SKIMMING THE WATER: Rent-seeking and the Performance of Public Irrigation Systems

Robert Repetto

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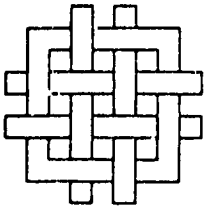

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R. R.

Foreword

This study, the second in a series of five, examines practices of governments and international agencies around the world that discourage sound resource use, and hence sustainable economic growth, through the use of misguided economic incentives. In sector after sector, detailed analyses show that perverse tax, price, and credit policies are simultaneously costing governments huge sums while distorting private investment, encouraging environmental abuse, and wasting precious natural resources.

The first study in this series revealed that in nine representative developing countries the median level of pesticide subsidies was nearly half of the chemicals' retail cost. In some countries, the costs run as high as several hundred million dollars per year. Yet, in part because many different economic mechanisms are used to deliver the subsidies, most governments are unaware of their policies' costs either in terms of direct budgetary outlays or of lost opportunities to buy greater agricultural output for the same sums spent in other ways. Questions have not been asked, nor cost-benefit analyses performed. Hence, the pesticide subsidies continue largely unexamined.

This study of the effects of economic and financial incentives on the performance of public irrigation systems tells a similar story. It traces the effects of financing systems in which the prices charged for delivered water are very low in relation to its benefits and to the costs of supplying it. Robert Repetto shows how charges that often do not even cover the costs of irrigation systems' operation and maintenance adversely affect investment planning, system design, water delivery, maintenance, and farmers' actual water use. The problem is not confined to developing countries—as Section IV, which details the history of public irrigation systems in the United States, amply testifies.

The stakes are extremely high: estimates are that $350 *billion* will have been spent on irrigation by the end of the century in the Third World alone. With investments on this scale, most of the world's taxpayers are affected by the inefficient financing either directly, or indirectly through the provision of international assistance. So Dr. Repetto's detailed proposals for economic, institutional, and broader policy reforms could make a substantial worldwide impact.

Subsequent studies in this series, shortly to be issued, investigate subsidies in the energy and forestry sectors.

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Jessica T. Mathews
Vice President and Research Director
World Resources Institute

I. Introduction

Economic and financial incentives can greatly improve the performance of irrigation systems, especially public systems. While it is widely recognized that most public irrigation systems throughout the world suffer from serious physical, managerial, and financial problems, current practices in irrigation finance affect performance more broadly than is now generally acknowledged. Direct and indirect water charges that are low relative both to irrigation's supply costs and to its benefits have consequences that extend beyond poor cost recovery and shortage of funds for operation and maintenance, the two problems most often discussed. Drawing on country assessments of China, India, Bangladesh, Pakistan, Mexico, and the United States commissioned by World Resources Institute, along with numerous additional country studies and published research reports, this paper suggests how current financing policies in public irrigation adversely affect investment decisions, system operation, and on-farm water use.

In current prices, $250 billion has already been invested in irrigation in the Third World, and $100 billion more will be spent in this century to create more capacity. The World Bank devotes 25 to 30 percent of all agricultural lending to irrigation, and AID commitments have averaged several hundred million dollars per year in the 1980s. Costs have been much higher and agricultural benefits lower than projected when investments were approved. Operation and maintenance of completed systems have been deficient, and farmers have not responded as hoped. At the levels of performance actually experienced, many current projects cannot be economically justified.

Public irrigation is heavily subsidized in the Third World as well as in the United States, and has become an enormous fiscal drain. Revenues collected from farmers in most countries cover barely 10 to 20 percent of the costs of building and operating the systems, less in many countries than the costs of operation and maintenance alone. These subsidies, borne by taxpayers in the United States as well as in Third World countries, go predominantly to better-off farmers, not the dry land farmers, the marginal farmers, and the landless who are truly the rural poor.

Yet, these financing policies undermine performance. Neither farm beneficiaries, irrigation agencies, nor international banks are financially at risk for the success of irrigation investments, and so pressures for new capacity lead to a proliferation of projects, many of them of dubious worth. Benefit-cost analysis of such long-term investments is inherently speculative, and easily becomes overly optimistic when the political pressures of the pork barrel come into play.

