MANAGING THE MAIN SYSTEM:

CANAL IRRIGATION'S BLIND SPOT

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'Irrigation and water management' is enjoying a fashion in development planning circles and international agencies, and efforts are being made to step up spending under this heading all over Asia. There are good reasons why irrigation will continue to get very high priority in strategies to increase food production and labour absorption in agriculture, and why grants and loans from rich countries will continue to finance a large part - currently about a half (Colombo *et al*. 1977, p.XIII) - of irrigation investment in South and Southeast Asia. But the plans are being made with too little attention to diagnosing the causes of the generally disappointing performance of large, publicly-operated canal systems (on which the bulk of the irrigation investment will be spent). The problem is not that no statement of causes is made, but that one set of causes, which we will argue here are indeed very important, are simply not considered; they are 'screened out' from consideration from the very beginning. The remedies are hence unlikely to have the effects expected of them; and when such large amounts of resources are being allocated to them, this matters.

To be more specific: Much of the literature on the causes and remedies of poor canal performance in the tropics, though large and varied, is characterised by three assumptions, usually implicit: (1) that the problems are mainly of a 'technical' rather than an 'institutional' nature; (2) that the problems arise mainly 'below' rather than 'above' the outlet, that is, at the farm

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1. Main system management was described as a 'blind spot' by Anthony Bottrall (1978:322) in an article which makes a number of the points which are elaborated here.

and village level; and (3) that insofar as problems are identified as 'institutional', they relate to the institutions of farmers.

The meaning and significance of these assumptions can be illustrated by examining three recent reports on irrigation improvement. All are the work of distinguished specialists and all are likely to shape opinion widely in development circles and to have direct repercussions on how money for irrigation and irrigation-research is allocated.

Take first the report to the Trilateral Commission (Colombo et al., 1977). It proposes a fifteen year international programme for doubling rice production in South and Southeast Asia, 'focused on irrigation improvement as the leading factor in generating production increases' (XIII). The report focuses on Asia because two-thirds of the world's malnourished people live in this area, and because the 'gap' between projected food demand in 1985 and extrapolated food production in underdeveloped countries is concentrated in rice in Asia. It takes rice because rice is the staple food of most of Asia (nearly three quarters of foodgrain consumption), and because judging from average yield differences between Japan (6 tons per hectare) and South and Southeast Asia (about 2 tons per hectare), the potential for yield increases is very large. Whereas it took Taiwan and South Korea some 40 years to double their yields of the 1920s, it is thought that countries of South and Southeast Asia, which now have yield levels about the same as Taiwan and South Korea in the 1920s, can shorten the doubling period to about 15 years - given adequate investment in the right things.

To increase rice production irrigation must be expanded and improved. As the report says, 'In the case of paddy, controlled supply of water is an absolute prerequisite; and modern varieties and fertiliser have effects only when there is sufficient water. <u>It should be clearly recognised that good water control is the single most important factor in increasing paddy yield in Asia at this time</u>' (24, emphasis in original).

How to increase irrigation? The report gives the results of a series of cost calculations for a number of alternatives, based on recent experience in Asia. 'In general, all methods starting with previously uncultivated land are shown to be not advisable, because they cost more and take more time. The lowest capital costs for increasing paddy production by 1 ton per hectare per year are, first, in improving inadequately-irrigated land to adequately-irrigated land and, second, in improving rainfed cultivated land to adequately-irrigated land' (XII).

How to improve inadequately-irrigated land? 'The shift from inadequate to adequate irrigation facilities in most cases requires primarily digging out farm ditches, maintenance of ditches, and good management of water supplies' (XII). Hence irrigation improvement is to be effected by the construction on a huge scale throughout South and Southeast Asia of farm ditches to carry water from the canal outlet closer to each individual field. (The report suggests a density of 50 metres of farm ditches per hectare of cropped area as the dividing line between inadequately and adequately irrigated areas, p.21).

To achieve this investment the report calls for an increase of current annual budgets for irrigation in South and Southeast Asia from US$1.7 billion (in 1975 prices) to an annual average level over the whole 15 year period to 1993 of $3.6 billion.

The report thus implicitly adopts the first two assumptions stated earlier: that the problems are technical (inadequate physical structures), and below the outlet (farm ditches). To be sure, the report does emphasise that 'these improvements in water control will not automatically and in themselves bring about the desired production increases. A wide range of actions will be needed, including the critical need to develop rural institutions' (XIII). More specifically, the report emphasises the need to supplement farm ditch construction with intensified extension efforts, and by efforts to develop leadership and discipline in the rural community 'to organise its members for the protection of their common good and reconciliation of conflicting interests .... Serious extension efforts to organise farmers into such groups as irrigators' associations and compact farms should accompany the construction of irrigation facilities' (28). The report thus also assumes the third general proposition, that the needed 'institutional' developments relate mainly to village communities.

