

3

Critical Issues Facing Indian Irrigation

A. Vaidyanathan¹

The expansion and improvement of irrigation facilities occupy a central place in India's strategy for raising agricultural productivity. Investments in irrigation constitute the single largest component of agricultural investment overall and particularly in the public sector. Over the past forty years, the state spent a total of Rs 435 billion on agricultural and rural development, including irrigation and flood control; investment in irrigation alone totaled Rs 180 billion.² The largest part of state expenditure on irrigation went to construct new and rather large surface systems,³ as well as works to promote quicker and better use of the water made available by these systems. The state also gave a substantial amount of assistance to groundwater development by offering loans and grants to farmers for constructing and energizing wells, by supporting investment in rural electrification, and to a limited degree by setting up public tubewells. Total irrigated area reportedly rose from 22.6 million hectares (17 percent of crop area) in 1950-51 to 54.1 million hectares (31 percent of crop area) in 1984/85.

IMPACT OF IRRIGATION

In India the bulk of the annual precipitation in practically all parts of the country is concentrated in a short period, and, in large parts of the country, the average rainfall itself is quite low. In these agroclimatic conditions irrigation can make a big difference to productivity by permitting land to be cropped for a longer period during the year than would be possible on the basis of rainfall alone; by enabling longer duration, higher value crops to be grown; and by enlarging the scope for, and efficiency of,

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²The figures are based on computations by the Center for Monitoring Indian Economy (1988, Vol. 1, Table 7.21-1).

³On average, nearly one-fourth of the public investment in irrigation during 1950-84 went into major and medium works.

fertilizer use and therefore increasing average yields of particular crops.

Ample evidence shows that productivity on irrigated land is markedly higher than on unirrigated land. Some recent estimates, which are admittedly approximate, suggest that across states the gross value of output per hectare of irrigated land is between 50 and 280 percent higher than that of unirrigated land (Table 3.1). Differentials of a much larger order are apparent when we consider territorial units smaller than the states.⁴ Moreover, except where irrigation is largely from small storage works that depend mainly on local rainfall, the productivity of irrigated land appears to be more stable across years.⁵

Regional variations in the difference between productivity of irrigated and unirrigated land are partly related to differences in rainfall. Productivity differentials between irrigated and rainfed land seem to be inversely correlated with the level of rainfall: the differential tends to be higher in regions with low rainfall (and lower in regions with high rainfall), both in absolute and relative terms.

The quality of irrigation, which reflects the extent to which the timing and quantity of irrigation supplies are regulated in a controlled fashion, is among the determinants of the productivity increase associated with irrigation. Quality is, however, difficult to measure: indexes like the proportion of irrigated area served by groundwater, the extent of conjunctive use of groundwater with surface water, and the characteristics of surface irrigation works can be used to capture qualitative differences indirectly but only partially. The available data suggest that greater reliance on groundwater than on surface water does not affect the impact that irrigation has on productivity, once we control for the effect of rainfall. Some evidence suggests that a higher degree of dependence on small storage works is associated, given the rainfall, with a

⁴For districts in Tamil Nadu the ratio of productivity on irrigated land to that on unirrigated land varies from 2.6 to 7.7 (Vaidyanathan 1987).

⁵Analysis of district-level data for the 1970s in Tamil Nadu shows that the productivity of irrigated land varied less around a linear trend than that of unirrigated land in nine out of twelve districts (Vaidyanathan 1987, Table 5).

Table 3.1--Selected indicators of the potential, cost and productivity of irrigation, by state

State	Average Cost of Additional Potential ^a			Productivity Difference between Irrigated and Unirrigated Land	Investment in Irrigation per Unit of Additional Output	Irrigation Potential Created up to 1984/85	Ultimate	
	Major	Minor	All					
	(Rs per ha)							(1,000 ha)
Andhra Pradesh	15,200	2,260	9,780	1,236	3.3	7.9	5,600	9,200
Assam	5,208	6,770	5,960	n.a.	n.a.	n.a.	520	2,670
Bihar	12,690	1,660	6,030	600	1.5	10.1	6,300	12,400
Gujarat	37,690	4,630	23,730	1,250	2.8	19.0	2,940	4,750
Haryana	24,130	1,580	12,860	1,355	3.6	9.5	3,326	4,550
Jammu & Kashmir	15,225	1,480	15,050	n.a.	n.a.	n.a.	n.a.	n.a.
Karnataka	11,000	3,100	7,510	1,265	3.2	5.9	2,400	4,600
Kerala	12,190	4,000	9,550	n.a.	n.a.	n.a.	950	2,100
Madhya Pradesh	14,700	5,360	10,170	605	1.9	16.8	3,790	10,200
Maharashtra	20,700	4,990	14,810	1,325	3.8	11.2	3,700	7,300
Orissa	14,400	2,070	6,740	389	1.7	17.3	2,630	5,900
Punjab	16,290	400	7,000	1,465	2.5	4.8	5,640	6,550
Rajasthan	11,360	2,270	8,520	900	3.5	9.5	3,800	5,150
Tamil Nadu	21,400	2,320	7,880	1,677	3.6	4.7	3,190	3,900
Uttar Pradesh	8,750	840	3,750	980	1.7	3.8	18,800	25,700
West Bengal	12,000	3,060	5,650	n.a.	n.a.	n.a.	3,300	6,110

