revised 4/3/1991

WATER DEVELOPMENT IN INDIA: AN HISTORICAL OVERVIEW

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March 29, 1991

Paper prepared for delivery at the Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, Indiana, Colloquium Presentation, April 1, 1991.

Water Development in India: An Historical Overview

Total annual rainfall varies widely among different regions of the Indian sub-continent, as do other features of the physical environment (topography, soils, river flows, groundwater storage). However, a common feature of nearly all regions, even those with high precipitations (1200 mm. and above), is a very intense concentration of their rainfall within 3-4 monsoon months. Agriculture in all regions with such rainfall patterns thus stands to benefit substantially from some form of control or conservation of water so that it can be used during drier parts of the year.

To simplify discussion (and, in the process, inevitably over-schematize things), we shall focus in this paper on three main regions, each with strongly contrasting agro-climatic characteristics: (1) the low-rainfall (500-700 mm) plains of the North West (Punjab, Haryana, western Uttar Pradesh, extending westward into Pakistan); (2) the higher-rainfall (700-1500 mm), flood-prone Eastern Gangetic plains (eastern Uttar Pradesh, north Bihar, West Bengal, extending eastwards into Bangladesh); and (3) the drought-prone undulating/hilly terrains of the central Deccan plateau, which can be further sub-divided into (A) lower-rainfall (400-700 mm) areas with a long history of settled agriculture (western Maharashtra, western Andhra Pradesh, Karnataka, Tamil Nadu), and (B) higher-rainfall (700-1300 mm) areas, traditionally remote and forested but coming increasingly under cultivation by predominantly aboriginal "tribal" people (eastern Gujarat, Madhya Pradesh, south Bihar, western Orissa). Other important regions that have been excluded from the main discussion, but may be referred to from time to time, include the arid western deserts (Rajasthan, western Gujarat), the foothills of the Himalayas (Himachal Pradesh, north-

western U.P., extending eastwards into Nepal), and the south-eastern river deltas of the Krishna, Godavari and Cauvery (Andhra, Tamil Nadu).

The pre-colonial period

Significant investment in water development was made in many regions, especially the more water-scarce, before the advent of British colonial rule. A few canal diversion systems were constructed in the North West under the direction of the Moghul emperors and major water conservation works were undertaken in and around urban settlements in arid Rajasthan, primarily for drinking purposes. Otherwise investments were relatively small and local: for example, many private shallow wells in the north-western plains, community-managed hill diversion systems, and community- and privately-managed water conservation systems in low-rainfall areas.

Within the latter category, the most impressive achievement was the construction of huge networks of tanks (small reservoirs) in the southern Deccan (upland Tamil Nadu and parts of Karnataka and A.P.). Major investment took place from the C12th onwards, largely at the initiative of local princes and landlords, with technical advice from specialist surveyors and craftsmen. Construction was undertaken by villagers, who also developed their own institutions for system maintenance and water distribution. The tanks were usually built in sequential chains, starting with smaller systems towards the head of a catchment and working downwards, with increasingly large systems, towards the valley bottom. By the time the British arrived, many areas were virtually "saturated": all the best tank sites were already developed. British engineers were extremely impressed by the

sophisticated hydrological and technical skills that had gone into their construction. As successive tanks were constructed down a chain, careful thought seems to have been given to the respective rights of upstream and downstream users when calculating the height of each tank's bund and overflow weir - the means of regulating how much of the catchment runoff could be conserved at any one site and how much could be allowed to continue to the next tank(s) below. In many intensively developed areas there appear to have been supra-village organizations with powers to arbitrate over any inter-tank water right disputes that might arise.

The British period

During the British period, from the 1840s onwards, the introduction of new technologies enabled the construction of huge canal systems on a scale previously unimagined anywhere in the world, with hundreds of thousands of hectares being commanded from a single diversion source. The principal areas chosen for this type of development were the big rice deltas of the south and - most spectacularly of all, since it involved the development of a hitherto sparsely populated region - the plains of the North West. Both, in their very different ways, provided extremely favorable (low unit cost/high return) environments for large canal-irrigated agriculture. Thus, in the north-western plains, with which we are particularly concerned here, gently-sloping land gradients were available over hundreds of miles, soils were alluvial and fertile, drainage was generally good, and the limited rainfall encouraged positive farmer response to the almost perennial flows available from the immense Indo-Gangetic rivers, which were fed by Himalayan snow-melt as well as the

monsoon rains.

