IMPROVING IRRIGATION SYSTEM PERFORMANCE

by

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Abstract

Performance of irrigation systems can be assessed in a number of different ways: output performance that addresses the tangible output from systems, operational performance that addresses the degree to which plans were actually implemented, and performance in respect of setting feasible and appropriate objectives for the system. Improving output it unlikely to occur unless there is an appropriate management system within which decisions are made and evaluated.

Examples from several different systems are presented to show that if objectives are properly identified, and accompanied by appropriate implementation plans, it is possible to improve output performance significantly. In all of the studies presented, performance improvements were obtained without major interventions, with low financial requirements, and within the existing managerial capacity of irrigation agencies.

Inherent in any effort to improve performance is the collection of appropriate information: management required accurate and objective information. In addition, it is also clear that long-term sustained improvements in performance will only materialize if there are proper rewards for achieving high levels of managerial performance, and sanctions against managers who perform poorly. Performance improvement and institutional adaptability go hand in hand.

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1. Different Perspectives on Performance

Performance is one of those terms that we all think we understand but when we start to talk about it with colleagues it appears that we frequently are talking about entirely different things. Faced with the task of addressing issues of how to improve irrigation system performance, therefore, it is necessary to start with a few broad definitions concerning performance.

From the a management perspective, there are three broad categories of performance that appear relevant for irrigation managers: output performance, operational performance, and performance in respect of setting objectives. As we shall see, these three types of performance are linked by the management environment within which planners and managers function (Murray-Rust and Snellen 1991).

Performance assessment requires two sets of information to move from being descriptive to analytical: standards and causality.

Standards: Every performance indicator has to have an accompanying set of standards so that managers can determine whether the actual value obtained was within reasonable bounds. For example, merely to give information on yield or cropping intensity says relatively little: a rice yield of 5.0 t/ha may appear to be very good, but there are systems that routinely exceed these values and would be highly disappointed if averages fell to this level. Similarly, if a desired discharge is 1,000 l/sec, what is an acceptable deviation: ± 100 l/sec, ± 200 l/sec or 0 1/sec.

Causality: A simple value or measure of performance tells nothing about what would have to be done differently in order to increase the value to a more desirable level. Commonly, performance improvement is sought through exhortation ("we must all work harder to achieve the targets") but this will not be successful if there is some underlying barrier to attaining these goals. If performance is to improve, it has to address how things happen as well as merely describing the current level and hoping it will improve.

(a) Output Performance

Output performance is the tangible result of management of an irrigation system. It is frequently expressed in terms of agricultural factors: typical measures include yield, gross production, cropping intensity and irrigation intensity.

From the perspective of economic analysis of irrigation projects, output performance has to be measured: the production from the system is frequently the only measure of the benefits that accrue from the initial investment. Therefore, monitoring systems normally focus on these types of output parameters. From the perspective of irrigation management, evaluation of what led to a particular level of output is particularly difficult because there are many parties involved, no one of which ever has full responsibility. Output, measured in terms of agriculture, represents a synthesis or integration of such diverse factors as the decisions and inputs of farmers, actions of government officers, market conditions, weather, etc. Some of these factors cannot be controlled at all, so that output performance will never be completely predictable, while others result from the actions of a series of individuals in an environment that may be only partially coordinated.

The easy way out is to blame somebody else. This is a relatively common attitude of government officials throughout the world. If agricultural output fell below expectations, then it is easy to blame the farmers. If water was wasted, then again it is easy to blame the farmers. No doubt, in many cases, to some extent, farmers either individually or in collaboration, contribute to lower than desired performance. But it would be hard, if not impossible, to find a system where the actions of officers responsible for inputs into the system also did not fall below expectations. It is for these reasons that examination of operational performance becomes so important.

(b) Operational Performance

Operational performance is concerned with whether specified targets have been achieved. In colloquial management science, this can be expressed in the form:

"Am I doing things right?"

At each stage in the management process, it is necessary to compare actual levels of achievement with a set of specified targets. If actual conditions are at, or sufficiently close to, the target then operational performance is high. If, however, there is an unacceptable discrepancy between actual and target conditions, then some evaluation of the cause of the discrepancy is required. The advantage of this approach is that performance can be expressed as a simple ratio irrespective of actual quantities, and lends itself readily to comparison between different locations.

The initial focus of this evaluation must be to see what different actions can be taken in order to more closely meet target values. This requires that the individual manager is sufficiently in control of available resources and can make changes in management actions that will lead to a higher level of target achievement without having to seek assistance from outside.

Intrinsic to assessment of operational performance is the clear definition of tangible targets. Water delivery lends itself very readily to this type of target setting and achievement process. At any location, it should be possible to measure water and make the necessary adjustments to control structures to achieve a specified target discharge. The performance of the system operator can then be assessed relatively easily in terms of the ratio of actual to target discharges.

Interpretation of the ratio between actual and target conditions requires some idea of the acceptable range of values within which no remedial action need be taken. If, for example, water can be measured under field conditions with an accuracy of ±10% then it is reasonable to expect at least a similar range in acceptable values of target discharges.

What is not acceptable, however, is for managers to unilaterally change target values. The target that any given individual is attempting to meet may be linked to targets provided separately to others. Changing a target independently may result in unexpected negative consequences. For example, if all the outlets along the upper half of a canal are closed without simultaneously reducing discharge into the head of that canal, a breach is likely to occur in the tail-end portion.

It is also tempting for managers to change targets unilaterally because they do not appear to be appropriate. However, changing targets in this manner is not strictly part of operational performance but is part of objective setting.

(c) Objective Setting Performance

The third element of performance is that of setting appropriate and feasible objectives. At one level, this may seem to be a relatively straightforward task, but this is only so if objectives are set without due regard to the resources required to achieve the specified objective.

Setting an objective for which there are insufficient resources (water, staff, finances) is just as much poor management as failing to make adjustments to the setting of a gate so as to meet a particular target discharge. In this respect, performance assessment is much more closely concerned with the managerial performance of individuals.

Similarly, merely setting an objective is insufficient. It has to be accompanied by a simultaneous process of reducing the overall objective into a set of operational targets for each managerial division.

In colloquial management science, objective setting perform can be expressed in terms of a simple question:

"Am I doing the right thing?"

The focus is now both on the quality of the objectives themselves, and whether the subordinate targets are attainable. Any senior manager who insists on setting targets that do not result in the accomplishment of the overall objective is no longer playing an effective role. This is the underlying distinction between a manager and a bureaucrat: a bureaucrat is more likely to be concerned with the fulfillment of a target, irrespective of its immediate utility, whereas a manager is responsive to the consequences of previous decisions, and is wiling to make changes to resources and targets so as to achieve the desired objectives.

For a manager to be effective, therefore, there has to be an overall operating framework that facilities management inputs but also makes a clear distinction between the different types of performance, who is responsible for what actions, and when assessment and evaluations are required.

2. A Management Framework for Improving Performance

A well-managed enterprise operates through a cyclical set of activities, each of which is undertaken periodically by a clearly defined group of people. Within the publicly managed irrigation sector, it is rare to find such a process being implemented: instead, all activities get mixed up, and the responsibilities of each person or group of people are poorly defined (if at all).

Management science identifies a set of activities that are necessary components of a well-managed system. Although it is possible to envisage a situation where improvements can be made in each one of the activities described below, it is obvious that in the long term, it has to be an integrated process that is fully concerned with performance at each stage of that process.

In terms of an irrigation system, the five steps can be summarized along the following lines (Murray-Rust and Snellen 1991).

(a) Setting Objectives

The objectives of operation of the system have to be clearly stated so that managers can determine whether the results of their actions were what was intended. At irrigation-system level, typical objectives for water delivery might include equity of water distribution, matching water deliveries to field-level demand, or delivery of reliable water supplies. Output objectives would be gross production targets. Normally these objectives are long-term but are re-established prior to each season or year.

