

Sustainability of Improvements in Irrigation Management

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India, in common with the rest of South Asia, has seen rapid strides in irrigation development in the past few decades. The expansion and improvement of irrigation facilities occupy a prominent place in India's programs for agricultural development. The financial outlays and expenditures incurred on development of major, medium, and minor irrigation in the country's five-year plans are given in Table 13.1. As Desai's chapter in this volume (Chapter 4) shows, despite the sizable nature of the investments incurred in the irrigation sector, there has been over the years a persistent gap between irrigation potential and its use.

Historically, the focus of irrigation development in India has been on the design and construction of civil works for storage, conveyance, and distribution of water. The major objectives of irrigation development in the colonial days were to provide protection from droughts and famines, to appropriate revenues to the state, and to maintain colonial authority. These systems were essentially supply oriented, were administered rather than managed,² and lacked operational flexibility to deliver water at the right time and in the right quantities--essential prerequisites of an irrigation system for modern intensive agriculture. The objective of providing famine protection further implied extensive rather than intensive irrigation.

With rapid changes in Indian agriculture over the past two decades,³ the realization is growing in India of the need to improve the quality of irrigation supplies and services, particularly from existing large and medium surface irrigation projects. As a consequence, the emphasis in irrigation development is shifting to rehabilitating existing projects and improving the irrigation water

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²Due to a lack of trained manpower during that period, it was also essential to minimize the personnel required for operating such systems.

³The green revolution has brought high-yielding varieties, increased use of fertilizer, higher yields, greater production potential, and a shift from subsistence to commercial agriculture. Although productivity of irrigated lands has improved over time, the current levels of crop yields average only about 2 tons per ha compared with achievable yields of 5-6 tons per ha.

Table 13.1--Outlay and expenditures for developing irrigation potential, by plan

Five-Year Plan	Outlay			Expenditures ^b
	Major and Medium Irrigation	Minor Irrigation ^a	Total	
(Rs millions)				
First Plan (1950/55)	3,800 ^c	760	4,560	4,340
Second Plan (1956/60)	3,800	1,420	5,220	4,300
Third Plan (1961/65)	5,810	3,280	9,090	6,640
Annual Plan (1966/69)	4,340	3,260	7,600	4,710
Fourth Plan (1969/74)	12,370	5,130	17,500	13,540
Fifth Plan (1974/78)	24,420	6,310	30,730	34,340
Annual Plan (1978/79)	9,770	2,370	12,140	n.a.
Annual Plan (1979/80)	10,790	2,600	13,390	n.a.
Sixth Plan (1980/85)	84,480	18,100	102,020	n.a.

Notes: Irrigation schemes during the first plan period were divided into three categories on the basis of the capital cost of the schemes: (1) major irrigation schemes, which cost more than Rs 50 million; (2) medium irrigation schemes, which cost Rs 1 million - 50 million; (3) minor irrigation schemes, which cost less than Rs 1 million.

In 1978, the basis of classification of major, medium, and minor irrigation projects was revised; in place of capital cost, the categorization was based on cultivable command area (CCA) as follows: (1) major irrigation schemes with more than 10,000 ha CCA; (2) medium irrigation schemes with 2,000-10,000 ha CCA; and (3) minor irrigation schemes with less than 2,000 ha CCA. The revised classification aimed to adjust technical and administrative scrutiny of irrigation schemes according to magnitude and complexity.

^aGovernment outlays.

^bIncludes expenditures for flood control.

^cIncludes Rs 800 million incurred during pre-plan period.

n.a. Not available.

management from these projects so that irrigation and agricultural productivity is enhanced. Since the early 1970s, major programs have been under way to rehabilitate, modernize, and improve India's existing irrigation systems. Such rehabilitation implies not only bringing about physical improvements, but also introducing organizational, managerial, and other innovations.

