The Turnover of Deep Tubewells for Irrigation

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INTRODUCTION

In recent years there has been growing dissatisfaction with traditional modes of irrigation development and management, as with other forms of infrastructure, by centralized bureaucracies, and, it is claimed, there has developed a broad consensus on the need for and direction of reform (World Bank, [1994]). This involves a more commercialized approach to development and management, including privatization, of goods characterized by significant degrees of non-rivalry and/or [non-excludability], promotion of competition to the extent possible, and significant involvement of users and other stakeholders in all phases of the activity. Analyses of irrigation developments have played an integral part in the development of this consensus (together with analyses of power, transport, domestic and industrial water, telecommunications, and similar sectors). A particular view of the appropriate institutions for management of small and medium scale irrigation schemes has developed, involving user group management and ownership, with the state playing a limited role in the provision of technical advice, and regulation.

The case of Deep Tubewells[2] (DTW) for irrigation[3] appears to raise some awkward questions for this consensus. Originally developed under public sector management and supported by international development agencies, in the last 2 decades many DTW projects have attempted to transfer ownership management to user groups and to install new DTW under collective management and ownership, for which they seem eminently suited. These projects have on the whole failed dismally in these attempts. Apart from relatively small projects in Nepal, DTW have been abandoned by major donors in favor of shallow tubewells[4] (STW) which are owned and operated in the private sector, and which are associated with irrigation service markets about which many people, including the World Bank, express considerable ambivalence even when recognizing their attributes (Kahnert and Levine, 1993). Diagnoses of the problems of these projects tend to ascribe them to the failure of co-operation due to the inegalitarian and faction ridden agrarian structure ([MMI, 1992:3.4, Dasgupta, nd.,] Boyce, 1987), and in this the theory of local collective action would seem to support them (Bardhan, [1993]:637); but this same structure would seem to be inconsistent with the development of competitive markets (Boyce, 1987, Kahnert and Levine, 1993, Shah, 1993). More commercialized approaches for which DTW might seem appropriate, such as Build, Operate and Transfer, contracting, or franchising, have not been tried, raising questions about the confidence of development agencies in these approaches.

In this paper are discussed the history of the development of DTW in Asia, especially South Asia and in Nepal, Indonesia, the Philippines, and China; various attempts to improve their performance[5]; and, the recent development of the irrigation management consensus, based in large part on interpretation of experience on the Philippines. Since this approach has evidently not worked for DTW in the Philippines, and efforts to build on it have not been successful elsewhere, questions are raised about the way in which this consensus has been promoted, and its analytical foundations.

Background

From the mid-1930s the development of groundwater for irrigation in several countries in Asia by Deep Tubewells (DTW) has been promoted by various colonial, national and regional governments, and by bi-lateral and international

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[2]DTW consist of pumps set deep in tubewells driven either through shafts by surface mounted diesel or electric motors, or by submersible electric motors; they operate mainly in force mode and, consequently, can lift water from great depths.

[3]In Pakistan, DTW were largely developed for drainage and salinity control, but irrigation benefits play a large role in their justification.

[4]STW consist of pumps coupled to the top of tubewells driven by electric or diesel motors mounted on or near the surface; they operate mainly in suction mode and, hence, can lift water from moderate depths. Sometimes, STW are set in pits and operate partly in force mode; the lift of these Deep Set STW (DSSTW) is still limited by [the] practical factors.

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development agencies; on the whole DTW have been managed either by public sector bureaucracies, or by state-supported farmers groups. The promotion of DTW for irrigation has been justified on the grounds that such combinations of technology and institution were (a) more efficient, (b) more equitable than alternatives, and (c) more environmentally sound in that they were more consistent with regulation to prevent overuse of a common-pool resource than individually owned (Abbie et al. 1982). In many cases, they were conceived as the only viable technology for areas with limited opportunities for surface irrigation but with considerable groundwater resources. The alternative, in the absence of large- scale surface schemes was generally conceived as Shallow Tubewells (STW) owned and managed in the private sector. In Pakistan, India, and Bangladesh there have been major DTW projects and investments, absorbing significant proportions of development budgets, and in the case of Pakistan and India, significant operating subsidies; in Nepal, Indonesia and the Philippines there have been smaller projects based on largely the same technology. Although official ex-post evaluations have generally concluded that these projects have been successful, most have experienced performance well below expectations. Both capital and operating costs of DTW have been subsidized in all cases to varying, but significant, degrees, with very little cost recovery.

In recent years, disillusion with public sector performance, the need to cut government budget deficits, and so on, have resulted in pressures to hand over publicly owned DTW and to cut subsidies to their operation. Handover is embodied in Pakistan in the SCARP Transition concepts: in Bangladesh, the promotion of ownership of DTW by co-operatives, and recently the sale of installed and new DTW to any individual of private sector institution; and in India the promotion by the World Bank of technological and institutional innovations in its DTW projects, particularly in Uttar Pradesh, and recently the withdrawal of the World Bank from further DTW projects. Various state governments in India (for example Gujarat) are trying to divest themselves of DTW under other programs. In Indonesia and Nepal there have been similar initiatives to institute farmer management of DTW, and in the Philippines it was always intended that DTW should be farmer managed.

None of these initiatives can claim much success, apart from the small-scale and arguable cases of Indonesia and Nepal. In Pakistan, India and Bangladesh, which together account for the vast bulk of DTW used for irrigation, appropriate (financially and environmentally sustainable) institutions for managing the DTW installed under public sector projects have yet to be found. Most common prescriptions have centered on farmer management conceptualized as Water Users Associations. In Indonesia, considerable efforts have been put into establishing farmers groups to manage DTW, especially in the Madura Groundwater Irrigation Project (MGIP), but the results cannot yet claim to have established the long run sustainability of the DTW. In Nepal also, the farmers groups which manage DTW in the Bhairawa-Lumbini project pay only a fraction of the operating costs, and contribute little to the fixed costs of their DTW. Most of the DTW installed in the Philippines, which were to be operated by farmers from the beginning, were never taken over as farmers perceived them to be uneconomic; recently a few (about 20) of the DTW in the Guimba region have been operated with heavy support from the National Irrigation Authority, but even here the numbers in operation have been declining.