(b) Setting Targets

Targets are normally a specific quantitative value used in short-term implementation. Because they are expressed in numeric terms it is relatively easy to determine whether they were achieved, and the level of precision attained. For water delivery, typical targets include discharge, water levels, and schedules at each location in the system, and represent the instructions passed down to field-level staff for subsequent implementation. On the output side, targets include area to be irrigated each season, timing of agricultural activities, cropping patterns and yields.

(c) Implementation Plan

This represents the scheduling of the activities to be undertaken by the staff of the agency at different levels throughout the period, including the arrangements necessary for achieving the targets set down earlier. It will involve assessment of the financial, human and other resources necessary for effective implementation.

(d) Control

Managers have to be able to determine whether the plan was implemented as expected, and that targets were fulfilled. If they were not met, then managers need to be able to ensure that the required steps are taken to obtain a better level of achievement. This set of activities includes monitoring, which is no more than the process by which information on conditions within the irrigation system are collected for use by managers. The information may be used to adjust targets, but within any season it is impossible to expect to change objectives.

(e) Review and Evaluation

At the end of each irrigation season, the net effects of the management of the system have to be evaluated. Unlike monitoring, which largely focuses on the fulfillment of targets, and periodic adjustments of these targets in light of changing conditions within the system during the season, evaluation is concerned more with whether meeting the set of targets laid down resulted in the attainment of the wider system objectives.

In specific terms, the actual responsibilities for each step will have to be defined in relation to the overall institutional framework and responsibilities of different agencies and farmers. In so doing, a differentiation must always be made between responsibility for implementation of a particular target and where responsibilities are shared in respect of decision-making or objective setting. The relevance of these management conditions for irrigation system improvement can be illustrated by looking a little more closely at water delivery.

3. Improving Irrigation System Performance

A major function of irrigation systems is to raise agricultural output above the levels normally obtained under rain-fed conditions. From a strictly economic perspective, outputs from the system have to be sufficient to repay the investment and recurrent costs of the system; if water is delivered in such a way that farmer capacity to produce additional output is undermined, then performance is clearly inadequate.

Typical complaints about water deliveries are that they are unreliable, inadequate and inequitable. However, starting from this perspective does not by itself show ways in which performance can be improved because these are qualitative and ill-defined concepts. Many managers may, at least informally, recognize that they face these problems but they may not have either the facilities or the institutional support to make improvements.

In a management sense, reliability, adequacy and equity are objectives, and need to be broken up into more specific targets for operational purposes. If such targets are chosen carefully and operational performance is high, then there is a high probability that the wider objectives will also be obtained. This is best illustrated by a few examples of how performance can be improved in a systematic but relatively simple manner.

(a) Improving Reliability

Reliability in terms of canal operations means that there is some predictability in both discharge and timing of water deliveries. At each point along a canal, from the head of the system down to the individual farmer, there is always intense interest in the reliability of deliveries. It does not matter whether this is at the level of Executive Engineer, Assistant Executive Engineer, Sub-Engineer, gate keeper or farmer: each person in the chain is concerned with how much water will be delivered and when it will be delivered. In canal based systems, this is of critical importance because each downstream person is dependent on the actions of their immediate upstream neighbors.

Implicit in this situation is the need to be able to measure water at every location in the system where operational responsibility passes from one person to another. If water cannot be measured, then the result is frequently a set of interminable disputes about whether or not each person has or has not received their fair share.

Despite this, it is relatively uncommon to find an effective and reliable measuring structure at these key locations. An example of this can be seen from the Maneungteung system in West Java, Indonesia (Murray-Rust and Vermillion 1991). In this relatively small (7,160 ha) system, there are 12 irrigation inspectors, each of whom is responsible for arranging water deliveries within an area of about 500-750 ha. According to official operational rules, each irrigation inspector should know how much water was received. As can be seen from Table 1, of the 15 locations where water passed from one irrigation inspector to another, only 8 had a measuring device. Further, in order to facilitate water control, each location where water passes from one administrative unit to another should have a control structure. Prior to rehabilitation only 5 of the 15 locations had sliding gates: the rest required adjustment of stop logs at some arbitrary location in the canal. This type of mismatch between the administrative boundaries and the water control infrastructure means that plans may be difficult to implement, water cannot be measured effectively, and thus it is unlikely that water deliveries will be particularly reliable.

A second way of examining reliability is to look at the delivery performance ratio. This simple ratio compares the actual discharge at any location with the target discharge. Examination of the differences between these two values tells a lot about how the system is being operated and what steps might need to be taken to operate the system more effectively. Data from a Distributary canal in the Tungabhadra Irrigation system in southern India demonstrates well the effect of operational performance on output performance. Head-end discharges are frequently at or above target so that cropping intensities also exceed targets, while even by the middle of distributary, discharges are far below target (Figure 1). One result of this type of water distribution is that, over time, cropping intensities rapidly drop to close to zero (Figure 2).

Table 1. Handover conditions between Irrigation Inspectors (Jurus), Maneungteung Irrigation System, Indonesia.

From	To	Location	Gate Type	Measurement
		Maneungteung Barat (Ciledug)		
Juru 1	Juru 2	MTR 4 Main	Stop logs	Cipoletti
Juru 1	Juru 2	MTR 4 Sec. JTS	Sliding (new)	Cipoletti
Juru 2	Juru 3	MTR 5 Main	Sliding (new)	None
Juru 3	Juru 4	PB 1 Main	Sliding (new)	Cipoletti
Juru 4	Juru 5	PB 4 Main	Sliding (new)	None
Juru 3	Juru 6	BLS 3 Main	Stop logs	None
Juru 6	Juru 7	BLS 9 Main	Stop logs	None
Juru 6	Juru 7	BLS 11 Main	Sliding (new)	Cipoletti
Juru 7	Juru 6	BLS 10 Main	Sliding (new)	None
		Maneungteung Timur (Waled)		
Juru 8	Juru 9	Weir	Sliding	Parshall Flume
Juru 9	Juru 10	M 5 Barat	Sliding	Parshall Flume
Juru 9	Juru 1	M 5 Timur	Sliding	Cipoletti
		Maneungteung Timur (Babakan)		
Juru 10	Juru 11	MB 5 Main	Sliding	None
Juru 11	Juru 12	MB 8 Sec. GG	Sliding	Cipoletti
Juru 11	Juru 12	MB 10a Main	Stop logs	None

Control Facility	Sliding	11	73%
	Stop logs	4	27%

Measurement Capability	Parshall Flume	2	13%
	Cipoletti	6	40%
	None	7	47%

Figure 1. Weekly discharges, D36 Canal, Tungabhadra Irrigation System, India.