Most of the irrigated lands were taken up by new settlement. The principal objectives of the British administration were to raise substantial land and water revenues (in part to help cover the capital costs of canal construction) and to provide enough "protective" irrigation to safeguard the largest possible number of people from famine. This led to a policy of spreading the available water very thinly through an extensive network of canals operated on a strict rotational basis. The principle of water allocation was on an exactly proportional basis to land - each cultivator being allocated a time during each week when he was entitled to water (and would receive water whenever it was rotated to his part of the system). This supremely supply-led system was deliberately designed to be inflexible in operation, with the minimum of control structures. The uniformity of the terrain, soils and induced cropping patterns made such a design possible but it was also favored for administrative reasons: with only limited numbers of senior staff to supervise the systems' management, the British were concerned to minimize the scope for tampering with the officially authorized flow allocations, either by farmers or native field staff.

Overall authority for managing these large systems (and for framing the detailed rules by which they were to be operated) was given to State Irrigation Departments (IDs), headed by engineers. That authority was supported by new legislation that vested control over all the country's water resources in the government. Users' rights were confined to those limited ones conferred on them by the ID engineers - principally the right to a certain time for receiving water, referred to above. Otherwise, the canal rules had much more to say about users' responsibilities (and penalties for failure to abide by them) than about their

rights. And opportunities for users to hold ID staff to account for poor service were virtually non-existent.

Nevertheless, most of the canal systems appear to have operated with a high degree of efficiency and equity. This may be largely attributed to the strong pressures exercised on ID officials from above to ensure that the canals' financial and political (famine-prevention) objectives were successfully met - and the absence of strong local political forces capable of challenging or subverting the decrees of the "heaven-born". The consequence was the creation of several generations of engineer-managers of great professional competence and pride, dedicated to the achievement of their assigned tasks through adherence to a code of paternalist, quasi-military discipline. At the field level, farmers were generally willing to accept the disciplines imposed on them so long as they could be sure of receiving their water entitlements, of which they were precisely and acutely aware. On such a rigidly supply-driven system, the scope for community decision-making was necessarily limited, in most cases probably not going much beyond agreeing how to maintain the tertiary watercourse channels. Water scarcity tended to ensure that each farmer stuck religiously to his allotted rotational warabandi water supply turn - and made sure that his neighbor did not take water for a single second longer than he was supposed to.

The fate of smaller, farmer-managed irrigation systems during this period was mixed. In some areas, such as the Kumaon hills of northern U.P., traditional water rights were codified and protected with the help of the colonial administration. But, especially in those parts of South India that came under direct British rule, the previous prosperity of the tanks and the agriculture they supported was very adversely affected by predatory levels of land

taxation from the late C18th. Consequent declines in cultivators' incomes made it increasingly difficult for them to maintain their systems in good condition and this contributed in turn to declining agricultural production. The government's response to these problems of their own making was to compound them further by decreeing that, because of the physical deterioration in the tanks' condition, legal responsibility for their maintenance should be handed over to the recently-created Irrigation/Public Works Departments. Departmental staff were in no position to undertake directly the maintenance of thousands of widely scattered systems, and initial attempts to compel cultivators to work together "voluntarily" were predictably unsuccessful. Subsequent changes in fiscal policy seem to have helped many of the tanks to return to a new, relatively stable physical and institutional "equilibrium", with IDs providing modest financial and technical back-up for maintenance and cultivators continuing to allocate water through their own age-old institutions. But the legal changes introduced by the British (which effectively transferred the formal ownership of tank waters from communities to government and left cultivators with only unwritten, de facto rights over water allocation and use) contained serious contradictions and ambiguities which undoubtedly weakened the capacity of tank irrigators to protect themselves and their resource against possible future adversities that might arise.