While the user group has been the most common approach to innovations in the management of DTW, other approaches have been tried, especially in Bangladesh. Prominent among these have been widely noted efforts by NGOs to take over and manage DTW, including the landless irrigation initiatives sponsored by Proshika, and BRAC, and, formerly, the Grameen Bank; the GB has now adopted a more radical approach based on direct management of DTW, but this, while it is still evolving in interesting ways, is far from financial viability. In Indonesia and India, also, NGOs have experimented with management of pump irrigation systems and with the development of irrigation users groups. However, none of these imaginative initiatives is clearly sustainable in the sense of being viable independent of on-going subsidies from the sponsoring agency. What has emerged in most of the regions where DTW had been promoted is the spread of privately owned STW producing for a water market, i.e., in much more commercialized context than that espoused in the dominant literature on irrigation management.

The rest of this paper is laid out as follows; the experiences of India, Pakistan, Bangladesh, Nepal, Indonesia, and the Philippines, with DTW are summarized, together with a brief discussion of reports of management of groundwater in parts of China. This is followed by a critique of the theory of self-governance of irrigation management institutions, drawing in part on the success of STW and water markets, and some reinterpretations and suggestions as to the lessons for the failure of collectively managed DTW.

Pakistan

In Pakistan, DTW were installed mainly under the Salinity Control and Reclamation Projects (SCARPs) to deal with waterlogging and salinization problems in the Indus Basin; in areas where groundwater is fresh the DTW have provided water for irrigation often to supplement that in canals. The SCARP DTW have been managed in the public sector. The SCARPs have "not performed satisfactorily in providing timely and reliable supplemental irrigation at a sustainable cost to Government" (Anson et al. 1984:ii). Their performance has declined over time ... {due to} poor management,

inappropriate designs and construction materials, and inadequate availability of funds for operation and maintenance leading to frequent breakdowns and ... reduced pumpage {about 50% of design in the Punjab} ... {SCARPs} absorb 55% of the total O&M expenditure in the irrigation subsector, but account for only 10% of the irrigation water supplies ... furthermore, the gap between (O&M) expenditures and recoveries from irrigation water charges has widened because the provincial governments found it difficult to increase water charges in pace with rising O&M costs. The fiscal burden of the SCARPs has thus become unsustainable" (World Bank, 1991a:1).

More than 30 years after initiating the "modern, massive" approach to waterlogging and salinization, mainly based on large-scale turbine pumped tubewells, these problems are still extremely serious: in a situation where "future increases in {agricultural} production will have to come mainly from improving productivity and yields" (World Bank [1991]:18), "crop yields have stagnated and production has not increased as expected, despite significant increases in farm gate water supplies (32%) and irrigated area (14%). Even the most recent examples of the SCARP DTW technology have encountered the same technological and institutional problems (see, for example, Tillotson, 1991:28), and no ready made solution has been found in the SCARP Transition concept, which was found to be "not financially replicable on a national scale" (World Bank, 1991b:3).

Irrigation management in Pakistan has long been recognized as a problem and in the 1970s pioneering attempts were made under USAID-funded projects to establish farmers organization -- Water Users Associations -- to take on management of the watercourses. The approach was based on concepts developed predominantly within the irrigation management profession which were subsequently taken up by the World Bank, which had been a major funder of the SCARPs. While considerable success is claimed for this approach, it has not been established as sustainable (Byrnes, 1992).

Meanwhile, it had been recognized that private sector groundwater pumping contributed much more to total groundwater pumpage than SCARPs. The response to these problems was the SCARP Transition concept, which was based on the recognition that private sector STW contributed much more to drainage by pumping much more groundwater, and more to irrigation because private groundwater was used more efficiently than SCARP water. Scarp Transition Pilot Projects consist of attempts to privatize or phase out and replace SCARP tubewells with smaller private sector tubewells; in practice this concept is proving financially unviable (World Bank, 1991a), and drainage and groundwater irrigation will depend mainly on trends in existing private STW irrigation.

Private sector groundwater exploitation in Pakistan is characterised by extensive water markets which have enabled small farmers to gain access to groundwater; however little is known or understood about them. Notwithstanding this development, it needs to be recognized that private sector groundwater exploitation may not provide a long term solution to the management of the resources of the Indus Basin which will almost certainly require better management of the surface waters and drainage (Kijne and Vander Velde, 1990). The particular spatial distribution of fresh groundwater and watercourses may make for more imperfection in these markets than in many other areas where groundwater is more uniformly distributed, and it will require more regulation to deal with the complex externalities involved in private exploitation of poor quality groundwater. Recent initiatives to improve water management, in Pakistan and each of the other countries studied, have largely been based on the assumption of a large role for management by user groups -- Water Users Associations (World Bank, 1993a)[6] -- which, it is argued here, have not proved a solution to the problems of managing either watercourses or SCARPs.

India

Most groundwater development in India has been in the private sector; however, there are a significant number of DTW in the public sector in most states in India installed primarily for irrigation; Uttar Pradesh has by far the greatest number of public sector DTW, with nearly half the total of some 64,000 (GoI, 1991). There are also a significant number of turbine pumps used for irrigation owned and managed in the private sector in a number of states, especially Gujarat, and Karnataka, Tamil Nadu and Andhra Pradesh, and more recently 'mini deeps' -- small scale submersible pumps in STW bores -- have been adopted in West Bengal, and no doubt elsewhere. The public sector DTW have everywhere encountered similar problems to those summarized by the World Bank in its review of the irrigation sector in India[7]: "assumptions about command area served, yields, and cropping intensity {in SARs of World Bank DTW projects in UP, Bihar and West Bengal} have proved to be far too optimistic. Field observations indicate modest impact on average productivity and difficulty in sustaining these improvements, which can be expected to be reflected in ex-post ERRs"

[6]This document advocates a thoroughgoing and radical reorganization of irrigation and drainage in Pakistan along the lines suggested in World Bank, [1994], with a large role for user organization. It does not explicitly discuss the problems of the STPP. Nor does World Bank, 1993b in its discussion of tubewell development in Pakistan.