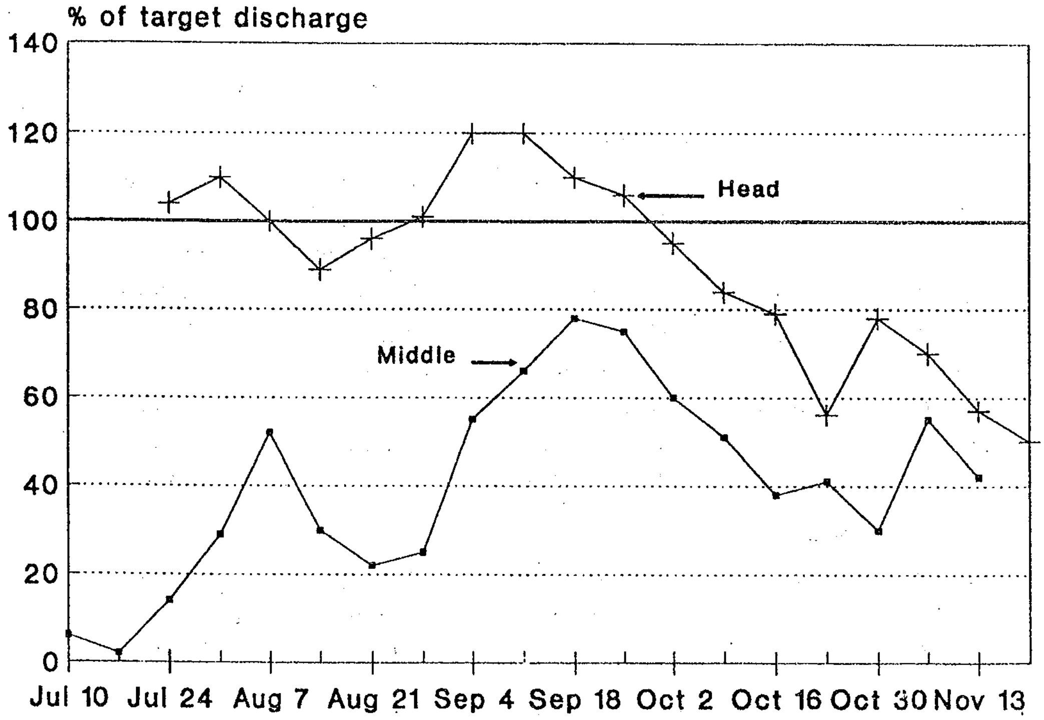
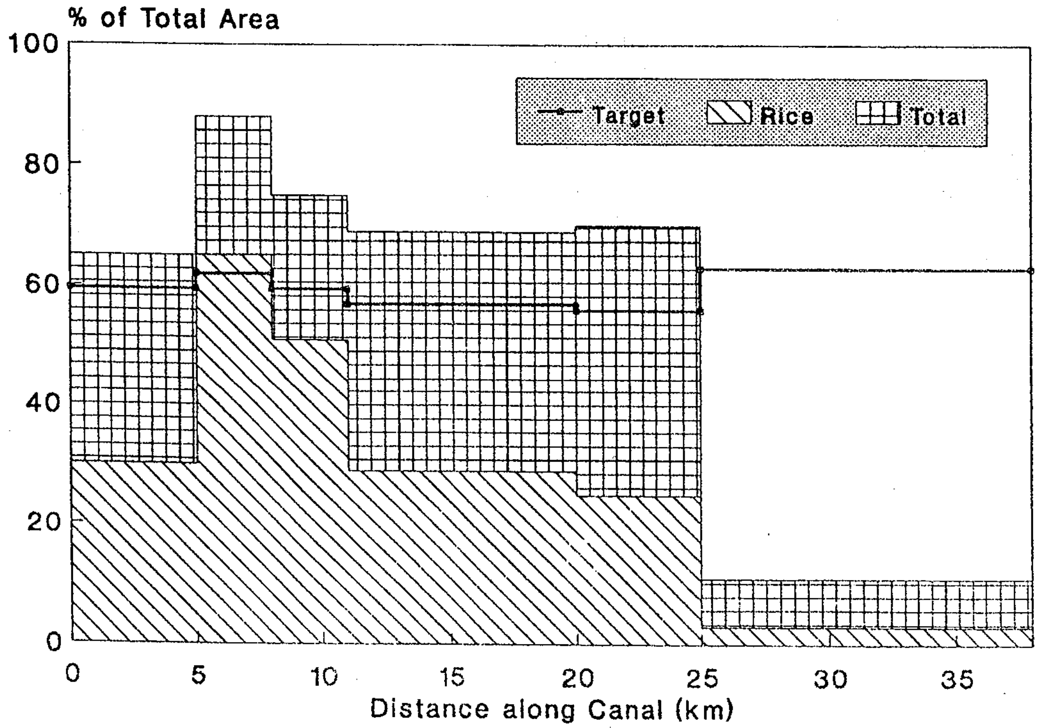


Figure 2. Planned and actual cropping intensities, D36 Canal, Tungabhadra Irrigation System, India.



The same data shows that daily fluctuations are also significant. In the head-end reaches, fluctuations are small, so that there is a relatively high predictability of tomorrow's discharge being the same as today's (Figure 3). In the middle reaches, however, fluctuations are sufficiently large that it becomes impossible to predict whether or not there will be more or less water available (Figure 4). It is common to find that in systems where the main and secondary canal system are operated in an unpredictable manner, there is greater discord between farmers and irrigation officials, and that there is a greater likelihood or unplanned interference in system operation.

An example of a highly successful intervention in terms of improving reliability of both the timing and volume of water deliveries comes from the Thamiravarani Irrigation system in Tamil Nadu (P. Gomathinayagam, personal communication). Traditionally, the start of the season has been announced in terms of the day on which the sluice gate of the reservoir will be opened. However, this information is of relatively little value to farmers who may be as much as 125 km downstream of the reservoir. All sluices at each anicut were opened in anticipation of receiving water, it took a long time for the operating head to build up upstream of each anicut, particularly at the tail end of the system, and water levels in canals only slowly reached full supply level. Farmers lost confidence in receiving water on any given day, waiting instead for water to arrive before starting land preparation.

As an experiment in 1991, it was decided that to improve operation, the start date would reflect the opening of the sluices into each canal of the system, thereby significantly reducing travel time to farmers' fields. In order to accomplish this, the reservoir sluices had to be opened a few days before the official starting date, and the pool upstream of each anicut along the river allowed to fill completely without opening the canal sluices. Thus, on the agreed date, the water level was already at full supply when the sluices were opened as scheduled, and water reached the tail end of all canals more quickly and with greater operating head than under the old system.

(b) Improving Adequacy of Water Deliveries

Adequacy has to be managed using an entirely different set of indicators. There are three main ways of dealing with the problem which should, in theory, be related to relative water availability.

In systems where water is scarce, there may be no effort to manage water to meet farmer demands: the available water is divided up on some basis, and farmers receive their shares. The *warabandi* systems of northwest India are based on sharing of available water and it is left entirely up to individual farmers to adjust their cropping pattern to their shares of water. If farmers wish to choose to underirrigate or overirrigate, that is their own responsibility, and irrigation agencies have no direct responsibility for determining how water is used.

If water is less scarce, then the second way of addressing adequacy is to have some form of seasonal negotiation between irrigation officials and water users. Typically, this process starts with some form of seasonal or annual planning process that determines the area to be sanctioned for irrigation and either assumes or dictates a certain cropping pattern (such as "wet" or "dry" crops) which further helps to quantify water demand. The result of this process is that once an area is sanctioned for irrigation, irrigation agency staff are, at least in theory, responsible for supplying the appropriate amount of water.

Figure 3. Daily discharge variations, D36 Head, Tungabhadra Irrigation System, India.