Post-Independence

In just over 40 years since Independence, India's net irrigated area has more than doubled, primarily through the development of two kind of technology: very large canal systems, developed by State IDs; and lift irrigation from groundwater, mainly through

massive private investment in tubewells, starting from the early 1960s. The broad pattern of change is conveyed by the following figures:

Table 1

Development of Irrigation, 1950-1985
(Net irrigated area in million hectares)

	1950-51	1960-61	1970-71	1980-81	1984-85
Canal irrigation	8.3	10.4	12.8	15.3	15.9
Tanks	3.6	4.6	4.1	3.2	3.3
Tubewells	n/a	0.1	4.5	9.5	11.3
Other wells	6.0	7.2	7.4	8.2	8.7
Other sources	3.0	2.4	2.3	2.6	2.6
Total net irrigated area	20.9	24.7	31.1	38.8	41.8

The huge support given by government to this development, through direct investment in large canals and bank credit and subsidies for tubewells, was impelled by an urgent concern to achieve major increases in food production in the face of rapidly expanding population. For the time being, that critically important goal has been met, largely through the Green Revolution that began in irrigated areas from the late 1960s. It is not a criticism of that remarkable achievement to suggest, as this paper does, that many of the policies and institutions for water development that have been dominant since Independence are seriously flawed.

Among the most striking features of the pattern of water development during this period have been:

(a) With respect to surface water development, the absence of any significant change in

the old colonial legal and administrative framework created by the British; persistent (and still continuing) efforts to transfer the technologies and institutions of the North West plains and southern deltas to other areas where they are inappropriate; and a marked deterioration over time in the quality of irrigation system design, construction and management.

(b) With respect to groundwater, the adoption of an essentially free market, laissez-faire approach, under which water is left to be exploited as an open access resource by individual investors - almost the complete antithesis of the surface water development framework.

(c) The virtual absence of any effective national or regional institutions for the coordinated planning and management of surface and groundwater, despite their interdependence and the increasingly complex and intense demands being placed on the total resource in many areas, not only for agriculture but also for domestic, industrial and other uses.

How can these features be explained?

Surface water development. There is a striking contrast and apparent contradiction between the numerous and far-reaching changes that immediate post-Independence governments made in earlier legislation relating to land rights (curtailment of feudal zamindari powers, land redistribution, etc) and their willingness to take over essentially unaltered a legal framework for surface water development that denies any worthwhile rights to the cultivator. However, at that time the governments concerned probably saw both sets of actions as broadly consistent with a socialist philosophy which required the state to play a directly interventionist role in promoting greater social justice and protecting the interests of the poor. While those goals called for radical reforms in the prevailing pattern of ownership

in the case of the privately-owned resource of land, no such need was perceived in the case of water: the best agency to ensure equitable distribution of such an important common pool resource was seen to be the state, and the law already provided it with all the powers it could want. In the light of subsequent abuses of those powers, some may now find it difficult to imagine that the political leaders who reasoned thus were not either naive or cynical. But it is likely that many of them believed sincerely that the officials of the State IDs would continue to exercise the same rigorous control over the distribution of water and its benefits after Independence as they had before it. Paternalism ruled.

The suggestion here is that the remarkable success of the centralized, authoritarian canal administration of the North West in achieving its productivity and equity objectives, over such a large area, was an important factor in persuading India's leaders to accept the existing legal framework (and other "software" components of the NW irrigation system) rather uncritically, instead of going back to first principles and constructing a new framework. For similar reasons (the success of the NW canals and a lack of experience of any other design, construction and management traditions), the irrigation engineers - most of them, naturally, natives of the North West - also fell into the trap of supposing that the only recipe for successful water development in other "more backward" parts of the country must be to transfer to them the whole NW package - hardware as well as software.

Even into the '70s and '80s, when there was plenty of evidence to show that NW canal technologies did not fit the needs of other environments, the idea of "transferring the NW model" still exercised strong appeal, especially in the national capital, New Delhi, which is itself part of the North West. A major reason for the idea's astonishing persistence was the

spectacular success of the Green Revolution in the NW canal areas - although the most immediate reason for that success was the proliferation of private tubewells which had come into existence "on the back" of the canals (recycling their seepage) and provided all the flexibility of water supply that the canals lacked. (This was a uniquely fortunate outcome of the way in which the design and operation of the old canals happened to interact with the local aquifer conditions, and was certainly not foreseen by the canals' original planners.)

A parallel adherence to a single, top-down technology transfer approach to development can be seen in India's agricultural research and extension system: because the approach has worked rather well in the more favored and homogeneous irrigated environments, especially the North West, it has been widely assumed until very recently that it should work equally well in more complex, diverse and predominantly rainfed environments - and when it does not work, it has been the scientists' stock response not to question the approach but to blame the non-adoption of recommended technologies on the unreceptiveness and backwardness of the farmers in the area concerned. This kind of perception has had particularly unfair and unfortunate consequences for the higher-rainfall, flood-prone plains of eastern India. To many in the North West, they have appeared to be an extension of the NW plains, only more fortunate because they are "blessed" with more abundant water (a very simplistic view in the eyes of anyone who has to cope with the risks and complexities of agricultural management in the midst of floods, but superficially appealing to someone from a semi-arid background). It follows from this kind of thinking that the failure of any technology in the eastern region must be the consequence of local "political and social factors" rather than a fundamental fault in the conceptual design of the technology itself.