[7]Shah and Bhattacharya, 1993:1-2, draw similar conclusions.

(World Bank, 1991c,1:10). "The performance of the deep tubewells {in UP} however, has declined over time while their impact on equity has been much less than expected" (World Bank, 1991d:i). "The budgetary burden of subsidies {for capital and operating costs for state tubewell irrigation} is also serious" (World Bank, 1991c:2:31). Perhaps the most serious aspect lies in the high subsidies to electricity used in pumping, much of it from greater depths than is necessary, due to drawdown and rent dissipation. Electricity suppliers are in poor financial state and there are frequent and wasteful power shortages, cuts, and voltage reductions (World Bank, 1991e).

In other parts of India private sector DTW have caused serious externalities significantly harming other users of groundwater (in much of Central and South India (see [IRMA, 1989], Reddy, [1991]), and in some cases causing saline intrusion and severe degradation of the soil and groundwater resources (e.g. in Gujarat see for example Bhatia, 1992). "With roughly 20% of India's electricity production devoted to pumping groundwater and massive energy shortages affecting all sectors, the energy-related costs of falling water tables could be huge" (Moensch, 1991:1).

The World Bank has withdrawn from the promotion of public sector DTW except in West Bengal, at least for the time being. India's agricultural growth and poverty alleviation achievements have ultimately proved better than many expected (Osmani, 1993), and much has depended in large part on irrigation by privately owned shallow tubewells. Even in West Bengal most groundwater irrigation development even during the period of the latest World Bank minor irrigation project, has been undertaken by the private sector outside this project (and indeed independently of the panchayat system -- contrast Saha and Swaminathan, 1994, and Harriss, 1993). This type of development in North Western India (Punjab, Haryana, and Western UP) was readily understood in the context of the arguments usually advanced for public sector DTW in Eastern India -- these areas were characterised by larger farm size with lower degrees of fragmentation which made individual ownership of STW viable ([Dasgupta, nd]). In the case of Eastern India where the agrarian structure was seen as an obstacle to the adoption of STW, public DTW would promote efficiency and equity. In fact, rapid growth of agriculture in the Gangetic plains of Eastern UP, North Bihar and West Bengal has been associated with the spread of STW (Kolavalli et al. 1993?, for eastern Uttar Pradesh; Palmer-Jones, 1992, for Bangladesh; Palmer-Jones, [1994], for West Bengal). The agrarian structure has not proved the obstacle anticipated in large part through the development of (groundwater irrigation) water markets (Shah, 1993).[8] The development, characteristics, and implications for growth, class, region, gender, poverty alleviation and equity, the environment, and for public policy of these markets are major issues for future research.

Moreover, India's agricultural growth still leaves much to be desired, and its recent achievements may prove fragile if the apparent stagnation and decline in the rice-wheat system productivity is widespread and resistant to reversal. While this might appear as largely an agricultural problem, it clearly also relates closely to water management, power sector, and also equity issues.

Bangladesh

Since the mid-1960s more than 35,000 DTW have been imported and installed in Bangladesh, at a present cost of more than half a billion [dollars]. In two major projects the World Bank, with technical assistance in large part through British ODA, provided much of the justification and set the standard for DTW development. In its most recent project (IDA DTW 2) it strongly promoted and supported the ownership and management of DTW by co-operatives.

The Government also installed DTW with other sources of funding. A recent estimate suggests that 30-40% of commissioned DTW are not in use, and for those that are used low capacity utilization has been a perennial problem (AST, 1991:2, FAO, 1994). Command areas IDA DTW 2, reported through the monitoring system, have been falling significantly to less than 2/3 of design capacity ([MMI, 1992]:6.7). Many DTW stand idle because farmers are unwilling to pay for water from them, and the present policy of selling installed DTW encountered a lack of demand (despite sales prices representing subsidies of over 70%). The prospect is for most of the installed capacity in DTW in Bangladesh to be seriously under-utilized, representing in large part an unremunerative investment, making little contribution to repaying the (foreign exchange) loans incurred to install them.

There has been much experimentation with alternative forms of management of DTW and projects to improve management including technical (e.g. buried pipes) and institutional innovation (KSS - state sponsored farmers co-operatives, Water Users Groups, Landless Groups supported by Non-Government Organizations (NGOs), and Quasi-Non-Government Organization (QUANGO) management), but none have proved able to manage DTW on a sustainable unsubsidized basis.[9]

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[8] Palmer-Jones, 1944b, provides a further discussion of water markets.

[9] The Bangladesh experience with different innovations in institutions is discussed in many places, including Palmer-Jones and Mandal 1987, Wood and Palmer-Jones, 1991, Kahnert and Levine, 1993 and Ed Mallorie, 1994.

The World Bank's new project -- the National Minor Irrigation Development Project -- has a minimal DTW component, consisting largely of demonstrations of equipment with fractional (smaller scale) capacity. New DTW are to be sold unsubsidized to the private sector, whether formal or informal farmer groups, or individuals. It is unlikely that many such DTW will be purchased under these conditions.

Since the mid-1970s there has been a rapid spread of privately owned STW, initially promoted by the Government of Bangladesh and aid agencies, including the World Bank. This growth was nearly halted in the mid 1980s; this slowdown was attributed variously to contradictions between the technology and the agrarian structure, and obstruction by government bureaucracies which feared losing their control of the sector. The role of incentives was explicitly dismissed by the World Bank (World Bank, 1989:58). While the institutional factors may have played a role, unfavorable price trends, particularly the rise in wage rates in relation to rice prices also played a role (Palmer-Jones, 1992). Removal of constraints on private sector imports and deregulation of spacing of minor irrigation equipment in the later 1980s was followed by rapid agricultural growth and poverty alleviation. Significant environmental concerns have been widely anticipated, but do not yet appear significant. As in the case of India and Pakistan private sector STW developments have been dependent on the development of water markets. Sustaining and enhancing these achievements is a major problem for the 1990s, which will require better understanding of groundwater irrigation markets, and of the agricultural economy generally.