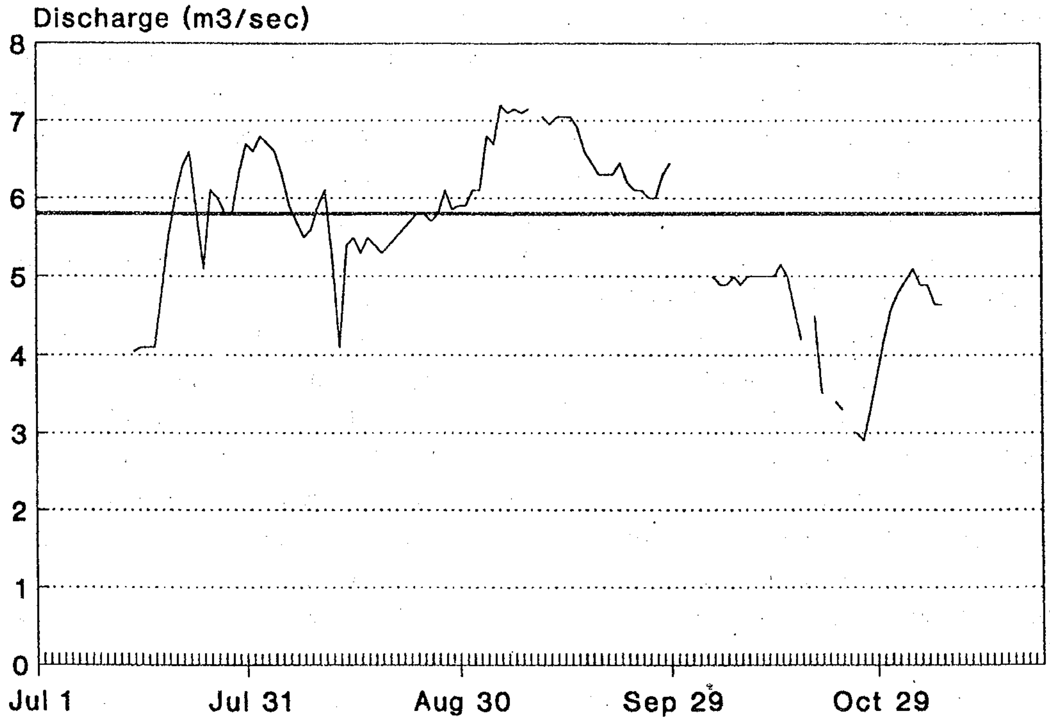
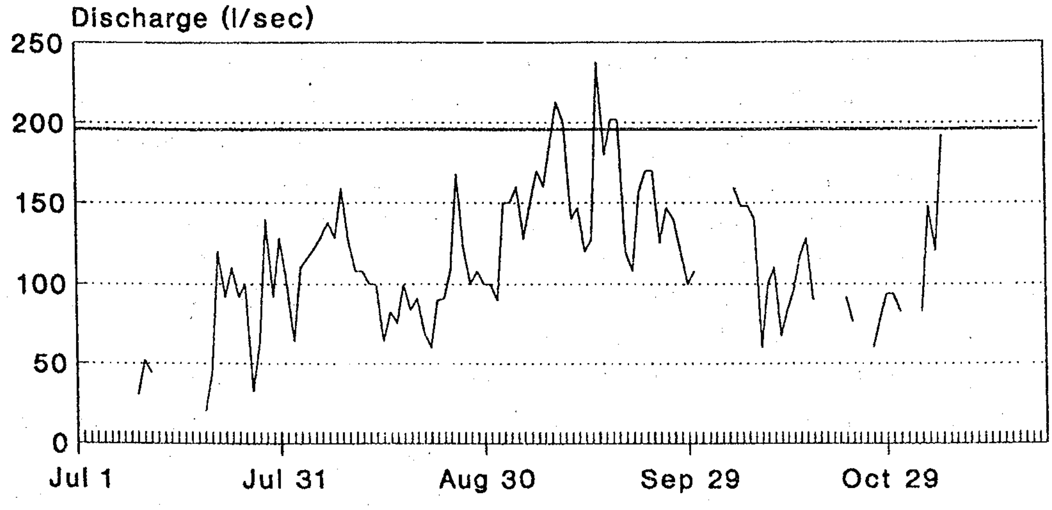


Figure 4. Daily discharge variations, D36 Middle, Tungabhadra Irrigation System, India.



The third approach is to allow farmers to grow what they wish, and then guarantee to meet the full demand. This method can only be effective if there is sufficient water to meet any possible cropping pattern, and water management focuses as much on avoiding over-supply of water than trying to share water equally between all areas.

In this section, the focus is entirely on the second approach based on seasonal planning because this is both the most common method and the most difficult to manage.

Effective planning requires that water supplies can be predicted. If no reliable predictions are made, then the planning process has to rely on careful analysis of what was achieved in the past. Typically, however, neither approach is undertaken and seasonal plans for areas to be sanctioned for irrigation becomes more of a game, and a political game at that, which reduces the manager's capacity to manage water effectively.

An example of a simple way of assessing the likely available water supply comes from Indonesia (Murray-Rust and Vermillion 1989). The Way Jepara system of about 6,200 ha is served by a small reservoir which can be used to regulate discharges into both main canals. There is frequently insufficient water in the dry season to irrigate the entire system, and a system had been developed that sanctioned irrigation for half of the system only in the dry season. On this basis, all farmers would get a crop in every wet season and every other dry season.

Although this approach achieved equity, it was inefficient. In many of the dry seasons, water was more than sufficient to meet demand for the 50 percent of the system sanctioned for irrigation. By analyzing the inflow patterns into the reservoir, it proved easy to develop a simple decision chart for the system engineer to use in determining how much land could be sanctioned for irrigation by comparing actual conditions to past conditions.

The basis for this analysis is a simple probability analysis of net inflows into the reservoir (net inflow means the balance between change in storage minus releases and spills). For each time period, a simple estimate of probable inflow into the reservoir is determined (Figure 5), and these plotted throughout the year (Figure 6) for different levels of probability. The same analysis can also be undertaken for reservoir storage levels (Figure 7) and for rainfall.

With this information, it is then possible to construct a simple table that indicates the area that will be possible to irrigate based on probable inflow, probable rainfall, and actual storage in the reservoir on a given date (Table 2). The only choice the manager has to make is to estimate system losses, and, over time, this information should be available based on measurements within the system itself.

It should be noted that the calculations involved are very simple and could be done within a few hours. The only requirement, as always, is that there is data available but then, without data management, it is not possible.

A second way of managing for adequacy is in adjusting discharges to meet a set of seasonally determined targets. A good example of how this can be done comes from a study in Kalankuttiya Branch Canal in Sri Lanka (Sakthivadivel and Merrey 1992). The seasonal planning process determines the area to be cultivated, an area that changes depending on overall water availability at system level, and which includes a mixture of rice and nonrice crops. The task of the manager is, therefore, to ensure that for the sanctioned areas water deliveries are sufficient to meet the planned crop demand.

Figure 5. Probable inflow into reservoir, 1-15 May, Way Jepara, Indonesia.

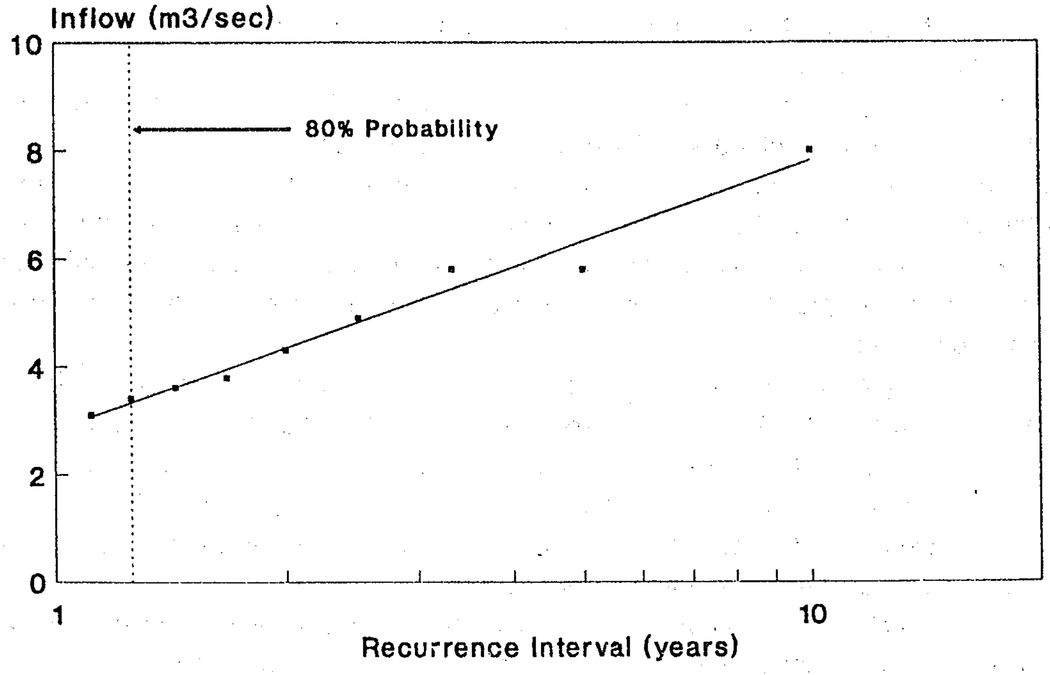


Figure 6. Probable net inflow, Danau Jepara, Indonesia.