Operation and maintenance are also undermined by the excess demands generated by this system of financing. When funds for O&M depend on collections from farmers, a vicious cycle of dissatisfaction, declining collections, and declining performance can ensue. When funds are allocated from general revenues, operating agencies don't feel themselves accountable to users to provide an optimal service, but as allocating a resource of which there is not enough to go around. So, operators are susceptible to pressure, inducement, and influence. However, when farmers' trust in the impartiality of the system is destroyed, they are less willing to contribute to its upkeep. The fundamental problem is the financing system, which creates huge rents for those able to obtain water from public systems, and chronic excess demands. Unless these pressures are reduced, attempts to strengthen irrigation management will have limited success.

In addition to performance shortfalls, adverse environmental impacts from irrigation investments have been extensive. Diseases have spread, whole communities have been displaced and valuable crop and forest lands have been flooded. Dams have affected river hydrology, fish populations, erosion, and siltation. Tens of millions of acres of agricultural land have been lost through waterlogging and salinization. If the performance of existing irrigation projects were improved, these impacts would be mitigated, and the apparent need for additional, large-scale, and increasingly costly new projects would be much reduced.

Skimming the Water presents a variety of options to dampen rent-seeking influences on public irrigation systems, to improve efficiency, equity, and environmental management. Specific recommendations are put forward for development agencies, including the multilateral banks, AID, and other bilateral aid agencies. Up until now, while generally in favor of

increased user charges, development assistance agencies have not insisted that irrigation supply agencies be financially autonomous and responsible, and depend for revenues on collections from those their projects serve. For example, borrowing governments have frequently failed to live up to loan conditions and covenants in World Bank irrigation credits obliging them to raise irrigation charges or take equivalent steps, sometimes reneging repeatedly, but the World Bank has rarely taken action. Decisive policy changes are needed if serious problems in these public irrigation systems are to be resolved.

The organization of the paper is as follows: Section II summarizes the range of widely experienced problems in public irrigation systems, in order to establish the area of concern. This section is not intended as a comprehensive or balanced assessment of irrigation problems and achievements, but rather identifies the problems that will later be linked to current financing policies. Section III presents the concept of rent-seeking behavior and explains some of its general implications for economic behavior. Section IV uses the history of federal government-sponsored irrigation in the United States, for which the results of rent-seeking behavior are well-documented, to illustrate how the performance of irrigation systems is affected by these financing arrangements over the long run. Section V presents more detailed evidence linking irrigation financing policies in the Third World to the performance problems discussed in Section II, including problems of investment planning, system design, operation and maintenance, and the efficiency of on-farm water use. This evidence is drawn both from country case studies and other sources. Section VI discusses forces impelling and resisting policy change, and Section VII presents some general strategies and a number of specific recommendations for improving current practices.

II. Performance Problems in Public Irrigation Systems

Huge investments to expand worldwide irrigation capacity have given farmers the water supplies they have needed to raise agricultural yields in step with rising demands for foodstuffs over the past three decades. Yet, today, public irrigation systems themselves are in danger of sinking under their managerial, economic, and environmental problems.

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If irrigation is to continue to support rapid agricultural growth in the future, as it should and must, basic problems in the supply of irrigation services must be resolved.

Certainly, irrigation's achievements have been considerable. More ample and assured supplies of water have enabled farmers to shift from hardy but low-valued crops—such as oilseeds, millets, and sorghum—to more valuable crops—such as wheat and rice—and emboldened farmers to use new high-yielding seeds that respond well to heavy fertilization. Farmers have been able to break the constraints of rainfall on cropping patterns and harvest two, or even three crops a year from the same land. In the "package" of inputs that produced the green revolution, irrigation was a crucial component.