Sources: A. Vaidyanathan, "Irrigation and Agricultural Growth," Indian Journal of Agricultural Economics, Basic Statistics 42 (October-December 1987): 514; and Center for Monitoring Indian Economy, Basic Statistics Relating to the Indian Economy, Vol.2 (New Delhi: CMIE, 1988).

n.a. Not available

^aPublic sector outlay during 1980/85 per hectare of increase in irrigation potential during the same period. Due to difference in size, date of start, and mix between completed and ongoing projects, the estimates may not give a correct picture of relative costs.

smaller difference in the productivity of irrigated and unirrigated land.⁶

The level of biochemical technology--which operates through the genetic potential of crop varieties, the quantum of nutrients they can absorb, and the efficiency at which the nutrients are converted into crop yields--is also important in determining productivity. The high complementarity between biochemical elements of agricultural technology and irrigation makes it difficult to disentangle their relative influence in accounting for differences in output per unit of area. It is even more difficult to disentangle their contributions to differential increases in productivity over time because, apart from irrigation level and quality, changes in biochemical technology take place on both irrigated and rainfed lands. In the circumstance viewing growth of output per hectare purely as a function of differential changes in the irrigation ratio is simplistic and misleading. Even though biochemical technology is developing and spreading faster on irrigated tracts, such changes augment productivity both on the preexisting stock of irrigated land and on area newly brought under irrigation.

Although the development of irrigation has been rightly given a key role in Indian agricultural development strategy, the experience of the past four decades highlights several issues, particularly concerning the kinds of irrigation works that should be promoted, the relative emphasis that should be given to quantitative expansion as distinct from qualitative improvement, the means of achieving qualitative improvement, the question of the distribution of benefits from irrigation, and the recovery of costs from beneficiaries.

BALANCE BETWEEN LARGE AND SMALL WORKS

There is a view that small irrigation works should be given greater importance than large storage-based canal systems, which currently absorb the bulk of public investment in irrigation. The argument is twofold: small-scale works are less expensive and easier to manage, and large canal systems give rise to serious environmental problems.

⁶A multiple correlation (across states) between the ratio of productivity on irrigated to unirrigated land and amount of rainfall and percentage of irrigated area under wells shows the partial correlation coefficient of rainfall to be negative and highly significant and that of well irrigation to be negative but not significant.

Across districts of Tamil Nadu, a similar, strong inverse relation between rainfall and productivity differentials between irrigated land is corroborated. The percent of irrigated area under tanks also shows a significant inverse correlation with the productivity ratio. The partial correlation coefficient for percentage of well-irrigated area is not significant.

It is true that, on the average, public sector outlay per unit of irrigated area is lower for minor works than for large canal systems. That is not, however, an adequate basis for judging the relative merits of these two categories of works: while the bulk of the cost of developing major and medium projects is borne by the government, a large part of the cost of minor works (especially wells) is borne by the farmers. Comparisons based on outlay per hectare of potential do not allow, in a systematic and explicit way, for unproductive investment and for existing works that are displaced or go out of use. What is relevant is the total cost per unit of net addition to irrigation potential.

Apart from the lack of reliable estimates of private investment in different categories of works or of their rate of depreciation, the potential addition to irrigated area is often overestimated. This bias, although by no means confined to a particular category of works, seems to be more pronounced in the case of wells. The potential of well irrigation is estimated by the number of wells dug and pumpsets installed; this method does not consider that a significant proportion of wells is located in the command of surface systems and does not add to irrigated area; nor that, in many areas, increasing well and pump density lowers the water yield of preexisting wells in the area.

Furthermore, the investment cost per hectare of additional irrigation is obviously an inadequate basis for judging the relative economic merit of different water sources, whose recurring costs differ, because it does not take into account significant differences in the quantum of water supply, its reliability, and controllability. A small tank that depends on a local catchment may require less investment per hectare than a large system, but provide much poorer quality irrigation. A well may need a smaller direct investment per unit of area than surface irrigation, but require supporting investment for extending power lines and expanding capacity to generate power. These considerations should be, but seldom are, taken into account in calculating of social costs and benefits.

The choice between different categories of irrigation works is not unconstrained, nor can they always be substituted for each other. In any given tract, the effective scope for choosing between large and small storages or between surface water and groundwater is limited by rainfall pattern, topography, and geology. Thus over large parts of peninsular India, the scope for expanding well irrigation is strictly limited. It is no accident, for example, that small irrigation tanks are concentrated in the southern part of the peninsula, which receives rainfall in both monsoons, but are scarce in tracts depending primarily on the Southwest monsoon, even when topography is favorable for local storage. In the latter areas surplus water from the monsoon months has to be harvested over a wide catchment and impounded on a large scale in order to serve the need during drier periods. In these conditions, large and small storage could complement, rather than replace, each other. Similar-

⁷For a rare instance of properly done social cost-benefit analysis of well irrigation, see Lal (1972).

ly, conjunctive use of surface water and groundwater in areas commanded by surface systems indicates a strong complementary relationship between the two types of systems.