The experience of these management interventions to improve the performance of irrigation systems is under debate, and concerns related to their sustainability are sometimes expressed. This chapter examines issues related to the sustainability of management

improvements, particularly of major and medium surface irrigation systems, and presents a framework for examining the elements of management interventions and evidence of sustainability of management improvements in Indian irrigation systems.

IRRIGATION MANAGEMENT AND PERFORMANCE OBJECTIVES

Irrigation management is the process by which water is manipulated and used in the production of food and fiber. A widely prevalent belief is that the needs of irrigation management are dictated by the goals of higher agricultural productivity.⁴ In most developing countries, irrigation and its effective management are also perceived as instruments to improve employment opportunities, incomes, social justice, equity in social and economic distribution of assets, and environmental conditions.

The purpose of an irrigation system is to service and sustain an agricultural system in a timely and adequate manner so that water, together with other inputs and requisite infrastructure, creates favorable conditions for achieving high levels of crop production and productivity. The components⁵ of a surface irrigation system that contribute to its overall performance are: a catchment contributing to runoff; a storage reservoir; a distribution and regulatory system consisting of mains, branches, distributors, minors, and farm-level networks; and farm-level and main drainage systems for removing excess water. For instance, catchment and upstream land management are vital to both the availability and quality of water for irrigation. Changes in one component may render another ineffective. The entire purpose of irrigation management is to achieve performance levels that are in line with the objectives of the irrigation system.

What are the performance objectives of an irrigation system? Can they and should they be common for different systems with varying characteristics? Only when the objectives are clear can performance be evaluated. Unfortunately, there are no accepted indicators of irrigation performance, and performance objectives often lack clarity and remain contradictory.

⁴These goals may relate to productivity per unit of water or land depending on whether water or land is the constraint. Generally, in public irrigation systems, the farmer's aim is to optimize the productivity per unit of land, while the irrigation agency's aim is to optimize the productivity per unit of water. Consequently, the conflict between private and social goals arises in irrigation management.

⁵The basis of this classification is the physical components of the overall system. There could, however, be other means of classification.

Some important objectives and measures of performance are related to the following:

- . Increased productivity per unit of water or land,
- . Improved equity of water distribution among users,
- . Increased reliability and dependability of supplies to match crop water requirements,
- . Increased control of water distribution and improved flexibility in operation and maintenance,
- . Improved environmental stability and maintenance of land and water productivity over time, and
- . Increased cost effectiveness of investments in the system.

Each component of the system must have the same goals, derived from the objectives of the larger system. Only by identifying the goals over the parts and the whole can a system capable of achieving the overall system objectives be sustained.⁶ Focused operations derived from a strategy explicitly defined for the total system produce high performance levels, which are now easier to define, measure, and control.⁷ Unfortunately, incongruent structures for different system components are common and lead to poor performance. The converse is rare. Some important reasons for this are the following:

- . Professionals in different fields attempt to achieve goals that, although valid and traditional in their fields, are not congruent with goals of other areas;
- . System goals are never made explicit;
- . Inconsistencies are not recognized;
- . More objectives are added, or objectives are modified, resulting in an often futile attempt to achieve them;
- . Inadequacies in design and built-in inflexibilities are unable to respond to changes.

Management interventions are required to sustain or improve performance levels of any system. Although these are important for all components of an irrigation system the present discussion is restricted to issues related to the performance of the main and farm-level distribution components of an overall irrigation system.

⁶Although the objectives of different components of a physical system must be congruent to achieve the overall objectives of the system, this is, by no means, the only condition to ensure high performance. To attain high performance levels, the objectives of system managers and farmer users must also be congruent.

⁷Here we draw a parallel with focused manufacturing operations, as proposed by Wickham Skinner (1974), which are a must for competitive advantage.