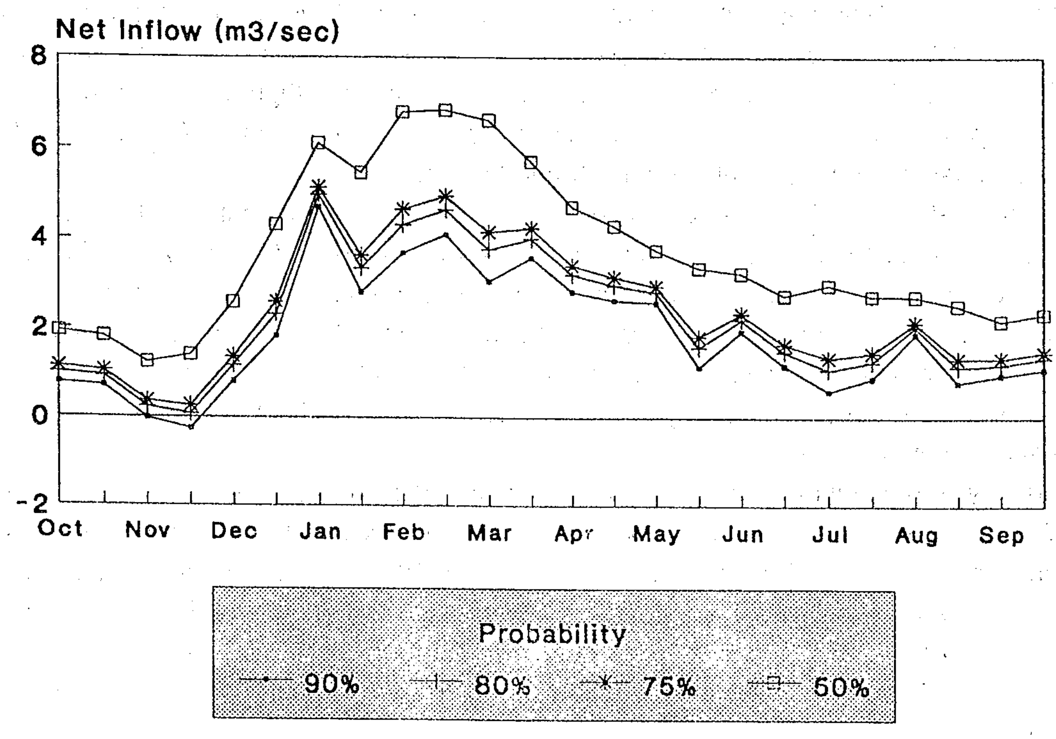


Figure 7. Probable storage in reservoir, Way Jepara, Indonesia.

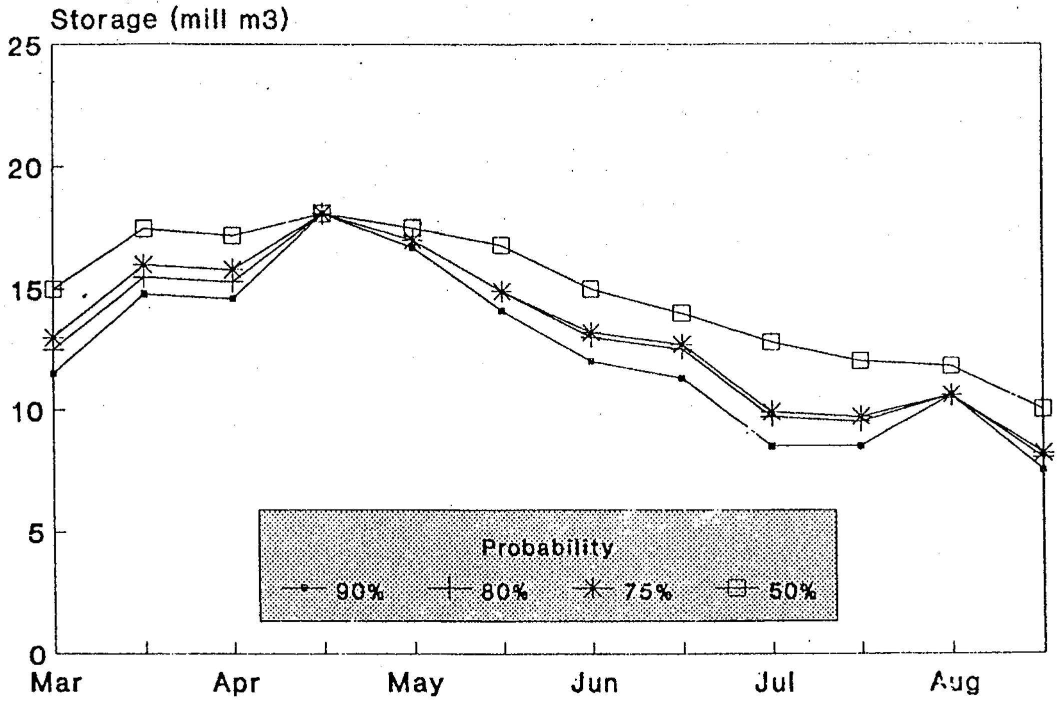


Table 2. Potential irrigated area (ha), dry season, Way Jepara, Indonesia.

System Losses	Storage in Reservoir: April 1 (mill m3)					
	20	18	16	14	12	10
10%	4538	4340	4143	3945	3748	3550
20%	4159	3978	3797	3616	3435	3254
30%	3839	3672	3505	3338	3171	3004
40%	3565	3410	3255	3100	2944	2789
50%	3328	3183	3038	2893	2748	2609

Note:	Basis for Calculations:
Water Availability	Storage on April 1 + 80% probable inflow until 15 August + 80% Probable Rainfall
Demand	1.0 l/sec at Tertiary offtake + Expected System Delivery Efficiency

Adequacy is expressed here as Relative Water Supply (RWS) (rainfall plus water deliveries divided by crop water requirement). The management strategy is to keep the value of relative water supply as close to 1.0 as possible but without going below this value.

For a subsystem the size of Kalankuttiya (5,000 ha) the selected management strategy is to try to keep the value of RWS between 1.1 and 1.25; for larger systems it would have to be higher to accommodate greater losses and greater uncertainty about actual demand. By plotting cumulative Relative Water Supply for each week during a season, the manager can keep track of performance in respect of keeping deliveries within the specified range (Figure 8). Canals that fall outside the range can easily be identified, and remedial action taken by giving slightly more water in the next time period (Figure 9).

Again, it is clear that data collection is essential to ensure that adequacy is met reasonably effectively throughout the season.

Figure 8. Cumulative Relative Water Supply, Kalankuttiya, Sri Lanka, April 01-September 06, 1986.