Indonesia

While most irrigation in Indonesia is from surface sources, the most favorable sites have already been exploited, contraction of irrigated area due to urban expansion, continuing rapid population growth, and the desire to extend the benefits of irrigation to areas, especially in Eastern Indonesia, where there is little potential for surface irrigation led to greater interest in groundwater irrigation in the 1970s (Johnson et al. 1992:Intro). Some 600 DTW have been installed, mainly in East Java. Performance has been disappointing in most cases and although operation and minor maintenance costs are born by farmers, capacity utilization, yields, cropping intensities and contributions to capital costs and major repairs have generally been disappointing (ibid, 6-5).

Since the mid-1970s the Government of Indonesia has promoted Water Users Groups to manage the tertiary systems of surface irrigation schemes ([Aziz et al. 1993]). These institutions were also promoted to manage DTW, particularly in the Madura Groundwater Irrigation Project which came to be seen as the model for future institutional arrangements for the management of DTW in Indonesia (Jackson, 1991). These organizations were not built on indigenous irrigation institutions, where they existed, and they have generally not survived the withdrawal of the project that set them up (Aziz et al. 1991:57). Faced with continuing financial problems the Government of Indonesia embarked on a program to 'turnover' smaller scale irrigation schemes to user groups; this approach uses irrigation organizers trained, and largely recruited through a Non Governmental Organization. This approach was partly based on the innovations pioneered in the Philippines by the Ford Foundation (Bruns, [1991]). These organizers are supposed to promote users organizations that will become viable.

This approach was not followed on the Madura Groundwater Irrigation Project, which employed sociologist consultants to assist in organizing the farmers. Considerable efforts were, belatedly and under unfavorable initial conditions ([Casey, 1991]), devoted to promoting institutions to manage DTW, and recent innovations have included use of DTW for domestic water supplies, and the organization of women's groups to facilitate their participation in irrigated agriculture and the management of the DTW. Towards the end of the project the issue of financial sustainability became urgent as it appeared that the majority of Water Users Groups were unlikely to be able to finance major breakdowns or amortisation, and the workshops of the Sub-Directorate of Groundwater Development Planning would be unable to sustain the mechanical services required, in part because of the usual bureaucratic inefficiencies. The present situation is evolving, particularly with regard to new legislation to enable the WUAs to operate as commercial entities and hence overcome some of the financial management problems experienced. However, it is far from clear that, except in Eastern Madurea where tobacco provides a very remunerative irrigated cash crop, sustainability has been achieved (Chapman et al. 1992). Elsewhere in East Java, and even on Madura, private pump irrigation, including shallow tubewells and the development of water markets, appear to be spreading rapidly.

Philippines

The National Irrigation [Authority] (NIA), is responsible for irrigation development and management in the Phi7lippines. For some time NIA has been quoted as having successfully developed participatory methods in the construction and management of both indigenous and modern irrigation schemes. Key methods used to develop this participatory approach -- community organizers and process learning and process documentation -- have been suggested for adoption in other areas (Korten and Siy, eds. 1989; Bruns, 1993). As important in its adoption of participatory methods

and their success has been the removal of subsidies and the requirement that NIA raise the bulk of its budget from irrigators (Svendsen, 1993).[10] DTW entered the Philippines in the early 1970s, but by the time the majority of them were ready for use power costs had risen greatly, and since NIA was required to charge at least full O&M costs farmers refused to pay the much higher water charges than were paid on surface irrigation schemes. In practically all cases, farmers refused to pay these charges and as a result most have remained idle. A few have recently been brought into operation in the Guimba area, but despite being managed by Water Users Associations organized through the participatory approach of NIA, command areas have been declining, and it is little contribution to capital costs, and hence sustainability, is being made.

Closer examination of the Philippines irrigation sector reveals that, notwithstanding the reputation of NIA, the Philippines irrigation system is under considerable stress, and performance has been below expectations on both national and communal systems (World Bank, 1991e:xii-xiii; Boyce, 1993). Participatory methods have been most successful where NIA has assisted existing or new communal schemes rather than NIA managed schemes (Bruns, 1993). Handover on agency managed schemes has been more problematic and has progressed only as fast as the rate of retirement of NIA staff (ibid:1845). This suggests that the participatory method has yet to establish its ability to result in sustainable efficient irrigation management on the larger-scale schemes.

Nepal

Nepal is best known for its surface gravity community managed irrigation systems ([Martin and Yoder, 1987, Pradhan, 1991]). In recent decades some 400 DTW have been installed through various government and aid supported schemes. Little is known about the outcome of these projects with the partial exception of the Bhairawa-Lumbini project funded by the World Bank. This project is described as 'one of the Bank's most successful agricultural projects in Nepal and has established an effective model and capacity for groundwater development using improved deep tubewell technology' (World Bank, 1990:4). The agricultural objectives are reported to have been achieved to an unusual degree under a non-participatory approach in the second stage of the project, and progress towards the formation of user groups has been made; farmers are still paying only a proportion of the O&M costs (< 50%), and even under stage III contributions 'would be only about 2 percent of total DTW costs' (World Bank, 1990:15). This can hardly be considered a sustainable model of groundwater development.

China

There is very extensive groundwater based irrigation in China (see [O'Mara, ed., 1988], Part 6), and some interesting groundwater management institutions (Sun Fu Wen, 1992), although they clearly have not solved all the groundwater management problems (Zhenmin, 1992). These institutions consist of three tiers -- resource unit based assessment, planning, zoning and regulation; community ownership of wells; individual or group contracting for the management of individual irrigation installations of some 70% of installations (Sun Fu Wen, op cit.: 40-iv-v); 48% of these contract systems consist of a 'call for tenders {based on expenditure over the past three years}. A contract is made ... The money saved belongs to the contractor and the money spent over is assumed by himself' (ibid). In a further 22%, village irrigation committees are responsible for the installation, and specify 'a water price and irrigation area {and} invite tenders from all the farmers; the households collect water charges in a certain proportion which is handed to the village committee as depreciation cost and the rest belongs to the contractor' (ibid:40-vi). Most of the remaining installations (27%) are managed by the user groups who hire workers who are paid according to 'how the target is fulfilled.'