NEW WORKS VERSUS BETTER USE OF EXISTING WORKS

A second class of issues concerns the balance between creating new works and making better use of the capacity already created. The government tends to start far more projects than can be accommodated within the amount of investment available for irrigation, so projects take longer to complete than anticipated. The average time taken to complete major projects (based on a study of eight projects), is estimated at eleven years to complete, about four and a half years more than projected in the original plans (Pant 1984b). Again, by the end of 1980/81, actual expenditures on projects begun prior to 1974 were barely 40 percent of the revised cost estimates (themselves much higher than the original estimates), and the actual potential created was around one-fourth of the expected level. All sixty five major projects begun before 1976 were to be completed by 1980/81, but only twenty five were in fact completed by that time.

Political leaders have a strong interest in promoting new irrigation projects for several reasons. Since irrigation makes a significant difference to farm incomes and can benefit a large number of farmers, public irrigation projects are a means of gathering and consolidating political support. In a system based on periodic elections, this is a particularly powerful motivation. Ongoing projects, especially those sanctioned by another minister or administration, give less political mileage than new projects, and constituents are always pressing for new projects in particular areas. Together with the rapid turnover of decision-makers at the political and bureaucratic level, this generally shortens time horizons, which militates against objective, comprehensive, and long-term planning of irrigation. These factors and the potential use of large projects to mobilize funds for party and other purposes account for the remarkable lack of concern for setting up and nurturing strong institutions to undertake surveys, design, engineering, and strict and objective evaluation before, during, and after implementation. Instead, engineers are under pressure to come up with new project proposals; the procedures for scrutiny of projects tend to be quite lax; and there is hardly any concern about when the approved projects will be completed. Delays, defective designs, and cost overruns are a direct consequence of this situation.

Fewer, more tightly designed projects should help the time taken to complete projects and facilitate speedier use of potential. The large and persistent gap between the potential created and the actual use in terms of irrigated area is widely seen as a major problem requiring special attention. Successive five-year plans as well as the Irrigation Commission emphasize the lack of field channels, drainage, and preparation of land for irrigated farming as the principal reasons for the persistent underuse of potential. Because farmers are allegedly reluctant to take up the construction of field channels, the state assumed greater direct responsibility

for field channels and other works needed to ensure the proper use of water as part of the Command Area Development Programs (CADP). The actual outlay for CADP in the Sixth Five-Year Plan (Rs 0.8 billion) represented about 8 percent of the total outlay for irrigation; outlay in the Seventh Five-Year Plan for CADP amounted to more than 10 percent of the projected total outlay for irrigation.

The problem is, however, considerably more complex than conventional wisdom would have us believe. In the first place, the estimates of potential and use are themselves open to question, partly because the definition of these terms is ambiguous, reporting agencies use different interpretations of the concept, and the system of monitoring and verifying the information provided by executing agencies is lax. More important, the potential area that can be irrigated in a system depends on several factors, including the volume and seasonal pattern of water supply; the losses in conveyance, distribution, and application; the extent to which conjunctive use is developed; and the crop pattern. All these are obviously interrelated.

If the design assumptions about any or all of these are erroneous--and the empirical basis for the assumptions tends to be gross and tenuous--the estimated potential may be quite misleading.⁸ In canal projects, assumed crop patterns diverge significantly from actual crop patterns: that the actual patterns are in general much more water intensive than the assumed ones is well documented. Objective measurements of various types of losses that affect the overall "irrigation efficiency" (in the technical sense, this is measured by the proportion of water tapped at the head that effectively reaches the root zone of the crops) are still far too meager. Project reports seldom recognize the conjunctive use of groundwater (which directly affects the parameters of irrigation efficiency) in the overall budget of water in the system. These aspects deserve far greater attention than the construction of field channels and land leveling.

The estimates of potential for major irrigation works suffer from two main weaknesses: one has to do with the allowance for the depreciation of existing works and for works that mainly stabilize water supply to areas already classified as irrigated. Nationally, a reading of the plan documents suggests that these factors are netted out in estimating the additions to potential. However, much of the estimate of potential is derived from norms for the area irrigated per well and per pumpset, whose empirical basis is unclear; the system of reporting and verification of achievements is again lax; and it is far from obvious how the area under minor works going out of use (which is the relevant concept of depreciation) is estimated.

A second and more serious weakness is the treatment of groundwater irrigation used in conjunction with surface water. As far as can be gathered, this aspect is not taken into account in the potential estimates. To this extent, the additions to potential ir-

⁸For a more detailed discussion and further references, see Vaidyanathan (1987).

rigated area would be overestimated. Given the apparently rapid spread of conjunctive use, this bias would increase over time.

Moreover, the estimates of area actually irrigated as reported by village revenue agencies are not as reliable as one might suppose. The responsibility for compiling statistics on cropwise irrigated area is vested in revenue officials in some states, the Irrigation Department in others, and sample survey organizations in yet others. The data contain substantial reporting and compilation errors. These errors may in some cases reflect systematic biases (for example, when the irrigation status of a piece of land is not of direct concern to the department collecting the data). The general deterioration in the quality of village-level record keeping--due in part to the enormous increase in the tasks assigned to village officials and, in some cases, the abolition of the traditional system of permanent, locally resident village officials--has almost certainly affected the quality of irrigation statistics.

The statistics on irrigated area thus need to be recast, at both the conceptual and the operational levels. We need much clearer and unambiguous definitions of potential and use; a more elaborate classification to distinguish land irrigated by single from that irrigated by multiple sources; and reporting of gross cropped area by crop separately for irrigated and unirrigated land. Moreover, in view of the deterioration in traditional systems of compiling data, alternative and reliable methods--preferably periodic sample surveys both at the system level and at the regional level--for estimating land use, cropping, and irrigation need to be given greater emphasis.