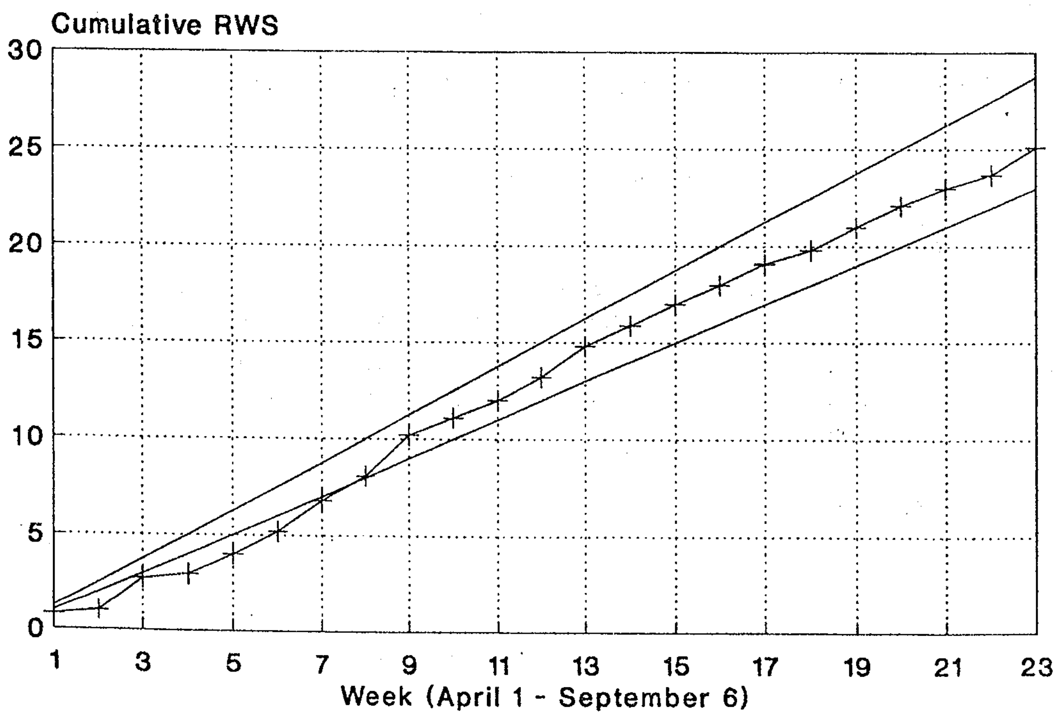
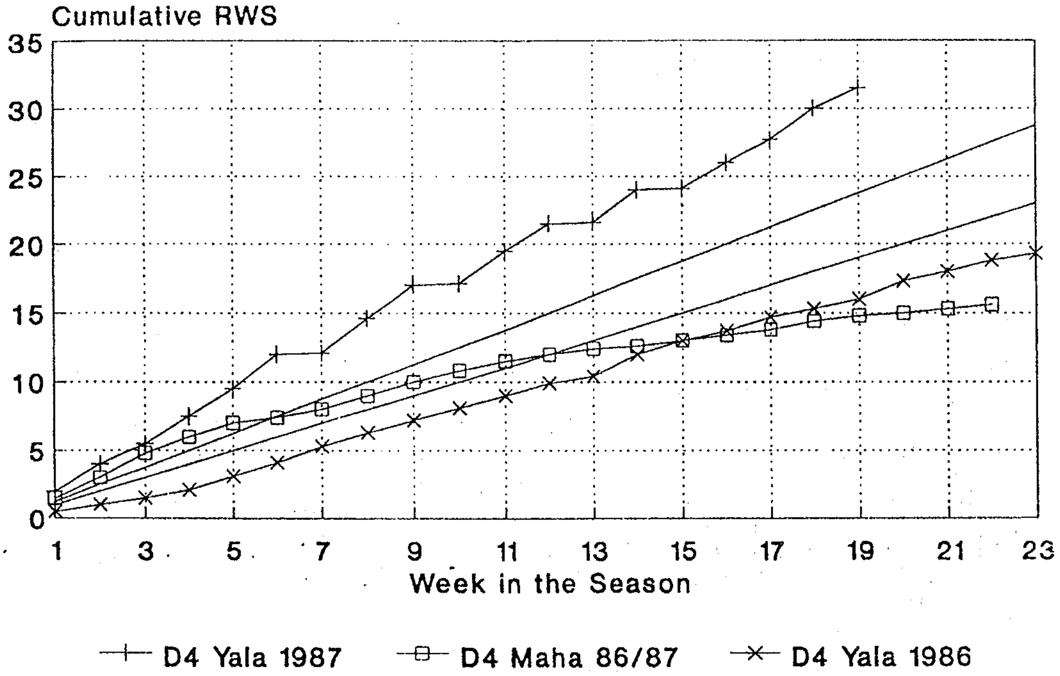


Figure 9. Cumulative Relative Water Supply, Kalankuttiya, Sri Lanka, yala 1986 to yala 1987.



(c) Equity

The final set of examples show how system management can be oriented towards achieving equity of water deliveries. In each case, equity has been taken as an equal share of water for all sanctioned users: there might be other ways of expressing equity which allow for differential water rights or to accommodate different physical conditions.

An excellent example of successful management for equity comes from the Viejo Retamo system in Argentina (Box 1990; Chambouleyron 1989). The management system here is very simple: each of the 33 tertiary blocks along a secondary is allocated a set discharge for a specified number of hours each month. Adjacent tertiary blocks are combined into a single group and are scheduled to receive water simultaneously so that discharge into the head of the secondary is kept constant any given time. One head-end group and one tail-end group are scheduled for irrigation at the same time.

This plan means that gate operations are completely routine: gates are either open or closed (no differential discharges are planned for) and the focus is on undertaking gate operations at the correct time. All farmers know the schedule, which has been agreed among them for many years, and so the operation of the system has become a simple routine. However, it is effective: equity along the secondary canal in 1988-89 was almost perfect, with only three blocks receiving significantly more than their fair shares, and three receiving less (Figure 10). When expressed in terms of volumetric deviations, the pattern of equity becomes even clearer, with only three blocks showing significant deviation, and two of these are at the tail where any excess water has to be disposed of through tertiary canals (Figure 11).

Figure 10. Delivery Performance Ratio, Viejo Retamo, Argentina.