Irrigation's direct contribution to agricultural growth has been substantial, because both the irrigated area and the yield from it have expanded rapidly. From 1950 to the present, cropland under irrigation increased by over 3 percent per year, from 94 million hectares to 271. Today, about 18 percent of the world's cultivated land is irrigated, but it produces 33 percent of the total harvest.[1] Projections of future agricultural growth count heavily on irrigation's expanded contribution. For example, a study in Asia, where two thirds of the world's irrigated lands are located, foresaw that 38 percent of *a ded* food production through the year 2000 would com from existing irrigated areas, and 36 percent would come from newly irrigated areas.[2]

The past and future investment in agricultural water supply is enormous. In current prices, the equivalent of $250 billion has already been spent to create irrigation capacity in the Third World only, and the pace of investment reached $10-15 billion per year in the late 1970s.[3] After looking at 36 important Third World countries, the International Food Policy Research Institute estimated that over half of all investment in agriculture in the 1980s would go into water resource development.[4] Since 1940, irrigation projects in Mexico have taken up 80 percent of all public investment in agriculture.[5] In Pakistan, which depends heavily on irrigation, 10 percent of the total public investment budget for the current five-year plan period is to be equally divided between ongoing and new irrigation projects. Development assistance agencies have also been heavy investors: irrigation has accounted for 28 percent of all World Bank agricultural lending during the 1980s, and commitments by all aid agencies exceeded $2.0 billion per year in 1980.[6] An FAO study concluded that a further $100 billion would be invested to extend irrigation capacity between 1985 and 2000.

Despite the high priority and massive resources assigned to water resource development, the performance of large public irrigation systems has fallen short of expectations, in low-income and high-income countries alike. Important performance measures, such as acreage irrigated, yield increase, and efficiency in water use, are typically less than projected when investments were made, less than reasonably achievable, and less than attained by private irrigators who operate more controllable decentralized systems. While major surface water developments and decentralized groundwater exploitation are not technical substitutes, performance comparisons are nonetheless interesting because they also reflect important differences in management, control, and the influence of economic incentives. In an important comparative study of private tubewell irrigation with public tubewell and canal irrigation in Uttar Pradesh (an

extensive region of irrigated agriculture in India's Gangetic Basin), cropping intensity, agricultural production, and income were significantly lower for users of public surface *and groundwater* irrigation systems, all of whom complained of unreliable and insufficient irrigation services.[7]

Evaluations of public irrigation systems have shown that, in most, service has deteriorated due to faulty design and construction, neglected maintenance, and inefficient operation. Distribution channels, if aligned properly to begin with, become silted up or breached as time goes by. Outlets and control structures are broken, altered, or bypassed. Even in systems designed for regular rotational water distribution, deliveries to most farmers are erratic and unreliable.[8]

Public sector irrigation investment programs have also suffered serious cost and time overruns. A review of nine major new irrigation projects in Asia, Africa, and Latin America found that, on average, the actual investment cost per hectare irrigated exceeded the planned cost by 285 percent, the actual irrigated area fell short by 33 percent, and the time taken to complete new projects ran over the target by an average of five years.[9] This general trend is corroborated by World Bank project audits, which find that the irrigation projects it has financed have had, on average, the biggest cost and time overruns of all agricultural projects.[10] Similarly, the 9 irrigation projects financed by the Asian Development Bank and completed by 1980 suffered an average time delay of 72 percent and an average cost overrun of 66 percent.[11]

World Bank project audits. . . find that the irrigation projects it has financed have had, on average, the biggest cost and time overruns of all agricultural projects.