SUSTAINABILITY OF MANAGEMENT IMPROVEMENTS

All management interventions, aimed as they are at arresting declining performance or upgrading performance levels, are achieved at some cost. Therefore, maintaining maximum benefits with the least cost over the largest possible time horizon is a valid concern of decision makers seeking to improve management. Sustainability is, in large part, a question of our expectations regarding longevity (Svendsen 1987). Consequently, there is a high degree of association between project rehabilitation or modernization and sustainability. High sustainability connotes prolonged periods between rehabilitation, during which performance of the system is maintained at adequately high levels. Although the factors that contribute to high sustainability are not well understood, the concept of life cycle is relevant for treating issues related to sustainability and performance.

The concept of product life cycle is widely used to describe the sales performance of a product over time but can be extended to any productive system. The stages of such a cycle are introduction and early growth; high growth; maturity and saturation; and, finally, decline. Productive systems are terminated when operations cease permanently or when the system itself is so greatly revised that the major portion of the original design is no longer relevant to its subsequent operations. If no management interventions are made, systems will naturally proceed to the termination stage. Interventions in the form of system redesign or rehabilitation are necessary to change system outputs before the termination stage is reached. Such interventions ensure that outputs are consistent with objectives and therefore enhance system longevity.

At the stage of project modernization or rehabilitation, indicators of performance on one or more of the above objectives are low as expected. Consequently, interventions are made to upgrade performance. These interventions may upgrade project hardware or software or both. Taken independently and in combination, they help upgrade performance. A framework detailing performance objectives and elements of managerial interventions that may upgrade performance is given in Table 13.2.

Understanding and measuring performance against each of the performance objectives detailed earlier are preliminary and essential for research related to management interventions, performance upgrades, and sustainability. A survey of the literature indicates a dearth of published material on monitoring project performance, especially in relation to the objectives of irrigation systems. Documentation of performance before and after project rehabilitation is limited. Yet these first steps are essential for meaningfully studying the problems of sustainability.

The pursuit of sustainability must ultimately address the issue of self-sustaining systems. This must involve the development of resource bases, organizational forms and processes that are geared to managing innovation, generating resources, and building the capacity to manage the process of change itself. This is a continuous process of building capabilities in the system to respond to challenges arising from uncertainties and changes in different components of the

Table 13.2--Performance objectives of an irrigation system and possible managerial interventions to upgrade performance

Performance Objectives	Principal Management Interventions	
	Hardware	Software
Productivity		
Improved water and land productivity through Reduction of water losses	Canal lining	Improved control and water distribution
Increases in the irrigated area per unit of water	Land leveling, land shaping, OFD, improved irrigation technology (drip, sprinkler)	Improved water application
Better crop yields	High-yield varieties, improved agricultural practices, credits	Agricultural extension
Shifts in cropping pattern	Multiple and relay cropping, shifts to high value crops	Agricultural extension, input and output prices
Equity		
Improved equity over Head and tail of the main canal system or command	Regulation and control structures	Main system scheduling
Head and tail of chaks	OFD works	RWS/warabandi; farmer organization
Large and small farmers	OFD works	RWS/warabandi; farmer organizations
Dependability/Reliability		
Greater dependability of Quantities delivered	Measurement and control structures, OFD	RWS/warabandi
Time delivered		RWS/warabandi

Table 13.2--Continued

Performance Objectives	Principal Management Interventions	
	Hardware	Software
Flexibility Ability to respond to changing crop and water needs	System design, regulatory and control structures	System scheduling and RWS practices
Environmental Stability Short- and long-term environmental stability through control of Areas waterlogged	Main and on-farm drainage	Improved irri- gation practi- ces, pricing of water, volu- metric charges
Areas rendered saline or alkaline	Drainage, leaching, salinity control works, crop selection	Improved irri- gation practices, pricing of water, volumetric charges
Groundwater levels	Drainage, pumping, conjunctive use	Improved irri- gation practices, pricing of water, volumetric charges
Cost Control of Capital cost	System design	Upgraded skills and manpower ca- pability, reduced corruption
O&M cost	System design, automatic regu- lation	Organizational design, beneficia- ry participation

Note: OFD, on-farm development; RWS, rotational water supply; O&M, operation and maintenance.

irrigation system. This is possible only if we accomplish the following:

- (1) Develop an explicit statement of objectives and strategy,
- (2) Translate the objectives and strategy into what they mean for system maintenance and operation,
- (3) Examine carefully and continually each element of the system's focus, organization, and tasks, and
- (4) Reorganize the complete structure to produce a congruent focus.