Yet on *a priori* grounds one would expect the reliability and adequacy of water supplies delivered by the main system to the outlet to be a very important influence on irrigators' behaviour and relationships below the outlet. Take farm ditch maintenance, for example. The report recognises that the farm ditch programme requires as an essential condition of success that the new farm ditches be adequately maintained; but sees this wholly as a problem of developing leadership and discipline amongst farmers. What is not recognised is the dependence of maintenance effort on the adequacy and reliability of supplies through the outlet. If the standard of water service falls below a certain level, one would expect this to have sharply increasing disincentive effects on maintenance effort. Where, on the other hand, unlimited supplies of water are available through the outlet, this too may lead to poor maintenance - since supplies will be ample for all even through poorly maintained ditches. Thus farmers will not maintain the ditches unless the government runs the canals effectively. And the same point applies to land development below the outlet: unless farmers believe the supply to the outlet will be adequate and reliable, they are likely to resist efforts to make them undertake expensive land shaping measures. Indeed, starting with field investigations, several authorities have converged on the conclusion that the delivery of appropriate and reliable amounts of water to outlets can be seen as a precondition for community-level action, including land development, field channel maintenance and irrigators' associations (Bottrall 1978, Hart 1978, Duncan 1978, Wickham and Valera 1978; also Wade 1979, Levine 1976, Moore 1979; also Bromley *et al.* 1980).

This latter proposition shifts attention to the way that the main canal system is operated and maintained, and particularly to the effectiveness of water control in the delivery system. Effectiveness is a function of two variables: control *capacity*, and control *utilisation*. (Levine 1977). *Capacity* is a function primarily of the physical structures - the gates, cross-regulators, measuring devices, canal linings, communication facilities such as telephones, radios, and, as the report correctly emphasises, farm ditches. However, it is misleading to assume, as this and most other reports on irrigation improvement do, that higher levels of control capacity will 'automatically' give rise to improved utilisation of that capacity by the canal staff, resulting in more effective water control to the outlets. *Utilisation* of capacity depends on many complexly interacting factors. Some are environmental, such as the percentage shortfall in water flow compared to normal - the greater the shortfall the greater the utilisation of control capacity is likely to be. Others are related to the communications system, to the training of canal staff, to the structure of the irrigation bureaucracy through which the operation and maintenance is carried out, and to the liaison (or otherwise) between canal staff and irrigators.

To give an illustration: Canal systems in South Asia are operated through large unified bureaucracies. At the top are the Ministers, the Secretary for Irrigation, and the Director-General or Chief Engineer General, the latter with a central technical staff for planning and design; all these are located in the capital city. At the next level are the regional administrations, in the form of Circles, headquartered in regional cities or large towns; then the executive units, the Divisions, headquartered in or near their command areas; then supervisors, foremen, and ditch tenders (or 'bankers'), located in or near their jurisdictions within the command areas (Levine 1977). Strict relations of supremacy and subordination are meant to hold between levels, the instruments for achieving organisational objectives are managed by sets of directives, and the incentives for compliance by subordinate units are based simply on conformity to orders - with a major asymmetry between small or negligible gains for conformity and severe punishment for 'laxity'. This form of organisation tends to generate a further asymmetry in information flows, as orders, instructions, directives come down the hierarchy relatively fast and without distortion, while feedback flows are more restricted and liable to distortion at each level, as a result both of geographical distance (and perhaps class and caste difference) and of the asymmetry in incentives and punishments, which prompts subordinates to conceal or falsify information passed upwards to protect themselves against coercive sanctions.

When there is little concern amongst farmers or government for water use efficiency, this restricted upwards flow of information does not matter. India's old rice canals were built at a time when concern for water use efficiency was indeed low: there was no storage, so the opportunity cost of wasted water was low (either the river water was diverted into the canal or it was let flow to the sea); and the water-response function of traditional varieties was relatively flat, so that canal operating policies that resulted in a widely fluctuating supply to individual farmers had a relatively small effect on relations between farmers and the canal system. In these conditions, most of the upward flow of information concerned the <u>security</u> of the physical structures, not the needs of farmers and their crops. Today however the concern for water use efficiency is much greater, and the value of accurate information about what is happening to water supply and crop water demand throughout the command area has increased greatly. But the bureaucratic structure and routines of the irrigation staff make the collection and transmission of this information upwards a major problem limiting the utilisation of any given level of water control capacity.