EFFECTIVENESS OF IRRIGATION

Far more attention is being given to the area under irrigation than is justified. What should be a matter for greater concern is the apparently limited effectiveness of irrigation in raising the productivity of land. The intensity of irrigated cropping as well as the yield of major irrigated crops are much below the levels achieved in other countries and those demonstrated to be feasible under Indian conditions. Moreover, available evidence does not point to significantly faster and sustained improvement of these levels on irrigated compared with unirrigated land.⁹

The impact of irrigation on productivity is a function partly of the characteristics of the system and partly of how well water is managed in terms of assurance and timeliness of supplies according to the need of the crops. From both viewpoints, privately owned and operated wells for own use are perhaps the best: the command area is small, and the decisions regarding the crops to be grown as well as the timing and quantum of water supply are more within the control of the owner. The marked increase in returns to irrigated agriculture that follows the introduction of new cereal varieties and the spread of rural electrification has, not surprisingly, resulted in

⁹This observation is based on analysis of district-level data for Tamil Nadu during the 1970s (see Vaidyanathan 1987, Table 5).

the rapid spread of well irrigation almost everywhere, both as a sole source of irrigation and in conjunction with surface water. The problem is how to regulate the number and location of wells in order to prevent overexploitation of aquifers, to ensure equitable access to water, and to keep costs in check.

Regulations concerning the siting of wells, especially within the command of public canal systems, have not, however, deterred the rapid expansion of conjunctive use. Although the regulations provide stiff penalties against violations, they have rarely been invoked or successful in checking the proliferation of wells (Vaidyanathan 1986). Many tracts that have experienced intensive development of wells, including the Punjab, report a progressive lowering of the water table,¹⁰ lower yield per well, and higher capital and operating costs. Wells used in conjunction with surface water affect the supply of surface water, and the consequences necessarily fall heavily on those who depend exclusively on canal water. The spread of conjunctive use among South Indian tanks tends to weaken the collective interest of farmers in maintaining and managing the tanks properly.¹¹

Collective efforts of the users themselves or state intervention to regulate the growth of wells, which could in principle lower costs and ensure more equitable access, are conspicuously absent. Private returns to well irrigation must be high enough to absorb the higher capital and recurring costs of pumping, or farmers will not have faith in the ability of either the government or their own collectives to keep the wells in good working order and ensure fair distribution in accordance with accepted principles. There is, however, evidence that farmers who cannot afford wells of their own are increasingly willing to purchase well water, despite its high cost and precarious supply. In some regions, the private purchase and sale of groundwater have assumed significant proportions (Shah and Raju 1988).¹²

¹⁰Although systematically compiled data on water tables is still lacking, the Center for Monitoring Indian Economy has reported progressive lowering of the water table in several regions. Surveys conducted by the Madras Institute of Development Studies in two large canal irrigation systems in Tamil Nadu also corroborate this.

¹¹This comes out clearly from our study of the Palar Anicut system in Tamil Nadu: where conjunctive well irrigation is highly developed, traditional community arrangements for tank management tend to be weaker.

¹²The incidence of water sale is, however, highly variable, as shown by Shah's studies. In Tamil Nadu, some systems have practically no conjunctive use (Tambaraparani system and New Kattali canal of Cauvery), while, in the Palar Anicut and Parambikulam Aliyar systems it is well developed. Among the latter, Parambikulam has hardly any water sales, while Palar has widespread sales. Within different segments of the Palar system command, the incidence of both conjunctive use and water sales is highly variable.

At the other extreme are the small irrigation systems that depend on local storage or river diversion. Most are old systems and traditionally managed by the user communities on the basis of well-recognized principles supported by social sanctions. For the most part they rely on seasonal irrigation sources and are marked by a relatively unstable supply and crude regulatory devices than wells and the larger storage-based systems. On both accounts, their impact on productivity tends to be smaller. Over the years the proliferation in the number of users, the change in the social locus of land control, the loosening of the traditional structure of power and authority in the village communities, and the progressive deterioration of the physical condition of the systems have also meant a deterioration in the working of these systems. The emergence of well irrigation in the command of such systems has helped to counter these tendencies insofar as productivity is concerned. But serious doubts remain about how far and how equitably this process has worked.

The area under minor surface irrigation systems has not expanded much in recent times. The bulk of the expansion of area irrigated by surface water has been accomplished by major and medium works, which are multi-village systems serving anywhere from ten thousand to one million hectares, usually from a single storage through a network of canals maintained and operated by the state. These systems are designed on the basis of available information on the volume of water flow at the reservoir site, its seasonal pattern and variability, and certain assumptions about conveyance and application losses, crop water needs, and crop patterns. The layout and specifications of the distribution network as well as the rules for operating the reservoir and the canals are derived from these basic factors.

Since system designers typically have to use incomplete and inaccurate information, even the design often shows inconsistencies in the command area, crop pattern in different parts of the command, and canal capacities. The Command Area Development Programs and the modernization of older systems seek to remedy these defects and raise irrigation efficiency by lining, recycling seepage water, consolidating landholdings, and providing better control over water management through better control structures, rotational supply, and conjunctive use of surface and well water. Many of these changes require not only physical investment, but also tighter organization capable of enforcing the necessary discipline.