EXPERIENCE FROM INDIAN IRRIGATION SYSTEMS

Since the early 1970s, management interventions (both hardware and software) of the nature listed in Table 13.3 have been used either alone or in combination to improve the performance of irrigation systems in India. The emphasis in such efforts has been relatively more on undertaking on-farm development (OFD) works, command area development, and strategies of improvement beyond the irrigation outlets and less on improving main system hardware. Published information on sustainability of such interventions is meager. Evidence currently available is sketchy and based on project-specific situations and value judgments. Since these experiences vary from project to project depending on factors such as the age of the system, agroclimatic situations, and cost and nature of the interventions, generalizations on the sustainability of interventions in Indian irrigation systems are somewhat hazardous. However, some evidence on sustainability of four specific interventions--on-farm development (OFD) works, rotational water supply (RWS), farmer organizations, and organizations for managing public irrigation systems--are detailed below.

An important component of the Command Area Development Program (CADP) in India is planning and implementing OFD works. The principal elements of such works are field channels (including partial lining), regulatory and control structures and measuring devices for better on-farm water distribution, land leveling and shaping, and field drains. In the OFD works actually undertaken, the construction of field drains and, to a degree, land leveling and shaping were neglected. Although construction of field channels facilitated the creation of a micro irrigation network beyond the irrigation outlets, enabling more area to be brought under irrigation and improving water distribution, regulation, equity, and crop yields, these improvements were in themselves insufficient to ensure reliability and adequacy of supplies at the irrigation outlets (Gopinath and others 1986). The reliability and adequacy of supplies are governed by extraneous parameters such as water availability in the system and main system scheduling and regulation. Consequently, enabling conditions for beneficiary motivation and involvement in water distribution and up-keep of OFD works for long-term sustainability have yet to be fully realized. These can only be ensured if decisions related to regulating and distributing supplies at the farm level are harmonized with those of the main system.

Another aspect related to sustainability of OFD works is the quality of works and their maintenance. The quality of works

undertaken has in many cases been poor, and maintenance scanty or nonexistent. For example, in the command of Mahanadi (Cuttack), Orissa,⁸ when the OFD works were initiated in 1980-81, the cost of the works was kept at Rs 460 per ha. This was revised in 1982 to Rs 680 per ha, and in 1984 to Rs 1,100 per ha. The annual provision for maintenance of works was fixed at Rs 30 per ha. Although the rationale for such decisions was to provide a larger number of beneficiaries with the available resources, they had a deleterious effect on the quality and the durability of the works. The net effect of these efforts was inadequate and improper coverage of work elements, poor regulation and control of water at the farm level, short-term effectiveness of OFD works (lasting only a few seasons), and partial loss of faith of the beneficiaries in such measures.

The sustainability of OFD works in the Lower Bhavani Project in Tamil Nadu is more encouraging than that in Mahanadi.⁹ The OFD works undertaken in the project area are of recent origin (1982), and their quality is usually good. Project authorities prefer quality to cost considerations, as witnessed by the norm of Rs 2,000 per ha compared with much lower figures in other CADP's such as the Mahanadi. Unfortunately, the current maintenance of OFD works is not optimal here either: the government expects the beneficiaries to do it, and they in turn want the government to undertake it. In this process, maintenance is not getting its due attention, and a valuable investment could become dysfunctional sooner than expected.