The main point, then, is this. Canal systems are being designed and constructed assuming a level of utilisation of control capacity which does not exist in most systems in South and Southeast Asia. The problem of poor utilisation cannot be solved simply by improving the control capacity, via improved or more physical structures. In this respect the Trilateral Commission's report is expensively misleading.

II

We can now consider more briefly the other two reports, to see how they too are shaped by some or all of the three implicit propositions stated earlier, thereby excluding the operation of the main delivery system as a problem.

The World Food and Nutrition Study (National Research Council, 1977), carried out by the prestigious US National Academy of Sciences, gives ample attention to irrigation and water management as a priority subject for research. It summarises priorities within the subject as: to find ways of 'improving on-farm water management, supplemented by research and development on physical improvement and on new planning techniques to guide farmers' (p.11). Amplifying, it classifies priorities under two headings: (1) 'altering physical conditions to provide optimal water supply for maximum crop production' (p.90-91), including adjusting tillage and cropping practices so that the soil can retain more moisture, and improving irrigation technology and related work to improve drainage and salinity management; (2) 'adjustment of overall farm management operation to improve crops under varying conditions of water availability' (p.91), including, 'field experiments with plant modelling and systems analysis' (p.91).

In the supporting paper on irrigation, somewhat more attention is paid to 'institutional' aspects. For example, the report says that the reasons for low water use efficiencies (low percentage of water supply which reaches the crop) - typically near 25 percent but which could technically be at 80 percent - 'are complex, but they are more often institutional and economic than technical' (vol.2, p.124-5). This promising statement is supplemented by general declarations like 'any attempt to choose or improve an irrigation design and management programme must consider all of the relevant social, economic, political and technical conditions', and 'The need is for careful determination of optimum management procedures and for innovators' solutions to achieve such management levels within local socio-economic and physical restraints. These studies must be inter-disciplinary in nature and should take into account human and socio-economic factors as well as physical and technological ones' (vol.2, p.129). But the relevant social, economic and political conditions are never spelled out in any detail, and attention remains firmly on those that are technical.

At only one place in the report is there recognition of the dependence of irrigators' practices and behaviour on features of the main system above the outlet, and this point is worth noting. 'Improvements at the farm-level depend, in the case of larger water supply systems, on the ability of the farmer to obtain water at the time and in the quantity required. Thus an important interaction exists between centralised water management/planning and on-farm water utilisation. The structure of an irrigation system can place severe restraints on the irrigator's options to apply sound conventions or innovative water management practices' (main report, p.91). What is striking about this statement is that while it recognises 'the interaction between centralised water management planning and on-farm water utilisation', this leads not to a consideration of how the system is operated but rather straight into an observation about physical structures as a constraint. Indeed, the paragraph comes under a section on 'altering physical conditions to provide optimal water supply for maximum crop production' (pp.90-91).

The only other place in the report where institutional aspects of irrigation are mentioned is in the paper of the work group on 'Rural institutions, policies and social science research'. The work group's objective was to analyse 'how US research and development could help to strengthen the performance of the principal public and private institutions serving agriculture in the developing countries ' (vol.3, p.105). Its section on research priorities for water management emphasises 'knowledge of water rights and legal rules', 'knowledge of the economic and social costs of water, the investments required to make it available and to control it', and the cost of failure to introduce volumetric pricing of water. It adds that 'political scientists can make an important contribution to establishing appropriate institutions, as can sociologists and representatives of the administrative sciences' (p.122). Again, the nature of that potential contribution is not spelt out (in striking contrast to the elaboration elsewhere in the report of the potential contributions of a large range of natural sciences).

A report to the International Development Research Council (Pereira *et al*. 1979) on 'Opportunities for increase of world food production from the irrigated lands of developing countries' similarly restricts its attention almost wholly to technical questions. It lists 30 priority topics for research, most of which are for the disciplines of physics, chemistry, plant physiology, field engineering, and agronomy. Seven topics are 'socio-economic':

- 'Economic analysis of yield versus water consumption functions and of returns versus total costs for alternative water management systems, with a view to defining criteria for optimising practices of irrigation, fertilisation, tillage and cropping sequences.
- 'Short-term versus long-term cost-benefit analysis for installation of alternative water supply systems....
- 'Analysis of water pricing policies in relation to water use efficiency and cropping patterns of variously structured farming communities.