Behind these figures lies a serious misallocation of resources. New irrigation projects have proliferated and public financial resources have been spread too thinly over many new projects, while completion of ongoing work, rehabilitation and modernization of existing systems, and regular maintenance have been neglected. The Government of India, which took the drastic action of proscribing new starts in the 7th Five Year Plan, had 150 major and 400 medium projects unfinished at the start of the 6th Plan period, with an estimated cost to completion equivalent to more than ten billion U.S. dollars (8 to 10 years of investment). According to a World Bank review,

> *"The GOI studied the reasons for delay in selected major irrigation projects started in the 1st and 2nd Plan periods that had been under implementation much longer than originally scheduled. . . . In all the projects, construction had been carried on at a pace far less than the optimum. This took place, despite generally rising expenditures on irrigation, due to the proliferation of projects under construction, as State governments succumbed to pressures to take up new projects wherever possible."*[12]

Public irrigation investments have become an enormous drain on government budgets because cost recovery has fallen far short of even modest targets. In Pakistan, for example, gross public revenues from irrigation services in 1984 were approximately Rs. 1.0 billion, compared to outlays for operation and maintenance of irrigation works of Rs. 2.0 billion and annualized capital charges on past irrigation investments of approximately Rs. 5.9 billion.[13] In other words, gross receipts represented only about 13 percent of the fiscal cost of public irrigation services. In the People's Republic of China, where concerns about water conservation led to a sixfold increase in water charges in the past few years, farmers still pay less than one fourth the average supply costs in major systems.[14] Another thorough investigation of irrigation cost recovery by the new International Irrigation Management Institute in Sri Lanka, covering experience in Indonesia, Korea, Nepal, Philippines, and Thailand, came to similar conclusions. Table 1, which shows these data along with figures from WRI's case study of Bangladesh, implies that in 1984 irrigation receipts were less than the costs of operation and management in all countries except the Philippines. Using the moderate estimate of capital costs in these six countries, actual receipts average less than 10 percent of the full costs of irrigation services.[15]

Further corroboration comes from North America. In Mexico, assumed cost recovery from users of public irrigation services created at an investment cost of 375 billion pesos (equivalent to US $16 billion in 1981 prices) averages only around 11 percent of capital, operating, and maintenance costs, recovery is even less in federally operated Irrigation Districts.[16] In the United States, cost recovery from Bureau of Reclamation irrigation projects averages only about 17 percent of total costs; the implied subsidy is about a billion dollars per year.[17]

Despite these investments on their behalf, farmers have not responded as project planners had hoped. Where field channels have been left to farmers to build, they often have done so only after long delays, if at all. Where maintenance in government projects has been made farmers' responsibility, it has often been neglected, even where other farmers in the same regions adequately maintain their own communal irrigation systems. Typically, farmers have failed to make the correlative on-farm investments—in land levelling, for instance—that would let them use water from government projects more efficiently. And the

Table 1. Cost Recovery Through Direct and Indirect Irrigation Charges Relative to Recurrent and Total Costs of Public Irrigation Systems

Country	1 Actual Revenue from Farmers	2 Operation and Maintenance Costs	3 Total Capital and Recurrent Costs: Moderate Est.	4 High Est.
	(All figures in $US/ha; parentheses indicate % of column 1)[b]			
Indonesia[c]	25.90 (100)	33 (128)	191 (735)	387 (1490)
Korea[c]	192.00 (100)	210 (107)	1057 (550)	1523 (881)
Nepal[c]	9.10 (100)	16 (181)	126 (1388)	207 (2270)
Philippines[c]	16.85 (100)	14 (83)	75 (443)	166 (984)
Thailand[c]	8.31 (100)	30 (362)	151 (1818)	272 (3276)
Bangladesh: Major surface systems	3.75 (100)	21 (500)	375 (1000)	n. a.

[a]converted from local prices at official exchange rates in June, 1985.

[b]numbers in parenthesis are percentages of the revenues obtained directly and indirectly from beneficiaries.

[c]based on L. Small et al., *op. cit.*, Table 4, p. 35.

[d]based on Q. Shahabuddin, "Irrigation Water Charges, Subsidies, and Cost Recovery in Bangladesh." Recoveries represent actual collections, and costs are average of existing systems.

bottom line, the increases in agricultural production and yields through more intensive cultivation of land irrigated by government projects, have been disappointing. In India, for example, production on canal-irrigated areas averages only 2 to 3 tons of foodgrains per net hectare—much better than on dry lands, but much less than the 5 to 6 tons attained under private tubewell irrigation.[18] In Mexico, a World Bank survey found, farmers still growing low-yielding maize varieties in Irrigation Districts harvest only 2.5. tons per hectare. Bank agronomists conservatively estimated that the overall productivity of irrigated farmland could feasibly be doubled.[19]

Only a small fraction of water diverted in most large surface systems in developing countries is available for plant use, typically 25 to 30 percent, compared to 60 to 70 percent in advanced systems.