What the contract institutions appear to possess compared to those promoted in South and Southeast Asia, is an incentive structure for the manager of the irrigation, and a nesting within viable village and regional institutions. While the rural social conditions in China following its profound agrarian reforms make it likely that village institutions are not compromised by the types of inequality characteristic especially of South Asia, and regional planning and regulation institutions may be more effective than their South Asian counterparts, it is still evident that even a (still) socialist country is prepared to use contracting systems for the management of irrigation in preference to direct community management.

Discussion

These experiences raise many issues relevant to turnover as well as other issues; here the institutional issues will be focused on.

[10] It is perhaps a little beyond what Svendsen himself concludes, but it is thought that the inference is legitimate.

An Inappropriate Technology?

However, first it will be necessary to dispose of at least one potential objection to drawing many conclusions from these experiences. It can be argued that the problems of DTW lie in their being an inappropriate technology for irrigation, in the sense that they are generally not financially or economically viable, and hence have little chance of success in the private sector, and should not be supported by the public sector.

The choice of DTW was in part based on economies of scale, and part on considerations of equity and efficiency. Generally, for deep aquifers, cost per unit water per unit lift (m^3 per m) at the well-head falls with increasing discharge (Stoner et al. 1979:68); engineers tend to design for least cost (ibid:63), hence DTW designs were based on the largest size compatible with management considerations. Thus it is nearly always outside factors that fix well capacity. If the well is to supply a single farm, the quantity that the farmer can conveniently handle may decide the issue. If it is to supply a group, then the number of farmers who can reasonably be expected to constitute a workable co-operative might be important. However, the rule is, that for cheap water at the well-head, the largest capacity well that can be drilled in the aquifer will be the best solution (ibid:68).

But it will be the cost of water in the field that is the more appropriate variable to minimize. Conveyance costs per unit of water (costs of construction and maintenance of irrigation distribution system and water losses) will rise with scale, and given the intensity of irrigation, the average distance from source to field will increase with discharge. Therefore, there will be a finite optimum scale even for an unlimited aquifer provided conveyance costs eventually rise faster with scale than [the rate at which] pumping costs decline; conveyance costs are likely to be high on alluvial soils typically associated with abundant aquifers. If transaction costs are included in the calculation and these rise more than proportionally area irrigated, for example, then optimum discharge may be even smaller.

These arguments certainly provide some justification for rejection of DTW. Force mode DTW is the only technology for high lifts where STW cannot work due to the depth to the water table, but here pumping will be costly because of the inherently high lifts involved, and hence may not be economic. But DTW may be appropriate for large discharges from abundant aquifers with high water tables where STW are technically feasible, because, even allowing for longer and larger diameter filters, at higher discharge the pumping water level goes below the suction limit (even allowing for reasonable deep setting), and the economies of scale more than offset the increased pumping height and greater distribution costs entailed, provided transaction costs are not too high. STW may have higher costs at the well head, for equivalent static water levels, and it is not clear that the lower average costs of conveyance are sufficient to outweigh these disadvantages at least comparing the 0.5 - 1 cusec STW with the 2 cusec DTW that has been most common. Other differences relevant to the most economic technology relate to the simpler technology of STW and the more rapid development of an infrastructure of maintenance and servicing facilities for the numerous small diesel and electric engines and for suction pumps involved in STW than for the fewer, larger, DTW engines and the more complex force mode pumps. However, it is not clear what importance should be attached to this since in parts of Gujarat State in India (e.g. Mehsana District among others) there are many privately owned DTW used for irrigation; but here STW are not viable because the water table is too low.

The point is that if one accepts that DTW are not viable and sustainable, then one either rejects tubewell irrigation as inappropriate on technological grounds -- it is too costly in terms of capital and operating costs -- or one argues that the institutions that have been adopted impose transaction and conveyance costs which rise faster with scale than pumping costs decline. Again, the apparent (and arguable) viability (admittedly with considerable indirect subsidies) of DTW in Gujarat suggest that this is not necessary.

Choice of Institution

The main difference between STW and DTW lies in the mode of cooperation; DTW have been managed through bureaucratic or state sponsored cooperative management, while STW have generally operated through markets. Most of the projects which have tried to improve the management of DTW have been based on user groups; exceptions are the various experiments initiated through NGOs in Bangladesh and elsewhere (Shah and Bhattacharya, [1994]:2-3 are rightly dismissive of the usefulness of the latter as models for collective irrigation institutions). Theoretical argument, rather than overwhelming empirical evidence, has been crucial in support of the user group.

Theory

The trajectory by which the WUA prescription was arrived at is by now fairly familiar (Bardhan, 1993a, Bardhan, 1993b, Seabright, 1993), and in many ways parallels the evolution of thinking about common property management (Ostrom, 1990); much of the literature has been a response to the naive model of common property presented by Hardin in his popular article on The Tragedy of the Commons (Hardin, 1968). Hardin's conclusions were that either privatization or

state ownership could provide a solution to the problem he diagnosed; it became common to point to contrary examples when holding up 'common' management as a viable and desirable alternative. The model was criticized as relating to open access rather than common property, or to situations of degradation of traditional common property management associated with modernization. Many authors argued that Hardin's model could be understood as a Prisoners Dilemma (PD), and have shown that the conclusions may not follow when participants face each other in repeated PD situations, or where it is in the interests of each alone to provide (some of) the public good. In such situations people have incentives to devise and adhere to institutions which lead to co-operation. Sociologists argued that the assumptions required for co-operation were appropriate in situations characterised by community (Taylor, 1982, 1987), and many of the institutions could be understood as responses to repeated PD situations, which shifted the structure of interactions to something more akin to the assurance problem.