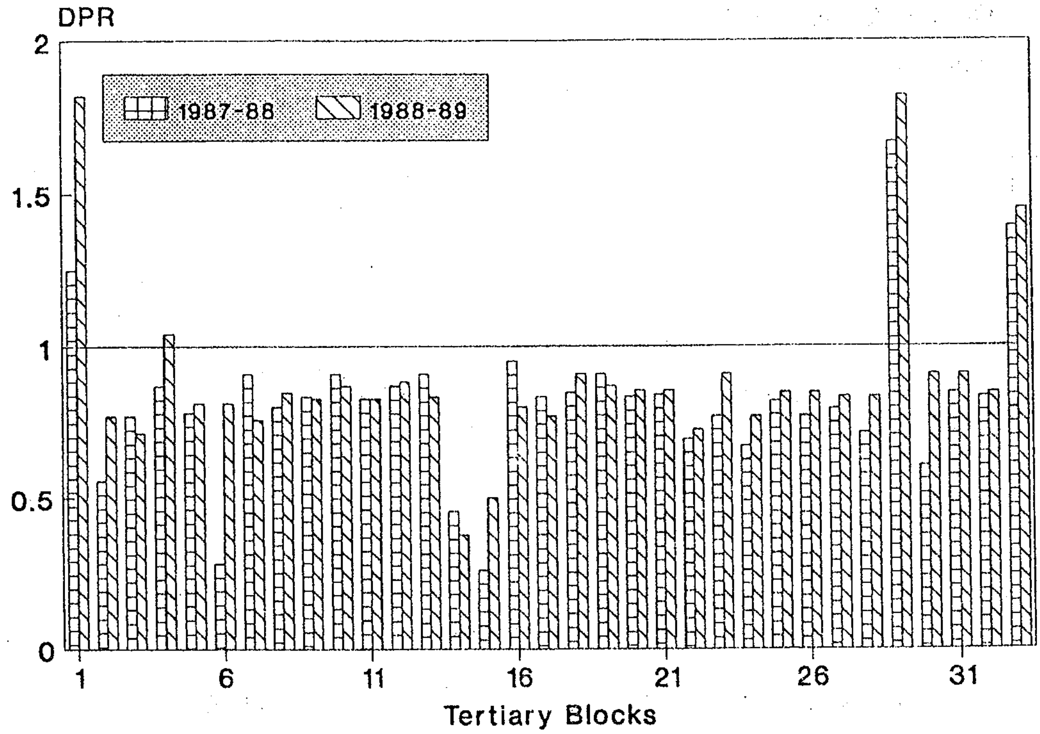
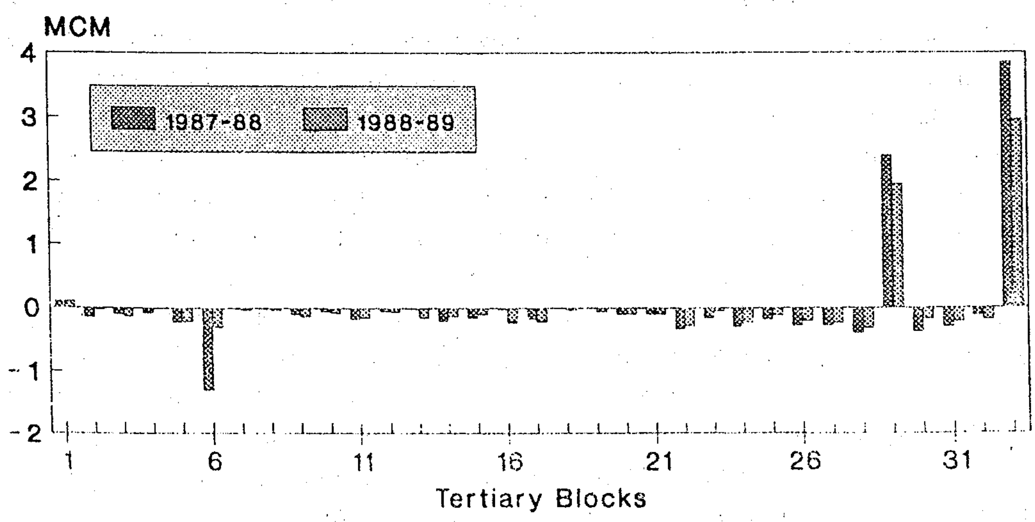
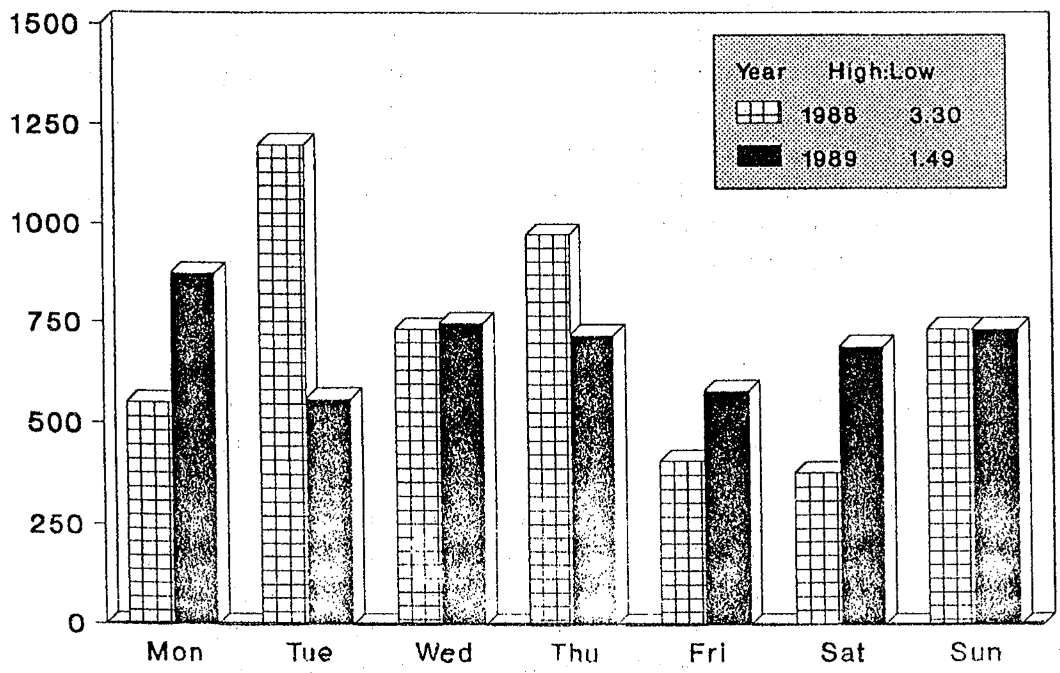


Figure 11. Misallocated volumes, Viejo Retamo, Argentina.



A second example of how management can affect equity comes from Indonesia (Vermillion and Murray-Rust 1991). During water short periods, rotational irrigation has to be introduced, and under extreme circumstances, water can only be delivered one day a week. In analyzing the plan for rotational deliveries in Maneungteung system for the 1988 dry season, it was obvious that there were significant differences in areas scheduled to receive water on each day of the week (Figure 12). On Saturdays, less than 400 ha were scheduled to receive water, while on Tuesdays over 1,200 ha were included in the plan. However, discharge into the system was assumed to be constant, resulting in a pattern where some farmers received more than 3 times as much water than others. The reason for this lack of equity, even though equity was nominally stated as the primary objective of the rotational plan, was because powerful farmers had influenced irrigation staff to give then more water.

Figure 12. Areas scheduled for irrigation, 1988-89 dry season, Indonesia.



A revised schedule, made in agreement with farmer representatives, modified the operational plan so that the area irrigated each day was more or less uniform. The most favored day had 580 ha scheduled for irrigation, the least favored had 820 ha, resulting in a ratio of only 1.50 between best and worst condition. Complete equity could not be obtained because of operational constraints inherent in the design of the system: nevertheless, the performance improvements were achieved with fewer managerial inputs that with the order system (Table 3).

Table 3. Improvements in rotations, Maneungteung East.

Irrigable Area (ha):		4871	
Number of Gates:		114	
Number of Tertiary Blocks:		70	
1. Management Requirements	**1988**	**1989**	**% Change**
Total Management Inputs	279	241	-13.6
Total Gate Openings & Closings	104	94	-9.6
Gate Supervision (hrs/week)	32.4	27.4	-15.4
a) Gates to be adjusted	16.4	9.7	-40.9
b) Gates to be kept closed	16.0	17.7	10.7
Downstream Flow Must Be Stopped	10	6	-40.0
a) Using Stop Logs	10	0	-
b) Using Sliding Gates	0	6	-
2. Equity of Rotations			
Water Planned > 1 Day/Week	6	0	-
Weekly Inequity Index	3.30	1.49	-54.8

Notes: "Gate Supervision" means that either a gate must be kept closed because water is flowing on the upstream side, or that water is passing through the gate and discharge must be controlled to distribute water fairly. Keeping a gate closed is an easier management input than having to control discharges throughout the rotation period.