Consolidating holdings and reshaping land significantly alter, for example, the location, soil composition, and boundaries of individual holdings and are therefore difficult to accomplish on a purely voluntary basis. Consolidation would no doubt collectively benefit the farmers involved by improving the conservation of moisture from rainfall, raising the productivity of water, and facilitating the development of wells. The higher the potential benefit of consolidation, the greater the willingness of affected farmers should be to accept it. However, the precise magnitude of the benefit cannot be estimated in advance with confidence. This inherent uncertainty about aggregate benefits is compounded by the even greater uncertainty about the benefit that an individual farmer is likely to get. Under these conditions voluntary consolidation is

likely to be a slow process. A strong case can be made for compulsory consolidation and even for public funding of part or all of the costs involved.¹³

The principle has been accepted, but so far implementation has been limited to the Punjab, Haryana, and Uttar Pradesh. Elsewhere the government has been remarkably and also universally reluctant to take this responsibility. Perhaps the task was more manageable in the Upper Gangetic Plain where the soil and topography are more homogeneous than elsewhere. The greater the heterogeneity, the greater the uncertainty of individual outcomes. And when individuals lack confidence in the fairness and objectivity of the officials charged with deciding who shall get which land where, unmanageably numerous and acrimonious disputes may arise.

The proper management of water allocations--that is, making the required amount of water available at the required time and place--is impeded not merely by inadequate regulatory structures, rigid designs, and physical constraints, but by institutional weaknesses as well. In the first place the systems are invariably manned and managed by the government bureaucracy with hardly any user participation, or even consultation, in making the principal operating decisions. The basis for operating procedures and for changing them are seldom clear to the users. The arrangements for collecting relevant data on actual water releases, loss in conveyance, the kind and extent of crops grown, and the conditions of crops in different segments are grossly inadequate, and the capacity to correlate them systematically in order to make operating decisions is even more so. Managers are drawn from the general engineering cadre, which means that the system does not permit the accumulation of the specialized knowledge, skills, and experience necessary to operate such complex irrigation networks.

Improvements in physical design and control structures only facilitate, but do not guarantee, better management unless the institutional arrangements are also tightened. Conjunctive use adds greatly to flexibility in water management, but cannot compensate for sizable shortfalls in canal supplies, which are the primary source of recharge. Even warabandhi, which seeks to impose some order and predictability on water supplies, cannot go far in raising the quality of irrigation without tackling organizational questions.

The warabandhi system works best within a season and in areas where the bulk of irrigated area is devoted to the same crop or to crops of more or less similar level and pattern of water requirements (as, for example, in the Rabi season in wheat-growing areas). But some studies in the 1960s (Reidinger 1974) show that even in the Punjab, where the warabandhi system has a long history and is reputed to be effective, the system gives reasonable assurances of the dates on which farmers in a particular outlet can expect to get water, but does not guarantee the amounts they will get. There is,

¹³The importance of this was stressed by Minhas (1970), who argues for compulsory land consolidation along with integrated land improvement works as the major focus of a rural development program to create employment and remove poverty.

in fact, considerable variation in the amount of canal water received by the farmers.

The system is apt to be less effective when crops with diverse water requirements are grown unless the system's management is strong enough to enforce crop patterns or water deliveries. To some degree crop patterns, especially between seasons, could be regulated by scheduling the canal operation appropriately. For example, restricting supplies to eight months is an effective way of checking the area devoted to perennial crops. But regulating an area sown to crops with different water needs (such as paddy and millets) within a given season requires the capacity to enforce sanctions against violations strictly. To be effective the sanctions must be severe enough, and the managers should be free to enforce the sanctions without interference.

In fact, system managers are rarely able to enforce restrictions on crop patterns, regulate the tapping of groundwater, or prevent unauthorized diversion of canal supplies. Users can interfere with water allocation by growing unauthorized crops in unauthorized places, diverting more water from the canal than they are supposed to, and digging wells and installing pumpsets in prohibited zones. This is possible when some farmers are in a favorable location (upstream farmers invariably have better access to water), but also when they can influence how water allotments work at different levels of the bureaucracy that runs the system and can get centers of power outside the system management, such as state-level officials, ministers, and the political party network, to intervene on their behalf. The system managers thus have no effective power to enforce the rules or the penalties for violating those rules.

Improved management of canal systems therefore requires that physical improvements of the kind mentioned earlier be combined with institutional reform. The management of each system should be vested with an autonomous organization manned by its own professional cadres and ensure the effective participation of user representatives in making and implementing policy. The rules governing its operation should be made or modified openly in consultation with (and preferably with the participation of) the farmers affected, and their rationale should be made clear to all concerned. When the interests of different segments of users are explicitly taken into account in decisions about allocations, compromises are made with the full knowledge and participation of users, and the rationale of the rules are understood, the decisions are more likely to be accepted. Whenever possible, the operation of the main system should take into account the possibilities of conjunctive use of groundwater as well as intermediate storages (as in the case of system tanks) to permit greater flexibility of water use at intermediate and lower levels.

A management system with full user participation and control requires a radical departure from present arrangements. Although it will take time to accomplish, such a system should be the ultimate goal. In the meantime, a beginning could be made by making the management of each system an autonomous entity, building up a cadre of professionals with a broad concept of water management and preferably employed permanently by each system organization, and using the proceeds of water fees from the command area of each

system for maintenance and administration. When users see that the water charges they pay are used for running their system, they should be more willing to pay for them.