Another important factor that impeded the development of alternative concepts for planning and managing India's water resources was the very urgent pressure from the beginning of Independence to create massive increases in the country's irrigation capacity in order to meet the food needs of its ever-expanding population. The first priority was new construction and, because of the long gestation period of most large canal projects, the primary attention of irrigation engineers was turned increasingly away from the finer points of system design and management (which had included regular interaction with farmers) to the world of contractors, materials and workforce organization. As new large canal systems were introduced into increasingly problematic physical environments and the inadequacies of the inflexible NW designs were manifested through the classic problems of upstream waterlogging and downstream drought, the colossal attendant problems of system management tended to be shelved for the time being - because there was always more construction to be done. In the process, previously meticulous design and management standards declined: for example, each of the old NW systems had its own very detailed operational manual, but most of the new systems had none.

Meanwhile, major changes were taking place in the political and social context of water development. Before Independence, the IDs' engineers had exercised their authoritarian powers over a relatively docile population of water users and their actions were controlled in turn by a colonial government with an over-riding interest in extracting revenue and maintaining order. With the advent of democracy, all kinds of new political and social pressures came into play. Being locked into a rigid, unitary framework of management rules and technological choice, the engineers were able to respond to this outburst of

pluralism in only two ways: either to reject the pressures put on them (eg., to realign a projected new canal, turn a blind eye to an illegal outlet, or give more water to A at the expense of B) through the exercise of "discipline" and the rule book; or to accede to them, in the expectation of private reward and at the expense of efficient and equitable system management. On the inflexibly but appropriately designed systems of the North West, the scope for rule manipulation is relatively limited and the traditional quality of management has remained high to this day. On most of the new systems, however, the much greater difficulty of imposing principled and orderly control over water allocation has led increasingly to the adoption of "rent-seeking behavior" as the norm. Those honest officials who try to resist the pressures of the politically powerful are likely to be transferred elsewhere.

In a classic case study of a canal in Andhra Pradesh, Wade (1982) has documented in detail the processes of corruption that typically operate in such a context. Discussion with knowledgeable informants in other states confirms that officials and field staff who control the distribution of canal water are often siphoning very large sums of money away from water users not only for their own use but also to finance the electoral campaigns of local political parties. In Bihar, much of the (regularly inflated) state budget for construction and maintenance is said to "disappear" directly into individual and party pockets.

Political pressures have also adversely affected the revenue-raising side of canal operation. Election campaigns run on the platform of reducing water charges are universally popular among irrigators (who are invariably portrayed as "too poor to pay", even when they will readily pay far higher prices for privately sold groundwater). As a

result, irrigation revenues in most states are much smaller than the IDs' operation and maintenance budgets (in Bihar revenues have fallen to less than the cost of collecting them). This means (a) that those fortunate enough to benefit from canal irrigation are being heavily subsidized at the expense of others, including much poorer cultivators in rainfed areas, and (b) that the central exchequer is reluctant to provide IDs with sufficient funds for operation and maintenance, thereby contributing to the further decline of system performance. (Whether some IDs would perform any better with a larger O&M budget is a moot point, since most of the budget is invariably spent on "establishment", the size of which expands on Parkinsonian principles to whatever level the ID can persuade the government to pay.)

This is something of a "worst case" caricature; not all state IDs have become equally corrupted. However, there are so many obvious weaknesses in the prevailing management system that radical reforms are clearly called for. Many of the system's severest critics are astonished that the government should continue to nurture it with apparently limitless supplies of public funds. That it does so is a measure of the formidable political power that many IDs have managed to acquire for themselves over time, through means outlined above.