- 'Farm unit size, land tenure and water rights as determinants of irrigation and drainage methods.
- 'Cost-benefit analysis of alternative drainage methods....
- 'Definition of credit marketing and infrastructure requirements for regional development of irrigation and drainage schemes.
- 'Economic, social and administrative factors affecting the motivation of farmers in the sharing of water supplies and improvement of water use efficiency...' (39).

What is missing from this list is reference to research on how the main systems are being operated in practice, and of the room for improvement in the performance of canal irrigation by means of improved working of the administrative hierarchy which operates canals. Factors affecting the motivation of farmers are to be researched, but not, apparently, those affecting the motivation of the people who manage the canals.

Note finally and incidentally a further clear illustration of the third assumption in action: On irrigation in Pakistan, the authoritative World Development Report (World Bank, 1978) asserts: 'Wasteful water management and poor maintenance can be blamed in large part on the hierarchy of social relationships among farmers' (para.40).

III

The blind spot over main system operation is the more surprising when one reviews the potential for higher production and more equitable water distribution through improvements in this field.

This is suggested by evidence of underrealisation of 'irrigation potential'. We know of scarcely any case where a major irrigation project has provided reliable irrigation for the whole area planned. While there are several reasons for this (including unrealistically high expectations), the most common and significant may be the excessive allocation of water to 'topenders' - those in the head reaches. What seems to happen is this. In the early stages of development of a canal irrigation system, the headworks are completed and the water supply for the whole system is available, but the canals are incomplete. There is thus virtually limitless water at the topend, and irrigators receive and become accustomed to liberal and continuous issues. Later, as the tailend is developed, topenders have already established customary access to more than the share of water implied in the original planning, and they are able to retain this access not least because of their physical position near the source. It is thus notorious that topenders commonly receive more water than is needed for crop growth and receive it more continuously than necessary. Conversely, those in the lower reaches of command areas suffer from small, unreliable and untimely deliveries, where indeed they receive any water at all.

That it is physically possible to redistribute water from the head to the tails is suggested by what is sometimes achieved when monsoons fail and water is short. It is quite common then for issues to the head reaches to be curtailed and rotated so that water can be directed towards the tailend to save a threatened crop. If the same control and rotation, issuing less to top-enders, could be implemented in normal times, then tailenders should receive more water in a more reliable and timely fashion, and higher production and more equitable distribution would likely be achieved (Chambers 1980).

The extent of this potential may vary considerably. Evidence from two trials in the Philippines suggests that in some cases at least it may be very large indeed. In both cases staff from the International Rice Research Institute and from the National Irrigation Administration collaborated in tightening up the scheduling of water issues and in directing more water towards the tail. In the first case (Valera and Wickham 1976), on Lateral C of the Peñaranda River Irrigation System, an area of about 5,700 ha., dry season production for the lateral as a whole in 1975 was estimated to be 97 percent up on the base year of 1973, with gains for the four main sections from head to tail of 23, 69, 154 and 1,494 percent respectively. All gained, but the tailenders gained most dramatically. In the second case (Early 1979), on the Lower Talavera Irrigation System, increased production was reported of about 60 percent comparing a benchmark year with the following year. The percentage increases were 94 and 62 for two topend laterals, 16 and 10 for two middle laterals, and an average of 104 for three tailend laterals. Yields levelled up at the topend and tailend, having previously been highest in the middle.

Two examples from India are less clearcut, because not from an 'experimental' situation and because of problems in using official statistics to estimate costs and benefits in each case. In one, water scarcity was induced administratively. The canal (in Andhra Pradesh) had a potential cultivable command area of 112,000 acres but by 1976, some 10 years after water had first been made available, only 75 percent of the potential was being irrigated. Part of the reason for the shortfall had to do with the large area of unauthorised paddy in the upper reaches, which had the consequence (1) that zoned ('localised') land at the tailend of distributories received either no water at all or so irregularly that farmers did not want to risk irrigated crops, and (2) that some tailend areas suffered from water logging and salinity where large expanses of unauthorised paddy were being grown higher up. However no serious attempt to cut back on unauthorised paddy was made until the beginning of <u>kharif</u> 1976. The following year the second stage of the command area was due to be opened, adding another 140,000 zoned acres to the first stage's 112,000 acres, and there were serious fears about the adequacy of water supply for the enlarged command area. By resolute administrative tightening of controls over water releases and enforcement of existing regulations, a large extension of unauthorised paddy in the head-reaches was eliminated, and where it had been growing on land zoned for lightly irrigated crops (as opposed to land zoned for no irrigated crop), a lightly irrigated crop was grown instead; elsewhere too a substitution of lightly irrigated crops for paddy took place, and several thousand acres which had suffered from waterlogging showed no sign of it and grew an irrigated crop for the first time in years. Details on the outcome and on how it was achieved have been described elsewhere (Wade 1978), and here it is sufficient to note that it owed much to the conjunction of a new, interested and determined Collector, a new and equally interested and determined Superintending Engineer, and the support of the local Minister, whose constituency lay towards the tailend of the first stage.