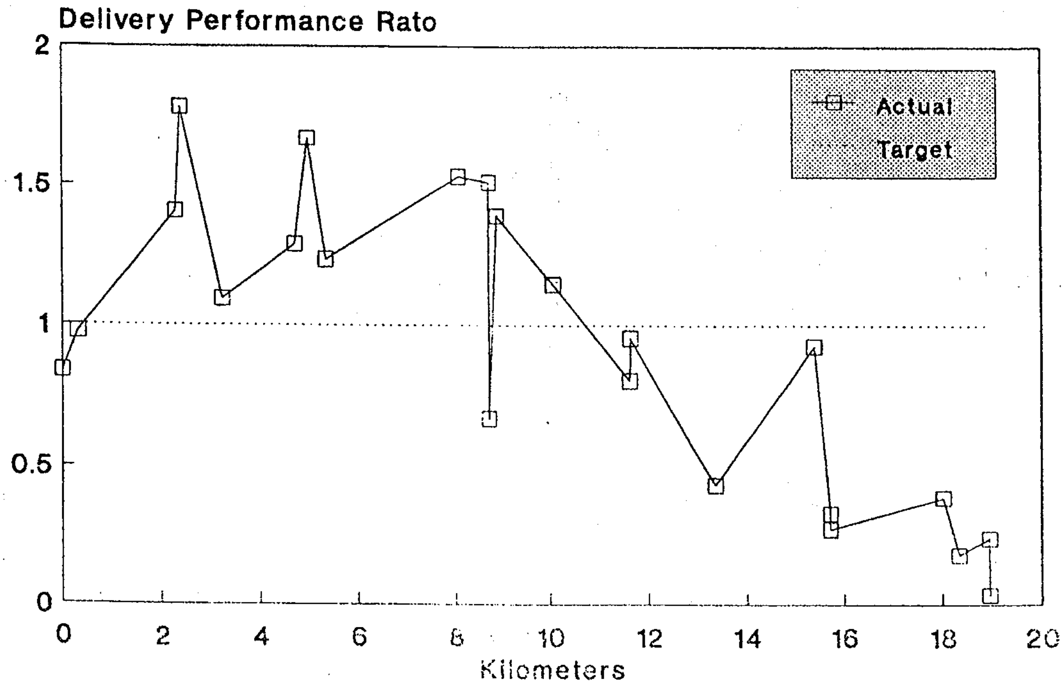
"Downstream Flow Must be Stopped" means that the main or secondary canal needs to be controlled to prevent downstream areas getting water out of turn.

"Weekly Inequity Index" is the ratio of the maximum to minimum area planned for irrigation on different days of the same week.

The reductions in management inputs and decreases in inequity were achieved with no expenditure.

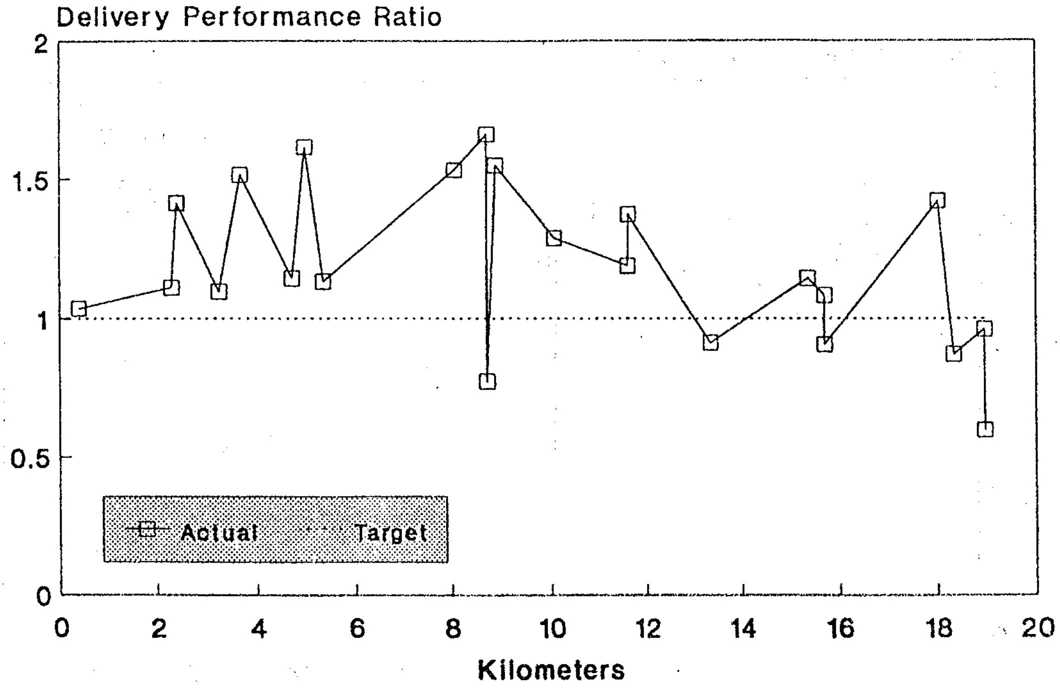
The final example of improvement of equity comes from a *warabandi*-based system in Pakistan (Vander Velde 1990). Lagar Distributary (approximately 8,000 ha) is in the Lower Chenab Canal command in the Punjab. Although, in theory, the design of the system, based on adjustable proportional modules and with no operable structures below the secondary head gate, should result in a high degree of equity of water distribution, the actual pattern of water distribution in 1988 showed that head-end areas received about 1.5 times their share, while hardly any water reached the tail end (Figure 13).

Figure 13. Water distribution equity before desilting, Lagar Distributary, Pakistan.



The cause of this was due to neglect of maintenance. Sediment had build up in the head end so that operating water levels were much high than designed, and thus discharges through upper-end models were also high. Following a modest program of desedimentation in the upper half of the canal, the water distribution pattern showed a dramatic change. Head-tail differences were almost eliminated, the residual equity being the result of design or construction conditions, rather than operational (Figure 14).

Figure 14. Water distribution equity after desilting, Lagar Distributary, Pakistan.



4. Conclusions

The examples all indicate that it is possible to achieve significant improvements in canal performance. A number of general conditions do, however, have to be observed.

Improvements in performance can only be achieved if there are clear objectives for which operational plans can be developed. Performance improvement will be unlikely to come about if the assessment of performance is based on objectives not included in the operational plan. Objective setting must include users as well as system managers: unilateral objective setting rarely satisfies other participants.

Objectives should be clear-cut, and the operational plan kept simple. There is plenty of evidence to show that complicated operational plans are hard to implement, and thus performance tends to deteriorate as a consequence. Simplicity makes a manager's job easier because implementation can be organized efficiently, and it can be easily monitored.

Data is essential. Without data performance cannot be assessed and evaluations cannot be undertaken. A critical conclusion is that large amounts of data are not required: data collection programs merely need to reflect the objectives of the system. All of the examples cited above had simple measurement programs focused to determine whether stated objectives were being met. Large monitoring programs are neither desirable nor sustainable.

Objectivity in evaluating data is also essential. If managers cannot face reality, then they cannot be managers. If water is not being delivered in the planned amount or at the planned time, then that data must be faithfully reported. In many of the examples quoted above, inaccurate or unreliable data was being used, giving managers a false picture of what was actually happening. More commonly, there was no real data at all: what was reported was the intended plan, not the actual conditions in the system.

Two further aspects of performance improvement need to be stressed. All of the examples cited above achieved improvements in performance with relatively little actual expenditure. The benefits came through an intensification of management, not of physical or other changes. To be sure, some expenditures were required in some cases, but these represented expenditures within the normal budgets of the agencies involved. Performance improvement does not have to be expensive.

Finally, and most important, is that there has to be the will to make things change. Initially the changes may only be in terms of improving information about what is actually happening in the system. This builds up a body of accurate data. Then there may be changes in procedures as objectives and implementation plans become better defined. Third, and the most difficult, is that institutional conditions have to change to support managers who do a good job in improving performance. If the rewards for improving performance through hard work and commitment are the same as for doing nothing at all, then it is merely fantasy to expect managers to perform better. Institutions have to provide the right incentives for doing a good job, and sanctions for failure.

Performance of individual managers is likely to reflect the environment within which they work.

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