Poor canal system performance and management has been a matter of serious concern at high levels of government from the mid-1970s onwards. However, all the resultant reform programs (Command Area Development Authorities, Water and Land Management Institutes, pilot exercises in "farmer participation") have either been given to the IDs to implement themselves, with a view to achieving "reform from within", or they have been co-opted or sidetracked by the IDs in such a way that any intended threat to their interests has been effectively neutralized. No program so far has questioned the basic legal and organizational

assumptions which have allowed them to operate since their inception without any formal accountability to their water user clients or the general public. Before trying to dismantle a Juggernaut, one must work out an effective strategy for doing so and have a clear idea of what alternative institutions are to take its place. There is no evidence that any government policy-making agency has yet begun to grapple with these fundamental issues.

Groundwater development. India has had a long tradition of well development under private ownership, both in the alluvial plains of the big rivers and in the water-scarce, hardrock areas of the central plateau. Irrigation from traditional dugwells, based on animal and human draft power, was already a significant factor before Independence (see Table 1). In the 1930s the U.P. ID introduced some large-capacity tubewells on an experimental basis in western parts of the state that fell outside the large canal commands. Direct management of the tubewells by ID staff was justified mainly on R&D grounds (farmers had had no previous experience of the technology) but also on those of ensuring equitable water distribution. Since Independence IDs have continued to invoke the equity argument as the principal reason for installing State-operated Deep Tubewells (DTWs), and public funds have been provided for the purpose in several states, fortunately on only a fairly limited scale. (Tubewells, being very flexible sources of water supply, are also, by the same token, highly manipulable. Placing responsibility for their operation in the hands of poorly-paid ID field employees is a recipe for disaster, as evidence from Pakistan has clearly shown.) By far the most dynamic engines of irrigated agricultural growth in India since the early '60s have been private Shallow Tubewells (STWs) in the higher watertable areas of the alluvial plains and private borewells in the hardrock areas.

Indian governments since Independence have shown very little interest in providing a legislative framework for groundwater legislation: draft laws have been prepared for Gujarat and Tamil Nadu, both extensively affected by acute water scarcity, but they have never been enacted. By default, the only relevant body of legislation dates back to the British period. This permits anyone who owns land to install a well or wells on that land and to draw apparently unrestricted quantities of water from the source(s) concerned. In effect, therefore, groundwater in India is an open access resource.

Since the private tubewell revolution began, central and state governments have given vigorous indirect support to its development (a) by providing individual investors with generous bank credit and subsidies for well installation, and (b) by providing often heavily subsidized electricity supplies. They also have groundwater investigation directorates, whose job is to estimate and map water availability and extraction levels in different localities. The directorates' estimates are used by the banks as the principal means of trying to control against over-extraction in areas of acute water scarcity or poor quality. Thus, certain districts or blocks may be declared "black" (no more bank loans to be issued). However, this control mechanism can easily be circumvented by anyone in a position to invest his own resources or to borrow from other sources - and most of the more aggressive exploiters of groundwater are in that position. Advocates of greater government intervention in the management of groundwater aquifers often call for legislation that would impose minimum spacing restrictions between wells, but this is generally felt to be unenforceable as well as inherently inequitable since it would tend to discriminate against less wealthy "latecomers". Power pricing is a potentially powerful instrument of policy - as an

incentive to increase groundwater use in abundant areas and to restrict it in scarce ones - but few State governments appear to have recognized it as such so far.

If one were to attempt a balance-sheet for the past thirty years of the benefits and costs of the very limited direct government intervention in groundwater development, it would surely come out very positive (especially in comparison with the polar alternative of very active government intervention). In relatively water-abundant areas in which canal irrigation was already well developed and a prosperous class of peasantry was emerging (the North West, the old deltas, parts of Gujarat), the productivity response has been enormous. Moreover, initial concerns about extreme inequity in the distribution of benefits as a result of exploitative monopoly control over the resource by big "waterlords" have been dispelled, or at least much muted, by more recent evidence of the extensive development of competitive groundwater markets in which buyers are often able to obtain water at only marginally higher cost than sellers. In the very water-abundant area of the east, where there remains tremendous potential for increased exploitation, the government's reliance on market forces has led to significant but, in many areas, slow and patchy development. A carefully planned and coordinated program aimed at improving weak infrastructure (especially power supply) and support services would have produced much better results. The greatest problems have inevitably been encountered in some (though by no means all) of the water-scarce areas of the Deccan. There the general absence of competitive markets has tended to introduce a sharp polarization between those who own wells and those who don't, and in some localities (Coimbatore District is a classic example) the resource has been mined far beyond its sustainable limits. Effective controls against over-exploitation are lacking, and the richer

farmers who have the greatest influence on government policy will do nothing to encourage their introduction.