Part of the problem is the misallocation and wasteful use of water. Only a small fraction of water diverted in most large surface systems in developing countries is available for plant use, typically 25 to 30 percent, compared to 60 to 70 percent in advanced systems.[20] The remainder seeps or evaporates from unlined or obstructed canals and distributories. Farmers at the tail ends of distribution systems in large projects usually suffer from water shortages during critical growing periods that reduce yields and greatly increase the risks of spending for fertilizers and other inputs. Near the water's sources, farmers are often assured of ample supplies, even for such water-intensive crops as rice and sugarcane. As a study of 11 major irrigation systems in China showed, for example, water use per hectare averaged twice and often exceeded three times the design application rate.[21] Not only do such farmers often use more water than necessary for crop growth, they have also been found to substitute water for other inputs, thus creating problems of rising subsurface water levels and waterlogging.[22] For example, according to Robert Chambers, an authority on Asian rural development, "On much major irrigation in Sri Lanka, it is notorious that top-end farmers flood their fields more than is necessary for the growth of paddy and substitute water for weeding, with little regard for their neighbors waiting dry further down the canal."[23]

Adverse environmental impacts from large surface irrigation systems have been extensive. In India, 10 million hectares have been lost to cultivation through waterlogging, and 25 million hectares are threatened by

salinization.[24] In Pakistan, more than half the Indus Basin canal system command area, some 12 million hectares, is waterlogged, and 40 percent is saline.[25] Worldwide, FAO estimates, half the world's irrigated land is salinized badly enough that yields are affected.[26]

Massive government soil reclamation projects in these countries have failed to reverse degradation. The waterlogged areas affected by Pakistan's 12,000 SCARP (Salinity Control and Reclamation Project) tubewells have initially improved as pumping lowered the water table; then irrigation from canals and private tubewells increase as soil fertility improved; finally, water tables and waterlogging rise as SCARP operations deteriorate due to poor operation and maintenance, lack of farmer demand, and other factors. In 1981, 4.3 million hectares (36 percent of all SCARP areas) were critically waterlogged, with water within five feet of the surface.[27]

Irrigation systems have provided breeding grounds and habitat for the carriers of malaria, schistosomiasis, and river blindness,[28] as well as for various agricultural pests.[29] River impoundments associated with irrigation and hydropower projects have had varied and serious impacts. Huge reservoirs have displaced whole communities, flooded valuable agricultural and forest lands, threatened critical ecosystems, and wiped out fish populations that move upriver to spawn.

Below the dam, impoundments markedly changed the seasonality, chemistry, morphology, and biology of downstream river flows.[30] The annual flow of sediment downstream is interrupted, which affects soil fertility and the rates of erosion of riverbanks and deltas. While storage may reduce the seasonal variation in river flows, disturbance of upper watersheds and diversion of river water may also increase flooding and reduce low flows. On the Periyar River Basin in Kerala, for example, where 11 dams have been built and 60 percent of the catchment area has been deforested, seawater now moves 20 miles upriver during the dry season, forcing factories near Cochin dependent on river water to close down. The deepwater port at Cochin is also silting up because not enough water flows downriver to flush out sediments.[31]

Storage dams markedly affect river ecology. Changes in oxygen, nutrient, and sediment content, and increases in salinity from increased evaporation and irrigation return flows all affect fish populations. Even coastal and offshore fisheries are affected, as the flow of nutrients and sediments into deltaic spawning grounds changes. Many of these environmental impacts are complex and exceedingly difficult to predict in advance. In most large water resource development projects, these side-effects were not adequately investigated when investments were planned. Still less were their economic costs incorporated into analysis of project benefits and costs.