In a second case, involving another Andhra Pradesh canal irrigating over 300,000 acres a year, a water crisis caused by drought in the middle of the first season led to a sharp, temporary tightening of water issues, by means of which the shortfall was distributed more evenly than would otherwise have been the case and aggregate production, as well as equity, was almost certainly higher. This was achieved especially through the introduction, for the first time ever in the canal's 100-year history, of a rotational delivery schedule for the canal as a whole, accompanied by a sharp increase in management effort. This case demonstrates that the level of utilisation of a given set of control structures *can* be much higher than the normal, and therefore that large and expensive rehabilitation of physical structures is not a *necessary* condition before institutional improvement can be attempted (Wade 1980).

There are dangers in generalising from these examples. In the two Philippine cases, flooding was a problem at the topends, and topenders could gain through water control with more sensitive management; this may not apply to the same extent in semi-arid or arid conditions. In addition pilot projects and experiments such as the Philippines' cases are liable to receive special managerial inputs and treatment, and may be difficult to replicate. Further, the Indian examples indicate not merely the potential, but also the administrative and political difficulties of implementing and sustaining redistribution. It is also true that physical structures may present constraints (such as the absence of cross-regulators, and eroded banks and silted channels). But all these qualifications and caveats can too easily obscure the main point. The evidence suggests that without large expenditure on physical structures, but with changes in the distribution of water on main systems, large increases in production may be achieved, with equity benefits to deprived tailenders as well. In India alone, the potential is probably for millions of tons of additional foodgrains. The argument and evidence indicate that to achieve such a quantum jump in production, main system management is the key.

IV

If the potential is so large, why is it not widely recognised? Six explanations interlock:

(i) Visibility

Deficiencies in community-level and on-farm management are more visible than shortcomings in main system distribution. It is at these lower levels that bad water management is most manifest, in the form of profligate water applications, failures to construct or maintain ditches, flooding, water pouring into drains, a few powerful farmers taking more water and depriving the weaker, and so on. These are phenomena which can be seen on a field visit to a single location, and which can become fixed in the mind of the observer. In contrast, irregularity, unpredictability, and inconvenience in main system supplies of water to an outlet cannot be seen in the same way; they occur over distances of canals, and over periods of time. They can be 'inspected' only through records or through interviews, and both are secondary sources, often of doubtful reliability.

(ii) Professional concerns and preferences

Each discipline has its own predilections for research, diagnosis and action. Engineers are trained in construction and are predisposed professionally to see problems and potential in terms of physical works rather than in the timing, location and amounts of water distributed. Agronomists are trained in crop biology and study crop water requirements; their eyes focus on plants, and especially plants in controlled conditions on research stations rather than plants subject to the vagaries of on-farm water supply. Economists think in terms of costs and benefits, and are inclined to recommend regulation through water pricing. Sociologists study water questions at the community level but not on the main system. But in between the areas illuminated by these disciplines there is a dark space. There is no professional discipline for main system management.

(iii) Blaming the farmer

Concern with farm-level water management, and with community-level institutions below the outlet, can indeed, be seen in psychological terms as an act of projection. Rather than self-critical introspection, leading to reform of main system management, professional actors project the blame onto irrigators and see the solution in 'farmer education'. Professionals are, after all, highly trained and knowledgeable; farmers are poorly trained and appear ignorant. It may then seem self-evident that 'water wastage' and 'bad water management' at the farm level can be attributed to that ignorance. But if the water supply to the outlet is inappropriate, this diagnosis, though convenient and reassuring, is wrong.

(iv) Water is politics

The allocation and appropriation of any scarce resource is political, and irrigation water is no exception. Unfortunately, technical disciplines, partly from self-defence, treat water allocation as though it were a purely technical matter. In consequence, the real world of influence, inducements and threats is left out of the analysis. From this it follows that political solutions to political problems are overlooked. It may well be that the priority for institutional development is often not below the outlet but above it, in the creation of institutional means by which irrigation groups or communities can represent and manage conflicts of interest in an overt political process legitimately linked to the bureaucratic process.