PRICING OF WATER

Another important theme in the discussions of irrigation concerns the pricing of water. It is well known that the water rates collected from areas served by public works do not meet even working expenses, let alone cover depreciation or earn a moderate return to investments. It is also well known that groundwater irrigation, although mostly in the private sector, receives sizable direct and indirect subsidies in the form of grants to cover part of the installation costs, low-interest loans, and electricity prices that are well below cost. The gap between price and cost has widened because the cost of irrigation development has soared, but water rates have not been raised significantly. Several states have actually reduced the tariff on electricity. Political resistance to raising water rates is clearly strong: indeed, the pressures are for further liberalization of the terms. Liberalization seems unjustifiable in view of the large gains in productivity that result from irrigation, especially when we see the considerable effort and expense that farmers served by public canals are willing to incur in order to get water. In parts of Tamil Nadu, farmers' groups collect and spend as much as Rs 250 per hectare every year for managing common irrigation works. On occasion they pay sizable bribes; and in the case of subsurface irrigation, farmers without wells are willing to pay as much as one-third of their gross produce in exchange for water from nearby wells.

Although it would be unrealistic to ignore the political roots of this phenomenon, we should consider the possibility that at least part of the resistance to a general rise in water rates or, for that matter, to paying existing rates, may occur because large segments of the farmers within the command of canals do not in fact get water at all or do not get sufficient supplies with reasonable assurance. Furthermore, if the costs of projects are inflated on account of bad design, overextended commands, delays, "leakages" in construction, and other factors for which the users are not responsible, it would be unfair to expect them to bear the high cost of construction.

The moral is that if the projects were more tightly designed and efficiently executed, and if all farmers in the command of a project were guaranteed water supplies according to a specified schedule, users would be more willing to pay higher charges for water. Improved design and execution could be achieved more easily if users were actively involved in planning and designing the projects, if the impact of projects were fully debated in the public domain before decisions were made, and the beneficiaries were directly involved in operating the system. Therefore conflicts would be resolved within the system and everyone involved would be informed about the basis for compromises. This is better than mediating conflicts through the bureaucracy or centers of power outside the system.

EQUITY

Since irrigation is a major source of increased productivity, its distribution between regions and classes is naturally a matter of contention. In fact, the extent of irrigation development varies greatly by region. At the end of the 1970s the irrigation ratio ranged from barely 10 percent in Kerala and Maharashtra to 66 percent in Punjab and Haryana. Although the irrigation ratio increased everywhere during the past three or four decades, the regional disparities did not narrow. If anything they seem to have increased, if only marginally. This is, however, almost exclusively due to the aggravation of disparities in well irrigation, which is predominantly in the private sector. Disparities in canal irrigation, which are mostly in the public sector, narrowed substantially.

If official estimates of "ultimate irrigation potential" are taken at face value, the interregional disparity in the irrigation ratio could be reduced substantially.¹⁴ To do so would require a significant change in the interstate distribution of investment for irrigation. Past experience suggests that such a shift may be difficult. Over the past three decades or more, the relative share that different states have in total public sector outlay for irrigation and flood control varied within remarkably narrow limits. This reflects constraints imposed by the existing division of functions between the central and the state governments: irrigation is a state subject, and must compete with other programs for state funds; the central government's ability to alter the state's priorities is quite limited.

We ought to be concerned with reducing disparities in irrigation not for its own sake, but as a means of reducing regional disparities in agricultural productivity and income. Changes in the interregional differences in irrigation ratio do not necessarily narrow regional differences in productivity. This is true partly because the impact of irrigation on productivity varies a great deal across states (the ratio of productivity per hectare of irrigated land to that of unirrigated land in 1984/85 range from 1.5 to 3.8) and partly because the pace of change in the quality of irrigation, reflected in the ratio of groundwater to surface water irrigation, varies a great deal. A recent study suggests that the weighted coefficient of variation in overall yield per hectare increased appreciably during the past two decades, which reflects the combined effect of differences in productivity growth on irrigated and unirrigated lands. Partly for this reason and partly because regions with low rainfall tend to be less densely populated, reducing regional disparities in the irrigation ratio is not a necessary condition for reducing regional disparities in the per capita income of the agricultural population. Policy must take into account the constraints imposed by the technical feasibility of irrigation and interregional differences in the cost of and returns to irrigation.

¹⁴The estimates of ultimate potential must be viewed with abundant caution; inasmuch as their basis is not spelled out, the concept itself is inherently ambiguous.

The cost of irrigation development relative to benefits and the types of irrigation--each with different cost-benefit ratios--that can be developed vary widely across regions. Moreover, productivity can be raised through investments on rainfed land. Roughly two-thirds of the increased irrigation potential are in states where the ratio of irrigated to unirrigated yields is less than 2, and only one-third is in states where the ratio exceeds 3. Again, about one-third of the unused potential is in states where public investment in irrigation per unit of addition to output that is due to irrigation exceeds 10, and around 30 percent in states where the ratio is less than 5. The eastern region, which has a large part of the unused potential, is marked by a high public investment-to-output ratio for irrigation. This may be misleading, however, because much of the past experience in respect of cost-benefit ratio relates to surface water, but the remaining unexploited potential is for groundwater irrigation in this tract. The development of well irrigation does not call for as much public investment as surface works but is contingent on purposive and determined state intervention in land tenure and consolidation. The quantum of investment in irrigation needed in different regions to reduce disparities in agricultural growth clearly cannot be decided by reducing inter-regional disparities in the irrigation ratio alone.