The performance problems of large public irrigation projects and their environmental impacts are closely connected. Improvements in irrigation performance would reduce soil deterioration, particularly from waterlogging, which is caused by excessive seepage of water into underground aquifers. More important, if water currently diverted for irrigation were used efficiently, and potential agricultural yields from lands now under irrigation were realized, the apparent need for large additional and increasingly costly irrigation projects would diminish, if not disappear.

Improvements in irrigation performance would reduce soil deterioration, particularly from waterlogging. . . if water currently diverted for irrigation were used efficiently, and potential agricultural yields from lands now under irrigation were realized, the apparent need for large additional and increasingly costly irrigation projects would diminish, if not disappear.

Many proposed irrigation projects throughout the world have been shelved during the 1980s because of their dubious economics and worldwide fiscal restraint. Emphasis has shifted to improving existing projects. In some regions, if potential improvements can be obtained, agricultural demands will be met with few, if any, large new developments. For example, long-range Indian plans call for the development of approximately 107 million hectares under irrigation, even though the current irrigated acreage of 57 million hectares could produce the same output if current yields of 2 to 3 tons per hectare were doubled to a level comparable to irrigated yields in China.[32] Better use of water resources can save enormous amounts of money and avoid widespread environmental damage.[33]

Apart from the poor performance of large, enormously costly public irrigation systems, their contribution to agricultural growth has—compared to that of small-scale and private irrigation—been less than is usually assumed. In the United States, for example, the U.S. Bureau of Reclamation's projects irrigate about 11 million acres, about 20 percent of the total irrigated area in the American West, but only 3 million acres more than was *privately* irrigated in 1902, when the Bureau was formed. The fastest growing source of irrigation over the past two decades has been privately pumped groundwater, which now irrigates twice as much land as Bureau projects do.

In much of the rest of the world, large public systems are not the major or fastest growing source of irrigation water either. In Pakistan, despite the centuries-old system of surface irrigation, private tubewells have also

been by far the fastest growing source of irrigation over the last 20 years. They now account for about one third of all water delivered to the field.[34] In Mexico, roughly 40 percent of the irrigated area is in Irrigation Districts, where facilities are owned and operated by the federal government. The remainder is either private, or in Irrigation Units where water-user associations operate and maintain facilities.[35] In the Philippines also, the national irrigation system accounts for 40 percent of total irrigated area; the remaining 60 percent is irrigated by communal and private systems.[36] In India, major and medium-sized surface irrigation schemes built and operated by public agencies also account for 40 percent of acreage irrigated. The rest is groundwater irrigation, mostly private but heavily subsidized, and locally controlled minor surface-irrigation schemes. The dynamism of private irrigation is instructive, not because it can substitute technologically or hydrologically for large public surface developments but because it illustrates how successful a different kind of irrigation service can be. Since farmers can control water availability with little risk of supply shortages at critical growing periods, and then apply water to optimize farm income, agricultural yields under private irrigation are larger than under public canal or tubewell irrigation. Despite the higher costs of private tubewell irrigation, farmers also derive considerably higher net incomes, and they have demonstrated that they will bear the higher costs, even in the command areas of public irrigation systems. According to a USAID study in India: "Farmers in some areas with water control provided by private irrigation are willing to pay 6 to 9 times the water charges levied for canal supplies. Millions of private tubewells, some equipped with piped distribution systems serving graded fields, are evidence of this."[37]

In contrast to this dynamic growth, *at the levels of performance currently achieved*, many future large-scale investments in public irrigation systems probably cannot be economically justified. Investment costs have risen, and net returns will be inadequate unless the agricultural benefits are considerably better than those experienced to date.

In the major regions of irrigated agriculture. . . most surface waters that can be economically developed already have been.

In the major regions of irrigated agriculture, including the Indo-Gangetic plain, China, western North America, and the Soviet Union, most surface waters that can be economically developed already have been.[38] In the more advanced water-short regions—in Morocco, for example, and in Northeast China—non-agricultural uses are claiming increasing fractions of available supplies. Thus, investment costs per hectare for new systems have risen in all major regions, and, in some, the sacrifice involved in using water wastefully in agriculture is being felt more acutely.