In reviewing the larger picture so far, many would argue that the problems of the water-scarce areas have been a small price to pay for the immense benefits of non-intervention in other regions. However, from now on, India's groundwater resources are going to come under increasingly intense pressure in nearly all areas except parts of the eastern plains: for example, major problems of water quality as well as excessive drawdown have emerged in the North West. While the government's laissez-faire policy (or lack of policy) may have served the nation quite well on balance so far, it may not do so for much longer.

An interesting feature of groundwater development in India (and probably elsewhere too) has been the very insignificant part played in well development and management by water users' groups. Where they do exist, they have almost invariably been formed by some outside, often voluntary, agency and their continuity over time has frequently appeared to depend rather heavily on sustained external support. Why should wells be so different from small surface systems in this respect? The principal reasons appear to be that in the case of a STW, which is the most common and favored well technology,

- it is relatively easy for a single individual to raise the necessary capital to install the well and thereby secure control over the resource and its appropriation; on small surface systems, an individual requires the collaboration of others, especially in the form of labor contributions, both to secure initial control over the resource and subsequently to maintain it.

- flexibility of operation encourages a form of water distribution that is based on separate and differential contracts between the well owner and multiple users, under which water is sold for profit, rather than on a set of sharing rules commonly agreed on in advance; in this essentially commercial relationship, conflicts of interest tend to arise within a group whose members are both sellers and buyers of water.

- exclusive boundaries are often very difficult to establish over a particular "command

area", especially where water is relatively abundant; thus, the fields of some group members may also be irrigable from another adjacent tubewell, in which case they may find it attractive to switch allegiance to another supplier.

Where lower watertables call for the installation of a DTW rather than a STW, the attractions of private ownership tend to be substantially less, because both capital and transaction costs are much higher. Here, rather limited evidence suggests that some kind of water company or cooperative specializing in water service provision might prove more successful than a water users' group.

One field in which group action could have a critically important role to play in future is that of aquifer management, in areas where water scarcity or quality requires that all well operators agree to constrain their exploitation of the resource to secure its sustainability. One essential requirement for such a development would be accurate information about the characteristics and condition of particular aquifers and the availability of that information to all its users. Though some ground water investigation directorates appear to have quite good information about some of the more water-scarce localities, it is not currently part of their mandate to share it with well owners or other local decision-making bodies; nor do they have the resources that would enable them to analyze and disseminate it at the level of disaggregation required.

Water resources planning. Given the complexity of the total water resource systems (surface and groundwater) in most regions of India, and the increasingly intense competition for their use, it is astonishing that there should be virtually no institutions concerned with planning their future development. To be sure, numerous tribunals and commissions have been set up to deal with a succession of international and inter-State disputes over river

water, but their concern has been only with the allocation of rights to water in aggregate, not with detailed analysis of its potential use. A National Water Policy was formulated in 1987 at the behest of the then Prime Minister, Rajiv Gandhi, but it consists of broad principles only: how those principles are to be made operational is still obscure. The dimensions of the problem may be inferred from the fact that the nation's Central Water Commission is concerned with surface water development only (largely on a project by project basis) and that there is a separate Central Groundwater Development Board, whose functions are essentially confined to survey and monitoring. The same bifurcation exists at the State level: the main body of the ID focusing exclusively on structures relating to surface water development, and with no interest in groundwater development apart from the potential scope for installing and managing public tubewells; and the groundwater directorate (a Cinderella agency appended to the ID) publishing statistics often wildly at variance with those of the Central Board.

In partial explanation of this phenomenon, one could perhaps again point to the powerful grip over official thinking exercised by the "NW model": that region has developed very satisfactorily on the basis of discrete government-funded canal projects, followed by unplanned groundwater development to fill up the gaps, so why not others too? But a more immediate and profound reason appears to be the very strong vested interest that IDs have in giving primacy to surface water structures (which may include flood embankments as well as canal systems) and their profound suspicion of any process that might show alternative investments, especially in groundwater, to be preferable.