Many common property institutions have been described and analyzed within this framework (NAS, 1986, McCay and Acheson, 1987, Ostrom, 1990). The literature on irrigation institutions grew out of analyses of traditional irrigation situations (Coward, 1977), which identified irrigation communities with specific characteristics and arrangements, and drew on more general traditions of support for local organizations and participation (Uphoff, 1986).[11] Among the relevant characteristics were small size, relative equality and social homogeneity, clear boundaries, and so on. Among the arrangements were the common irrigators, accountable to users,

These models explain the operation {of irrigation systems} ... {and} are directly usable, in turn, in designing either new irrigation systems or programs to rehabilitate the physical, organizational and institutional arrangements of existing irrigation schemes (Cernea, 1991:44). A line of thought has also been important -- that of active participation of researchers in the solution of social problems through various forms of action research, or more recently process learning and process documentation.

Community

The sociologists who study them suggest that the problems of irrigation management appear not to arise in community managed small schemes. The typical irrigation problem of larger state sponsored schemes came to be conceived as a prisoners dilemma (PD) (Wade, 1987), and successful irrigation management understood as solutions to this dilemma -- for example the understanding that members of communities managing an irrigation scheme were faced with multiple or repeated PDs, and hence would be likely to evolve institutions which mitigated their effects (Wade, 1988, Sengupta, 1991). Social scientists described the characteristics of successful management and interpreted them as the conditions for local collective solutions to PDs;[12] hence, both empirical material and theory were mutually validating, and became the intellectual agenda for many analyses of irrigation problems.

Asymmetric Incentives

The basic theory of solutions to PD problems have assumed symmetric externalities, yet the typical problems of irrigation management, the top-end-bottom-end problem, and inequality in landholding, are based in asymmetry; this is thought to pose greater problems for collective management (Kanbur, 1992, [Ostrom and Gardner, 1993], Bardhan, 1993a). Inequality can be associated with collective action in some cases, such as traditional unequal patron-client relations, and it is the decline of these institutions that appears to be associated with the undermining of traditional common property management institutions (Jodha, 1986, Bardhan, 1993a and b; Wade, 1987:155-9, also notes the relationship; see also, Lipton transitions of trust, Lipton, 1985)). However, a number of authors have recently suggested that even where externality impacts are uni-directionally asymmetric, local collective action can occur, provided, for example, top enders can be better off by including bottom enders ([Ostrom and Gardiner, 1993]). Where the costs of construction or repair of an offtake can be shared with bottom enders it may be in the interests of top enders to allow water down the canal to ensure future co-operation by bottom enders. DTW appear to be a technology that fits these requirements since the initial capital cost is very high and a certain minimum economic scale must be achieved in order to break even.

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[11]It is interesting to note some aspects of the institutional history involved here; the irrigation management literature has it that probably the most institutional base is the Cornell University which was importantly involved in both the Community Development and, later, the Comila Cooperative development traditions. Cornell and other Land Grant Colleges were themselves drawn on older traditions of Rural Sociology which attempted to promote rural development through local organization and participation approaches; the Cooperatives were the models for DTW farmer groups in Bangladesh. Of course, there are other components to the history of these matters including British cooperative traditions, Rural Reconstruction and laboristic movements.

[12]Mosse, 1992:19, is thus partly right in arguing that 'present theories of participation' draw excessively on rational choice theories of collective action, but the populist tradition of idealization and romanticization of collective institutions (Williams, 1972) which has been influential in the formation of the understandings of many social scientists, has also been important (Kitching, 1982; Midgeley et al. 1986).

No doubt particular problems for collective action arise where there is asymmetry in incentives -- most of the theory described above assumes that each person has the same costs and benefits from cooperation. Irrigation systems are characterised by the top-end-bottom-end problem inherent in the spatial nature of the technologies involved and economies of scale, and this causes those with plots located in different regions of a scheme to have different [...] [(Ostrom and Gardner, 1993]:96). Asymmetry in incentives can also be caused by social or economic heterogeneity ([Kanbur, 1991:5]). Asymmetries cause problems in dividing up the net costs and benefits of cooperation because of the strategic advantages that better endowed people have in relation to poorer potential cooperators (Bardhan, [1993]:634). Where there are economies of scale it will be cheaper to have a larger scheme serving more people; but those further away will be at a disadvantage compared to those close to the head end of the scheme. Fixed costs per unit area or per person can be reduced by spreading them over a larger population providing an incentive to those close to allow to pass sufficient water to induce the latter to contribute to these fixed costs.[13] Ostrom and Gardner suggest that this may give rise to sufficient incentives for people to evolve institutions to allocate the extra work, cost and return between top and bottom enders to enable the production of the collective good. However, there is no reason to believe that the optimal scale can be produced in this way, or, indeed, that the self governing solution to this problem is better than some alternative.[14] Indeed the theory of labor-managed firms (Estrin, 1994:33) would suggest that those nearer the head would restrict membership to maximize the rent they receive, and the minimum scale required to cover fixed costs can be obtained by selling water to non-members rather than by including them as co-owners or profit sharers in the scheme. Some of the criticisms of DTW projects suggests that this argument may provide insight into their problems; thus the highly subsidized price at which DTW were sold to cooperatives in Bangladesh, and the subsidy involved in annual service and repair charges, meant that fixed costs were low and that consequently those who controlled the co-operatives had little incentive to enlarge command areas (Morton, [19??]). However, even at the very subsidized price, demand for DTW was inadequate, and as subsidies have been withdrawn, prices have risen and there is no evidence of rising command areas.

There is no reason to think that self-governing institutions are particularly desirable from the point of view of efficiency, or equity for that matter. Evidence produced comparing farmer managed with agency managed systems (Tang, 1992, and [Ostrom and Gardner, 1993]), can be considered little more than non-contradictory with the hypothesis that Farmer-Managed Irrigation Systems (FMIS) perform better than agency-managed schemes,[15] rather than stronger evidence in support of the hypothesis. Performance must be assessed in relation to the potential, [and the involved]; in contexts where economic efficiency is required for irrigation to be financially sustainable, traditional and participatory institutions, as so far conceived, may not be sufficient to the task.