The impact that irrigation has on the relative income of different categories of farmers is the other dimension of equity. Irrigation facilities have traditionally been much more evenly distributed than cultivated land across size classes of farmers. This is well documented: the irrigation ratio is, in fact, inversely correlated to the size of holding.¹⁵ Some people argue, however, that this relation may be getting progressively weaker for two reasons: large farmers have superior access to well irrigation, which is more productive and expanding more rapidly than other types of irrigation; and even in canal systems large farmers have the power to manipulate the distribution of water in their favor.

The first explanation sounds plausible inasmuch as groundwater development takes a considerable amount of private investment, which the large farmers are in a better position to afford. Conjunctive use along with surface water increases productivity, but the benefits tend to accrue more to farmers who have access to wells than to those who do not. Although the emergence of groundwater sales widens access, those who do not own wells still face greater uncertainty in quantum and terms of water supplies. Moreover, as the spread of wells weakens interest in proper management of canals, farmers without wells are apt to suffer a double disadvantage.

The basis for expecting a systematic bias in canal irrigation toward large farmers is quite tenuous: a farmer's proximity to canals and distributaries seems important in determining access to water. There is no obvious reason to suppose that all advantageous locations are systematically preempted by large landholders. Large

¹⁵The inverse relation is seen in the National Sample Survey estimates of irrigation ratio by size of holdings in its landholding surveys, but the relation may be weakening over time. The relevant data are set out by Vaidyanathan (1987, Table 8).

farmers are found in all reaches of the canal network, and the holdings of particular landholders are often widely dispersed in the command.

Empirical evidence of trends in interclass disparities in access to irrigation is scant and inconclusive. The National Sample Survey data suggest that the irrigation ratio for the country as a whole has risen faster in the class of large holdings than in that of small holdings and that interclass disparities have narrowed in favor of the former. This reflects the combined effect of differences in the pace of irrigation development across space (where both the average size of holdings and the irrigation ratio vary) and between classes. We need more disaggregated data to form a firm judgment on this issue.

Another aspect of equity concerns how water from a given system is used. In principle, the available water supplies can be used in a given system, for farming at different levels of intensity. These levels are reflected in the extent of multiple cropping, type of crops grown, and use of biochemical inputs. The more extensive the pattern of irrigation, the larger, in general, is the area that can benefit from a given amount of water and, in the context of relatively small holdings sizes, the more farmers can benefit. An extensive pattern of irrigation is socially preferable if it leads to an increment in total output as large as that of more intensive irrigation. Another school of thought favors intensive use of irrigation on the grounds that its higher cropping intensity, higher levels of biochemical inputs, and higher productivity of these inputs lead to a higher level of productivity per unit of land.

One needs in this context to distinguish between intensive use of water for particular crops and the kinds of crops grown (which also determine to some degree the cropping intensity). The case for intensive use of water for particular crops is strong because the supply of soil moisture has a direct effect on the level of fertilizer use and yield response to it. Surveys by Moorty (1976) and Pant (1984b) suggest that more intensive irrigation (associated with groundwater or a combination of canal and groundwater) accompanies larger volumes of water supplied per unit area, greater use of high-yield varieties (HYVs) and associated inputs, and much higher yields. Individual farmers prefer, wherever possible, to plant water-intensive crops, which suggests that the individual interests of farmers favor intensive irrigation in the more comprehensive sense. There is, however, some question about whether intensive irrigation necessarily gives a larger total output per unit of water, which is the appropriate criterion when water, rather than land, is the binding constraint.

The presumption that intensive cultivation in both senses is socially more productive has been challenged. Calculations suggest that in Maharashtra a crop pattern limited to irrigated dry seasonal crops benefits a larger area and gives more social value (calories and net farm income) per unit of water applied than a pattern that permits irrigated annual crops like sugarcane (Rath and Mitra 1982).

Generalization on these questions is, however, rather hazardous: agroclimatic conditions, the seasonal pattern of irrigation needs, feasible crop patterns, seepage losses, and the scope for recycling them vary from region to region, as does the state of biochemical

technology. There are complex interconnections between all these variables, and the costs associated with various alternatives also differ. Under these circumstances, determining the optimum use of given supplies of irrigation water requires a complex calculation. The sophisticated tools needed for these calculations are no doubt available, but the information for deriving solutions in which we can have reasonable confidence is woefully inadequate. We need to build up the information base for such studies and make them an integral part of project planning. The importance of this information is, unhappily, not sufficiently appreciated by those directly responsible for the process. Such analyses are essential to exploring the production and distribution implications of alternative patterns of water use and to balancing the needs of equity and efficiency. Without these analyses, pure political expediency takes command, leading to wasteful and wrong investments that prove difficult and costly to correct at a later stage.

