should be left to the groups, as they can do it with less costs and on time.
5. If there is crop diversity, outlets need to be gated for efficient use. It would be inadvisable to fix standard-sized pipes, throttled to the authorized discharge. Gated outlets would provide for variable supply and flexibility.
6. Rules have to be formalized as to when, where, and in what amounts, water would be provided to the members. Rules should provide for equity and efficiency. Penalties should also be specified for noncompliance .
7. The agreement between the irrigation agency and the society should provide incentives, financial or otherwise, to create an environment for farmer participation.

SUMMARY

The environment in Maharashtra is favorable for large-scale experimentation with water users' associations. Some experience has been gathered. Careful attention needs to be given to organization and technical designs, and details have to be worked out in consultation with the farmers. In order to obtain the participation of the farmers in managing irrigation systems at various levels the government bureaucracy must also be reoriented to accept and encourage farmer management and ensure equity for water users.