Rotational water supply (RWS) is a form of software intervention attempted in Indian irrigation systems to improve water distribution and use beyond the irrigation outlets. The warabandi system of RWS has been relatively successful in northwestern India for over a century. However, attempts to introduce RWS as part of the CADP have been only partly successful in a few pilot studies outside the traditional warabandi areas. In order to implement and sustain a program of RWS effectively, several system requirements are needed, but remain lacking. Among these are a well maintained, functional network of field channels with required structures for conveyance, distribution, control, and application of water. The system above the outlet needs the capacity to deliver assured, adequate, and timely supplies to the different outlets. A high intensity of managerial inputs, effective participation of the beneficiary farmers, and adherence to a discipline are other preconditions for successful RWS. Perceptions gathered in discussions with irrigation officials and farmers and from the experience of operating systems in India indicate that much needs to be done to implement and sustain a program of RWS. The following weaknesses require remedial action:

⁸The command has an average annual rainfall of 1,500 mm, and paddy is the principal crop grown. A major problem facing the command is inadequate drainage and heavy waterlogging. The drainage problem is aggravated by low gradients and limited natural drainage (Tripathy and others 1986).

⁹Rainfall in the project command is scanty, averaging about 700 mm per year. In the command area and the state as a whole, farmers attach a high value to irrigation water (Gopinath and others 1986).

- (1) Current resource commitment for managing RWS is not commensurate with the tasks to be accomplished;
- (2) Planning for RWS has basically been a top-down process, with very limited involvement of the beneficiaries. In spite of several meetings held and motivational methods tried, the large majority of cultivators do not feel a sense of participation in determining their allocations;
- (3) Assured availability of water, in the amount and on the schedule promised, above the outlet (main network) is still a long way off. In fact, the flow from the outlets is not the same as the quantity assumed in determining the schedules;
- (4) The crop water requirements on which the entire program is based are not appropriate, particularly given differences in topography and soil conditions;
- (5) The record of outlet operating times, amount of water discharged, and duration of operation is inadequate. Any corrective action is difficult in the absence of meaningful information;
- (6) Although the timings of irrigation for different cultivators are displayed on notice boards, adequate mechanisms are lacking for making changes and communicating them well in advance to the cultivators;
- (7) The supply of water at the outlets is generally the responsibility of the irrigation departments whereas promoting RWS and ensuring its success require the coordination and collaboration of the irrigation department with other agencies, such as the agriculture and revenue departments;
- (8) Outlet-level committees do not receive proper recognition from the beneficiaries as the legitimate agency to exercise control over distributing available water;
- (9) The practice of night irrigation does not receive full acceptance and commitment; and
- (10) The physical condition of the distribution network, both above and below the outlet, is not able to meet the stringent requirements imposed by the discipline of RWS.

In summary, the experience of introducing and sustaining RWS has not been very successful, essentially due to the lack of preconditions, including technical ones. More careful planning and efforts are necessary to create and sustain project-specific distributional and rotational water supply procedures rather than to create common procedures across projects of varying water availability. Additional managerial time and money will have to be invested in strengthening a program of RWS. Whether the returns justify the investment will have to be carefully examined in the light of experience gained from initial efforts. Special studies to monitor, document, and evaluate the present efforts also need to be undertaken to strengthen the RWS program.

Organization of farmer groups beyond irrigation outlets is a form of software intervention attempted in Indian irrigation systems. Although concepts and experiences are debated in academic and other forums and pilot projects are frequently visited (such as the Mohini Water Cooperative, Gujarat), farmer organizations have not been promoted as an integral part of any deliberate strategy. The roles to be performed by farmer organizations are neither properly iden-

tified and appreciated nor legislatively backed. The organizational functioning of the irrigation departments also does not promote the participation of water users in decision-making. Importantly, the lack of assured and timely supplies at the irrigation outlets does not encourage beneficiaries to participate. Consequently, farmer organizations largely remain on chapter, and the success and sustainability of such efforts are currently poor. Wherever limited success is reported (as in Mohini Water Cooperative, Gujarat), the characteristics such as caste and economic levels of the irrigators themselves are somewhat homogeneous, and the main system has a minimum capacity to deliver and regulate irrigation supplies.