ENVIRONMENTAL ASPECTS

Finally we turn to a few observations on larger issues concerning water resource planning and specifically on the connection between water use for irrigation and the environment. Concern over environmental aspects has been heightened by the unexpectedly high--and in some cases alarming--rates at which reservoirs are silting up; the direct effect that construction of large reservoirs has on the immediate environment (the submergence of forests that are economically and ecologically valuable as well as the displacement of people living in the area); and fear of overexploiting groundwater and damaging to cultivated land by indiscriminate irrigation. The environmentalists have marshaled a great deal of information on those aspects. Although the accuracy of the estimates may be open to question and one has to guard against environmental fundamentalism, there is little doubt that environmentalists focus on processes that are so prolonged and whose consequences manifest themselves so slowly that they are dangerously easy to ignore or dismiss.

It seems entirely sensible to insist that measures to check deforestation of upper catchments and to restore forest cover to an appropriate density must be an essential and integral part of planning for irrigation projects. Ideally this should be done on a watershed basis, but this does not detract from the necessity of ensuring that the catchment of particular projects are protected. The principle is now recognized, but apparently not taken seriously enough in actual planning. One way to generate greater seriousness is to insist as a precondition for considering all proposals for new irrigation works that the project design state the conditions of the catchment and propose concrete programs for correcting deficiencies.

The loss of forests and displacement of people are a different type of problem. There are those who accord such absolute priority to preserving forests and the lifestyles of the people inhabiting them that they oppose all large reservoirs. They might concede that if irrigation is needed, it is better to rely on solutions such as a number of small, local storages or groundwater development that do

not damage the forests and do minimize human problems arising from displacement. Although much can be said for tapping water in an environmentally safe manner, it is not always feasible. For instance, the Deccan has relatively little groundwater, and small storages that depend on rainfall in their respective catchments will not significantly augment the supply of water for crops in the nonmonsoon months, when it is needed most. Relatively large storages that impound the surplus flows during the short monsoon season are a technical imperative. One could, however, conceive of fewer large storages combined with and linked to smaller storages. This possibility needs to be assessed in each specific context.

Unless there are ways to raise output significantly on drylands, reservoirs and the attendant submergence are a cost society must pay in order to feed its growing population. It is perfectly legitimate to insist that proper rehabilitation of displaced persons must be provided whenever a project leads to such displacement. The environmentalists' apparently extreme position stems perhaps from their frustration and anger with the tendency to pay lip service to resettlement issues while doing little about them. Their frustration is understandable, but the answer does not lie in fundamentalism. They should focus instead on ensuring, by legal and political means, that this aspect is attended to seriously and adequately.

The problems of waterlogging and salinity rise primarily from irrational use of water on canal-irrigated tracts. At present an estimated 13 million hectares are affected (6 million by waterlogging, 7 million by salinity or alkalinity), and the extent is growing. This problem affects lands that, if properly managed, should be very productive, which adds to its seriousness. Providing adequate drainage facilities, which is emphasized under the Command Area Development Program (CADP), would help check the tendency, but only somewhat. Better adaptation of crops grown to the varied soil conditions in the command and more careful management to avoid overwatering are just as important. In existing projects, substantial investments will also be needed to return alkaline and saline lands to their full potential. The problems and the remedies are recognized, but the scale of effort is widely believed to be inadequate to the dimensions of the problem.

The problem with groundwater is to ensure that the overall rate of extraction does not exceed annual recharge and that access to groundwater is equitable. Neither is possible without fairly precise data on recharge and extraction rates. Despite the creation of groundwater survey organizations, the state of knowledge on these aspects remains inadequate. In several areas, especially Tamil Nadu, Punjab, Haryana, and Uttar Pradesh, the number of wells and pumpsets have increased rapidly at the same time that the average depth of the water table has fallen progressively. Although we know little about the trends in extraction rates per well the increasing depth from which water has to be pumped has undoubtedly raised the cost per unit of water lifted. Fewer wells operated collectively or by the state would presumably lower costs all around and make it easier to regulate extraction rates. And yet the strong, almost universal preference is for individual ownership of wells and pumps. The increase in the number of wells indicates wider access, but the resources needed to own a well and pump are beyond the reach of the

large majority of farmers, who are denied access to well water or get precarious, uncertain access at a high price. This anomaly raises a major question: what impedes collective or state regulation even when it could in principle confer substantial benefits on everyone? One answer could be that neither the state nor the cooperatives can be trusted--based on experience--to operate efficiently and justly. Is this inherent or correctable? Without answering this basic question, it seems futile (even if the necessary data base on recharge and extraction were available) to speak of the state regulating groundwater extraction, whether by controlling it directly or by legislating the density and spacing of wells.

CONCLUSION

As stated at the outset, this essay presents a general overview of the problems facing Indian irrigation planning and policy. The main focus of the observations is on the serious weaknesses in the basic data needed to support the proper planning and management of irrigation works and on the serious institutional weaknesses that produce delay, cost overruns, and poor use of water. Much tighter institutional arrangements are needed both for designing projects and, even more, for scrutinizing projects before they are cleared. Moreover, irrigation projects need more specialized and professional personnel, user representatives who are involved in both planning and operating systems. Management of each irrigation system--including all areas that draw water from a common diversion weir or storage--needs to be vested in an autonomous entity with its own personnel and budget, and measures to minimize detrimental environmental consequences must be incorporated as an integral element of irrigation planning. This is but a bare outline of the major issues concerning irrigation. Given the extraordinary diversity of conditions and complexity of the problem in India, solutions will clearly have to be derived from careful detailed analysis of specific situations. The prospects of finding viable solutions will depend on how the above class of issues, common to all regions and projects, is addressed.