(v) The belief that one man's gain must be another man's loss

Even if main system distribution is diagnosed as an opportunity, analysts may shy away from suggesting reform because they believe that productive and/or powerful topenders must lose if tailenders are to gain. After all, water which they would have received will be reallocated and redirected to benefit others. Topenders may indeed sometimes have to lose. If they are /receiving sparing issues, well-spaced, there may be little scope, short of a change in cropping patterns, for them to receive less without losing. But if as is normal they are receiving liberal issues, the very abundance of water may, even if they do not recognise it, be to their disadvantage. Each case should be examined on its own merits. But it can be noted that in the Philippine examples, all cultivators, topenders included, apparently gained. There may be tradeoffs here between quantity of water, and reliability and predictability of its supply. Valera and Wickham recorded of their Philippines experiment that

> 'Farmers in the upper reaches of the lateral gradually came to support the new scheme once they were assured of an adequate share of water even in times of water shortage' (1976:4).

Water reform need not necessarily be like land reform, in which the rich have to give something up. The game may be non-zero sum. Topenders may gain more through a reliable and predictable supply than they lose from getting less in quantity. In such cases, the political obstacles to improving main system management should be sharply reduced.

(vi) <u>Little incentive to canal operators</u>

Canal managers have little incentive to allocate water so as to capture the full economic gains from efficient use, even though the gains would be large. This lack of incentive has two dimensions. First, the form of organisation within which they work is usually a civil service department. The norms and regulations of these departments do not lend themselves to providing incentives in the form of financial rewards or prestige for improving the economic efficiency of irrigation systems. Second, the potential of water allocation to generate conflict is unusually large. Water is valuable to irrigators but unambiguous ownership rights are difficult to establish. Moreover, the problem is spread over time since continuous or nearly continuous supplies of water are needed, in contrast with, say, seeds or fertiliser which are supplied only once in a crop season. There are therefore pressures on canal managers to allocate water so as to minimise conflict and trouble for themselves. Generally this prompts highly permissive releases in the upper reaches with consequent starvation in the tails, even though, as we have argued, farmers in the upper reaches might in some conditions gain, or at least not lose, from less permissive but more predictable releases.

These six factors provide a starting point for thinking about why main system operation has been so neglected in recent discussion. Main system operation and the design of appropriate management structures were, however, given attention 80 years ago in India, by the members of the first Indian Irrigation Commission in their Report of 1901-03. That a change has taken place can be seen by comparing their report with that of the National Irrigation Commission of 1972; there, main system operation is scarcely mentioned as a problem. Reports are only reports; but the central strategy for improving canal irrigation in India today appears to accept the same three assumptions which underlie current irrigation orthodoxy internationally (though with some notable, if still partial, exceptions, as in Andhra Pradesh). It must be sobering for any would-be reformer to note that the blind spot has got worse, not better, over the past seven or eight decades; but it is also encouraging, since it reinforces the view that, precisely because of this, main system operation now presents a major opportunity.

V

To begin now to explore and realise the potential from improved main system management requires two thrusts.

The first is cognitive. The three reports cited at the beginning of the paper were highly professional; they were, in fact, too highly professional. For since no profession is closely concerned with water distribution on main systems, that set of concerns was simply not raised. The challenge now is to enable engineers and others to regard main system scheduling and distribution as professionally exciting, satisfying and rewarding. In the long term this may require new training for a new profession. In the short term, the question is whether those engaged in irrigation management can themselves raise the status of water distribution as a professional concern. This suggests that immediate attention should be given by national governments and international agencies to in-service training for canal operators, to the reform of university and diploma syllabi, and to the writing of textbooks on canal operation (at present virtually non-existent).

The second thrust is diagnostic. Can methods be devised for quickly and correctly identifying feasible changes in water distribution? Feasibility here must relate to the existing physical structures, to the extent to which conflict can be avoided by enabling all or most irrigators to gain from change, and to the institutional capability of the bureaucracy to implement a changed pattern of water distribution, preferably with collective involvement of irrigators. If such methods can be devised, used and evaluated, it should be possible to gauge more clearly the scale of the potential from improved system management. There is at least a chance that they might unlock a set of changes which would transform the productivity and equity of canal irrigation much more widely. With over 20 million hectares under canal irrigation in India alone, the stakes are so high that the case for an attempt is compelling.

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