Institutions and Efficiency

The first point to note is the uncertainty about the criteria of success in irrigation management, and the second refers to understanding the institutions which manage the resource (in our case, first, the WEM and second, the groundwater resource). Much of the work on common property management neglects the criterion of success;[16] for example, although Seabright, in an excellent article which discusses the issues of incentives in CPR management, draws attention to the neglect of the management of the resource as opposed to its distribution, he is concerned mainly with the problems of implementing a known production plan (Seabright, 1993:116). He points out that it is possible in some circumstances to separate the production from the distribution plan; this requires that the production decision makes no difference to the risk dispersion opportunities of CPR members. Such an assumption is implausible in the context of irrigation in poor countries where risk is mainly spread and dispersed through diversification and reciprocal exchange within a small locality ([Platteau, 1991]). Also, much of the discussion assesses success which it is claimed is explained by self-governance, in terms of the presence of intermediate variables -- rule conformance and good maintenance (Tang, 1992), or membership of WUA (Bardhan, 1993a:637) -- rather than clear indicators of productivity

[13]Distribution costs per unit area will rise with size of scheme (because, on average, land will be further away from the source). Transaction costs are also likely to rise with scale as the problems of coordination among larger numbers of people rise. Hence, there will be an optimum scale involving a trade-off between economies of scale at the source and diseconomies of scale in distribution.

[14]Ostrom and Gardner's original article has an arithmetical, error, noted in the Journal of Economic Perspectives, 8(2):2. Both parties can still benefit from the rule they suggest, but the incrementals for both top and bottom enders are below what they received before the cooperative arrangement, and the incremental net return to bottom enders is higher than for the top enders. May be they would not come to an agreement; rather, more analyses will be required before we can place much confidence in the conclusion that they will.

[15]This is not the place to explore this view in depth. Superficial reading of the material suggests a number of problems, including limited statistical rigor and completeness, and a high correlation of locational, scale and other factors with the different modes of management.

[16]or evade it; e.g., Wade, 1987:xi, 197.

and efficiency. Feeney et al. 1990:5, are at least clear that they 'use ecological sustainability as the working criterion of success ... {which} does not necessarily imply that resource utilization is optimal [=66] from either ecological or economic points of view.'

Clearly, success is complex, and would include sustainability and equity criteria as well as efficiency. What is argued here is that efficiency is also important, since otherwise the irrigation may not be viable. However, there is not much agreement on the connection between efficiency and institutions, with often directly contradictory views. Orthodox economists tend to argue that the institutions of capitalism are efficient, while their critics maintain that their main rationale is exploitation in the form of surplus extraction ([Bowles and Gintis, 1993]; Williamson, 1993, Stiglitz, 1993). Thus, it is argued, the typical institution of capitalism -- the firm -- is overwhelmingly more common than cooperatives because it is more efficient; the incentive mechanisms employed by firms -- piece rates, supervision, managerial remuneration, and so on -- promote efficiency by economizing on transaction costs. However, the inequality and asymmetry in power between managers and workers may increase transaction costs by undermining trust and promoting alienation. Some argue that cooperation induces attitudes which reduce transaction costs (an argument that bears some similarity with the view that participation educates, enlightens and empowers people), and this promotes efficiency. However, co-operation, and net benefit sharing in particular, gives rise to incentive problems by diluting the incentives to monitor effort of the owners of the residual benefits. Hence, the arguments in favor of hierarchy and private property. The issues are complex and subtle, and, still largely unresolved (perhaps they always will be). While it undoubtedly has been helpful to resist the crude conclusions that 'common property' is inefficient and should be replaced by state or private property, by pointing out the problems with both these alternatives, it is also important to resist concluding that the sophisticated informal methods of managing common property resources (Seabright, 1993:133) are necessarily sufficient to the task; urging that [']these mechanisms not be ignored, disparaged or lost (ibid) does not resolve the problem of how to take account of them, how to value them, or what is to be done.

Conclusions: Incentives, Institutions and Agency in Irrigation Management

The handover of DTW to local user group management has not been successful; one can conclude either that the technology is inappropriate at least for the times and the places where it has been promoted, [17] or that the institutional framework within which the handover has taken place has been unable to establish its viability. There is much to be said for the former position, and it is clear that the most important trends in groundwater development are using STW technology owned and managed in the private sector, and often operating through irrigation service markets. While this seems to raise productivity, and has benefits for the poor in many ways (see Palmer-Jones, 1992, and for the green revolution more generally, Osmani, 1993), it may not achieve all the objectives that were set for groundwater development -- for example, where salinity control is important, or where there are groundwater resources which can be beneficially exploited but are effectively out of reach of STW.

Privately owned DTW are widespread in South and Western India, where they are often associated with severe environmental problems (Bhatia, 1992), and there are some in West Bengal (personal observations, 1989). In Western India, these DTW are managed under a range of institutional arrangements, the most well-known being in Mehsana District in the State of Gujarat (Shah and Bhatacharya, 1993; Moench, 1991). Within the State of Gujarat there are some 3,000 state-initiated DTW which are supposed to be handed over to local user groups, with as yet little success. Here the initiatives have been largely based on state or NGO sponsored user groups, which seem unable on the whole to establish their autonomy, in marked contrast to those which have always been autonomous (although one should note the large indirect subsidies from which they benefit through, for example, subsidized electricity prices). The latter institutions have yet to be studied in detail (Shah and Bhattacharya interesting article does not go into sufficient depth), and, of course, those studies which have taken place will have been influenced by the assumptions and values of the researchers. These have predominantly been of a populist orientation, generally critical of water markets (Shah, 1993), and emphasize the cooperative aspects of water companies and the exploitative aspects of water sales, although some credit is given for the deep understanding amongst farmer groups of complex agency-type problems (Shah and Bhattacharya, 1993:25).