Another software intervention that has been attempted for improving the overall performance of irrigation systems in India is the introduction of newer organizational forms for managing public irrigation systems, especially the Command Area Development Authority (CADA). The organizational pattern of such authorities varies from state to state depending on each state's prevailing administrative arrangements.¹⁰ Although the CADA has made significant contributions by creating much needed infrastructure for development of irrigated agriculture, its organizational capabilities are still not strong enough to implement successfully a program such as the CADP that embodies an all-inclusive approach. Due to the multiple functions assigned to these authorities and the lack of effective integration of responsibilities at the project level, the most critical function of timely and adequate water deliveries at the irrigation outlets tends to be neglected, and sustainability of this organizational form is constantly under debate.

ISSUES FOR FUTURE RESEARCH

Sustainability of management interventions in Indian irrigation systems is a field that is poorly researched. This is not surprising since the key to such investigations is a close understanding of the performance objectives of irrigation systems, the criteria and instruments for measuring performance, and the ways of monitoring such performance before and after interventions. Studies on monitoring performance of Indian irrigation systems are themselves of recent origin. Consequently, empirical evidence to answer questions related to interventions, sustainability, and performance is limited.

To provide a firmer basis for research on sustainability of management interventions, we need to resolve the following related issues and concerns:

- (1) How do we prioritize the performance objectives of an irrigation system? Can we focus investigations on a limited number of performance objectives, such as productivity and equity?
- (2) For the objective chosen, what are the criteria and instruments for measuring performance so that sustainability can be quantified?

¹⁰In a few states, notably Tamil Nadu, existing line departments handle CADP related work, with no separate CADA.

- (3) On the basis of present knowledge what are the managerial interventions that have a high likelihood of success? Alternatively, can we generalize about the factors that contribute to failure?
- (4) Can we prioritize effectiveness of interventions by their input-output relationships? What are the trade-offs between hardware and software interventions? Do any easy options exist?
- (5) In undertaking research on interventions and sustainability, should we study the effect of one or two interventions (say, OFD works, RWS) or several? Since an intervention in any part of the system may give optimal benefits only when synchronized with other interventions in the system, how meaningful is research on one or two selected interventions? How reliably can we isolate the effects of interventions, taken singly, on performance and sustainability?
- (6) Since the ultimate object of research may be to select interventions that are cost effective and highly sustainable, how do we identify and prioritize them for research? How can we study the effect of each intervention and its interaction on sustainability?
- (7) To help us generalize from research investigations, how can we evolve a conceptual framework and methodology for research so that the overall research effort does not necessarily end up as individual case studies from discrete projects?

SUMMARY

The emphasis in Indian irrigation development is shifting from designing and constructing new irrigation projects to rehabilitating and modernizing existing projects. Such rehabilitation involves physical improvements to the system and introduction of organizational, managerial, and other innovations. This chapter reviews the recent experience of management interventions in major and medium surface irrigation systems in India and their sustainability.

Management interventions are undertaken to sustain or improve performance levels of irrigation systems. Unfortunately, there are no commonly agreed upon indicators of irrigation performance. Although the factors that contribute to high sustainability are not well understood, this paper gives a framework for detailing performance objectives and the elements of managerial interventions possible to upgrade performance, and applies the concepts of project life cycle to the treatment of sustainability and performance.

Since the early 1970s, management interventions (both hardware and software) have been used both singly and in combination to improve the performance of irrigation systems in India. The emphasis in such efforts has been more on strategies of improvement beyond the irrigation outlets and less on strategies of improvement in the main system hardware. The experience with these strategies varies from project to project depending on the age of the system, agroclimatic factors, and cost and nature of the interventions. Consequently, generalizations about the sustainability of such interventions are somewhat hazardous. This paper presents evidence on sustainability of four specific interventions: on-farm development works, rotational

water supply, farmer organizations, and organizations for managing public irrigation systems. However, the scope for research on performance remains large, including clarifying concepts and assessing the impact of management interventions.