The extent of this "anti-groundwater" bias among engineers has been very evident in

Bangladesh during and after the preparation of the first phase of an admirably objective and well-balanced National Water Plan (1986). Pressure from the Plan's financial supporters, the World Bank and UNDP, had led to its being undertaken by a specially created Master Plan Organization (MPO), operating outside the jurisdiction of the country's most powerful construction agency, the Bangladesh Water Development Board (BWDB). As the plan materialized, many BWDB staff seconded to the MPO became increasingly concerned that estimates of very abundant groundwater would lead to surface projects being given relatively low priority in the near future and suggestions were made that estimated groundwater availability be "made less". That did not happen. But the exceptionally heavy floods of 1988 enabled President Ershad, with the help of the French and other donors, to launch a new Flood Action Plan, which places heavy emphasis on embankments and has brought the BWDB (and many foreign contractors and consultants) right back into business. In the process, the carefully balanced recommendations of the MPO appear to have been conveniently forgotten. The same point could no doubt be illustrated from experience in many other countries, including the United States.

An Alternative Paradigm

The logical obverse of the foregoing critique of prevailing norms is an argument that Indian society would be served much better by policies and institutions for water development that evolve from a detailed and sympathetic understanding of the immensely diverse socio-environmental characteristics and traditional water management institutions of different regions and localities. Let us see where that argument takes us if we try to apply it

to the peculiar and strongly contrasting needs of the floodprone Eastern Gangetic plains and the drought-prone uplands of the Deccan plateau.

The eastern plains

Physically, the Eastern Gangetic plains are characterized by increasingly heavy rainfall (moving from west to east); fertile soils; flat overall gradients but very broken micro-topography (so that in a typical village two or three significantly different land elevations exist, each with a different associated farming system); proneness to heavy flooding in the monsoon; high watertables; poor natural drainage; and abundant groundwater. Most of the areas closer to the Ganges and its major tributaries have been densely populated for centuries (a consequence of the attraction of the fertile soils) and have been the center of several important past empires. Until the mid-C19th, eastern U.P. was economically and culturally far more advanced than the adjacent areas of the North West (Stone 1984), but the economic position was quickly reversed after the arrival of the NW canals and the region as a whole subsequently tended towards stagnation and involution. In some areas, notably north Bihar, land ownership patterns are often highly skewed and caste divisions are strong. In Bengal, the skewness and divisions are somewhat less pronounced, but most holdings are very small and landlessness is acute (about 50% of the rural population in Bangladesh). In contrast to some parts of the Deccan, much of the region appears to lack strong traditions of collective self-help at the village level.

Traditions of water management within the region are associated with a predominantly rainfed agriculture. Farmers are immensely adept at "living with floods", drawing on

generations of knowledge about flooding patterns and local land elevations to calculate the risks of different sowing times and varieties of summer paddy. In addition to these critically important decisions at the individual farm level, they also used to participate - in some areas of Bengal, at least - in a certain amount of collective action to maintain local drainage systems and small dikes, under the direction of their zamindar. Dry season winter cropping was carried out either under residual moisture or with the support of irrigation from hand-operated surface lift devices (Bengal) or dugwells (Eastern U.P. and Bihar). Neither had extensive coverage because of the limited capacities of the technologies concerned. Few British administmtors or engineers appear to have had a clear understanding of the principles that underlay the rather subtle and unobtrusive institutions of water management in the flood-prone areas of eastern India. But, recognizing the complexities of the situation and lacking new technologies that could have helped to transform agriculture (eg. shallow tubewells), they did not attempt any major interventions and stagnation continued. (The only large canal system introduced into the region by the British was off the Sone river in central Bihar - a relatively flood-free area.)

The introduction of NW-style large canal systems into eastern U.P. and northern Bihar after Independence (Sarda Sahayak, Gandak, Kosi) has proved a disastrous mistake - though the State IDs and many local politicians still appear not to recognize it: further schemes of the same kind are under construction or projected (Sarju, Bagmati). Not only are the systems themselves very difficult to operate (for reasons explained in Berkoff 1990), but they have inhibited the groundwater development to which those environments are best suited, by further aggravating already serious waterlogging problems and offering surface water at

virtually zero cost to the cultivator. For West Bengal, considerably more innovative thinking went into the planning and design of the multi-purpose Damodar Valley Project, which is as much concerned with flood control as irrigation and is managed by a Corporation that was originally intended to operate on the model of the Tennessee Valley Authority; but its management now is indistinguishable from that of an ID and many aspects of its performance have been problematic. (Interestingly, Bangladesh, when it was still East Pakistan, was also a victim of the NW model transfer syndrome - in this case from West Pakistan: the Ganges-Kobadak canal project and the large public tubewell project in Thakurgaon are almost grotesque transplants of alien technologies into an utterly different environment. But the model was already being challenged by other relatively home-grown approaches to water development well before the country's Independence in 1971 and its influence was much shorter-lived than in eastern India.)