Detailed examination of this approach is beyond the scope of this paper. Seabright deals with some of the issues involved under the heading of delegated management from a group of owners to managers, but emphasizes that his discussion is based on the assumption of complete risk-sharing opportunities (115), which is equivalent to the assumption of no wealth effects in the work on institutions of Milgrom and Roberts (1992). Seabright points out the

[17] It has been claimed that recent improvements in the understanding of tubewells should enable savings in the costs of construction and operation (Herbert, nd; Herbert et al. 1989). These enhancements are likely to have only marginal effects. The capital costs of DTW on projects installed under aided projects may be higher than necessary due to inefficiencies and corruption in these processes; these forces may also result in higher operating costs if, for example, aid-trying results in the use of engines with lower fuel efficiencies. [However, the general absence of DTW in the private sector in areas of abundant aquifers, apart from the debatable cases of Southern and Western India, where subsidies.]

conclusion that those with the power to intervene, (co)owners should also have the interest, and suggests that this accounts for the success of local management of state-owned common pool resources, since local users have the interest. But this assumes many of the problems of efficiency the author has raised, and also neglects the issue of who has the interest at the local level -- it may well not be the poor. Proposing contracting for the management of local common pool resources is a way of widening the debate about appropriate institutional innovations. Among the relevant characteristics of DTW are the considerable moral hazards in managing them, as with any irrigation scheme[18] and any activity involving motors, which suggests that the manager should own the water extraction mechanism. But there are also large risks (of breakdown, of climatic hazards leading to crop failure, of non-payment of water fees, and so on) which it may be inefficient to let the manager bear unless the manager has substantial assets. Ownership or management of DTW by the rich may reduce agency problems and increase economic efficiency if they have better access to credit and are more able to take risks; thus, Shah and Bhattacharya report that even in the quite democratic water companies of Gujarat managers are generally better off. However there are likely to be specific circumstances in which inequality raises productivity rather than inducing conflict and alienation. Of course, ideologies both that held locally and those brought from outside, affect the perceptions which influence whether trust is extended or not. Ideologies of participation based on inappropriate models of equality may help to undermine traditional forms of cooperation, or prevent the emergence of alternative forms of cooperation which are categorized as inegalitarian.

At present, levels of efficiency of user group organizations DTW do not appear viable. There are likely to be other cases where complete autonomy of irrigation schemes will not be achieved and is unlikely to be possible (Bruns, 1993), for example if the resources required for major repairs are difficult to raise locally, due perhaps to poverty, and to credit market failures. Indeed, some readings of traditional irrigation systems have emphasized their dependence on outside resources for construction and fairly regular rehabilitation, their reflection of the interests of locally dominant groups, and the decline of these institutions as local authority has been undermined (Mosse, 1992). The challenge, then, is to find institutions, or modes of intervention which give rise to institutions (broadly conceived as the socioeconomic environment), which are more efficient in the required sense. This may involve economic efficiency sufficient to establish autonomy, or it may involve minimizing the subsidies to achieve the desired objectives. It will require a package of initiatives in which more emphasis is given to efficiency, at least relative to populist conceptions of participation. This will not mean no role for local control; contracting management of DTW by local, democratically elected authorities has for some time seemed to me the most appropriate approach ([Palmer-Jones, 1989]).[19] Nor will it mean there is no role for supportive policies which are in effect pro-poor, even if not cast in the traditional molds of land reform or cooperation and participation. For example, there would be a role here for state bureaucracies to act as technical and perhaps commercial advisors, and in the planning and regulation of water resources in the context of externalities, and for legislation enabling and strengthening local democratic organizations; also, perhaps, there would be roles for appropriate credit institutions and technology development. Development projects would have to be carefully tailored to local political as well as ecological, technological, and socioeconomic circumstances.[20]

The persistence of participatory approaches to rural development and, in particular, the user group in irrigation management, despite opposition from local bureaucracies and others, requires some explanation. Experience indicates a strong outside influence driving these approaches, together with the ability of local interests to live with and even coopt them for their own purposes if necessary. Many indigenous initiatives for participatory approaches are in part responding to correctly perceived supply of resources for such initiatives from bi- and multi-lateral aid organizations. But, it is necessary to understand the apparent failures and lack of sustainability and autonomy of projects and programs based on participatory approaches, in part as the result of a failure to adopt more business-like and commercial methods; perhaps part of the answer to this lies in the ideological ambivalence that the sponsors of

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[18]For example, if irrigators pay in advance for irrigation then managers may have little incentive to ensure delivery of water, while if they pay after harvest, irrigators may face difficulties; managers may not consider it worthwhile to ensure some harvest and there may be some dispute as to whether low crop yield was due to inadequate water supplies or insufficient effort from cultivators, and managers may have great difficulty in collecting fees. In both cases, it may be hard to monitor whether the appropriate level of effort has been exerted.

[19]The case of irrigation tanks undermined by the development of private well irrigation is interesting. The decline of community-managed tank irrigation and associated rise of private well irrigation are often attributed to difficulties of collective action involved in tanks and the interests of the rich who own the wells. Perhaps, however, private wells, in some sense, have more efficient technology -- less land is lost to cultivation; evaporation and conveyance losses are less with well irrigation; and there is greater flexibility in cropping pattern and irrigation scheduling. The appropriate response might not be to rehabilitate the tank but to declare groundwater a common property and impose a tax on well owners corresponding to the rent they receive from its use. The community might invest in sufficient rehabilitation of the tank to enhance its role in water conservation and groundwater recharge.

[20]There is some superficial similarity here with Ostrom's idea of crafting institutions ([Ostrom, 1992]), but more emphasis on political constraints. Institutional innovations have to be piloted through the political process; the embedded nature of cultural resources for any constraints on collective action and on the commercial approach to management, and less on the degree of local autonomy that can be attained.

participation tend to have about commercialization and its presumed implications? Perhaps it also partly lies in the greater threat posed to vested interests.

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