Exploitation of the region's abundant groundwater resources through tubewells was markedly slower than in than in the North West and some other parts of the country. Numerous explanations have been advanced for this - environmental, economic, social, political. They include weak incentives to invest because of high watertables and high levels of post-monsoon soil moisture (natural and canal-induced); imperfect credit markets and limited capacity to invest, especially among the large majority of small farmers; fragmented land holdings as a deterrent to investment because of fears of high transaction costs in obtaining rights of way for distribution channels and in negotiating water sales with numerous users; inadequate and unreliable electricity supplies and high costs of diesel; and mismanagement by IDs of subsidy programs designed to encourage more investment by

smaller farmers (Ballabh and Shah 1989). The weight assigned to different factors has tended to vary according to the location of the various field studies that have been conducted and the (usually single) discipline of the research team concerned.

Initially, slow and patchy development led to the emergence of local monopolies and manifestations of "waterlordism". This persuaded some commentators (eg. Dhawan 198x, Dasgupta 198x) to support the view, always assiduously advanced by State IDs, that the best way to overcome the problem of poor people's access to groundwater was through large public tubewells - a view which should by now have been dispelled by mounting evidence of those systems' predictably abysmal performance (see, eg. Pant 1989, Kolavalli 1989, Ballabh and Shah 1989). Meanwhile, many of the earlier "social" constraints to private investment appear to have become increasingly surmountable over time, so that during the 1980s the number of private STWs rose spectacularly in many localities within the region, especially in parts of eastern U.P., West Bengal (Kolavalli 1990) and Bangladesh (Mandal and Palmer-Jones 199x). Wherever the concentration of well development has been high, evidence is being found of increasingly competitive water markets, in which many small farmers are participating. In many other localities, however, expansion has remained sluggish, probably mainly because of energy supply problems (especially in Bihar) and poor drainage of lowlands in the post-monsoon period (a substantially greater problem in eastern U.P. and most of north Bihar than in West Bengal and Bangladesh, since those areas' winter climate is too cold for boro rice and the soils are too wet for wheat or other alternative crops).

In planning for the future, the whole of the eastern floodplains would surely benefit from a determination to build on the water management traditions of Bengal (lift irrigation on

the back of surface drainage) rather than those of the North West (gravity canal irrigation followed by tubewells). The case for giving first priority to the acceleration of groundwater development appears overwhelming. The resource is abundant and still very under-exploited; unlike the region's surface water supplies, which tend to decline sharply after the monsoon, it can be withdrawn relatively easily from storage for use in the dry season, when returns to irrigation are highest; and, in the longer run, increased pumping can help mitigate flood and drainage problems by enlarging the size of the underground reservoir into which some of the excess monsoon waters can be absorbed. Many would argue that the best way to benefit the largest number of people (including the poor) in the shortest possible time would be to stop public investment in new canal development and concentrate it instead on "saturating" the region's most favorable areas with privately-owned STWs, by subsidizing installation and introducing forms of energy pricing that would encourage the maximum amount of competitive water selling (Chambers et al, 1989, Shah 1989). This would need to be accompanied by long-term investment in greatly increased capacity for electric power generation.

Such a strategy would treat as less favored (a) those areas where the watertable is too low to allow the STWs' suction pumps to operate satisfactorily, and (b) those low-lying areas in eastern U.P. and North Bihar which are currently left fallow in the dry season for lack of a suitable crop. In the former case, the problems so far encountered in managing large DTWs might be overcome either by developing sufficiently inexpensive "mini-deep" tubewells or by promoting new forms of DTW ownership and management (eg. water companies such as operate in Gujarat or other agencies specializing in water selling). Both these potential

options require further experimentation before they are likely to be widely replicable. Meanwhile, the problems of the low-lying fallow areas pose a major challenge for agricultural research. Innovative farmers have already succeeded in extending the traditional boundaries of boro rice cultivation from Bengal into eastern parts of north Bihar. If scientists could help accelerate the north-westward movement through a combination of more cold-tolerant rice varieties and modified cultural practices, the impact on tubewell development and agricultural productivity in hitherto backward, one-crop areas could be very significant indeed.

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