Although individual projects vary widely, the range of capital costs per hectare irrigated by new large surface water projects for Asian countries for which data are available (India, Bangladesh, Pakistan, Thailand, Indonesia, Nepal, and the Philippines) is $1500 to $4000 per hectare.[39] In other countries, capital costs tend to be considerably higher: in the vicinity of $10,000 in Mexico, South Korea, and much of sub-Saharan Africa. These figures typically do not include the costs of mitigating or avoiding environmental hazards: resettling displaced communities and providing adequate drainage, in particular, can add very substantially to project costs.

Investments in irrigation are difficult to justify if benefits are projected on the basis of current experience.

With these price tags, investments in irrigation are difficult to justify if benefits are projected on the basis of current experience. The high cereals prices of the early 1970s, which were incorporated into future price projections that inflated estimated benefits, have fallen by 50 percent in real terms. At current prices, simulations of typical irrigation projects in rice-growing Asia show that to provide a 10-percent discounted rate of return on investment costs of $3000 per hectare, production *increases* of over 3 tons per hectare are needed. This is well in excess of what has been achieved, on average, in most large public irrigation systems in Asia.

The gains in farm production and income that public irrigation systems have produced, in all the countries for which data are available, don't cover the full capital, operating, and maintenance costs of new projects at current cost levels.

The gains in farm production and income that public irrigation systems have produced, in all the countries for which data are available, don't cover the full capital, operating, and maintenance costs of *new* projects at current cost levels. In many countries, they don't even cover the historical costs of the irrigation services

provided, if fully charged to recipients. In other words, if required to pay for these irrigation services, farmers typically would be worse off than if they had no water supply. Most countries have rationales—some more plausible than others—for not requiring farmers to pay these costs, but the opportunity costs of supporting these political and other agendas are high. The poor standard of current performance makes investing in new public irrigation systems a questionable proposition until the serious underlying problems are resolved.

Table 2 provides evidence from five Asian countries. While actual cost recoveries represent only a small fraction of the additional farm income public irrigation projects generate, attempts to recover full project costs would burden farmers in all countries except the Philippines with charges greatly in excess of benefits. According to the International Irrigation Management Institute, "... the benefits of irrigation are not great enough to make possible the full recovery of costs in any of the five countries without making farmers worse off than they were before the introduction of irrigation."[40]

The same conclusion is suggested by WRI's own country study on public irrigation in Pakistan. The marginal value of an additional acre-foot of water has been estimated from data on farm performance at approximately Rs. 180 per acre-foot on wheat and rice, approximately eight times the level of existing water charges.[41] Although these benefits comfortably exceed the historical costs of water supply in the Indus Basin canal system, estimated at about Rs. 85 per acre-foot, there is little scope for diverting more water into the Indus Basin system. Additional water supplies must come from groundwater development and rehabilitation projects to reduce canal water losses. The costs per acre-foot of water saved in recent rehabilitation projects has ranged widely, from Rs. 256 in Baluchistan to Rs. 515 in the Northwest Frontier. In the Punjab and Sind, the two principal agricultural provinces, costs average Rs. 337 and Rs. 387 per acre-foot.[42] These figures again raise questions about whether current levels of performance of public irrigation systems justify proposed investments.[43]

These questions should not surprise observers of irrigation investments in North America. Few of the projects that the U.S. Bureau of Reclamation constructed during the 1960s and 1970s had favorable benefit:cost ratios if calculated on the basis of direct agricultural benefits. Until prohibited, estimated "secondary" benefits were usually relied on to justify investment decisions.[44] Few irrigators in current Bureau projects could afford to pay the full costs of federal irrigation services.

In Mexico, the estimated capital and recurrent costs of public irrigation, on an annual basis, range from $1200 to $1800 per hectare.[45] By contrast, the net value added per irrigated acre in 1980 averaged only $1100, and estimates of the marginal value of water in agriculture run from $525 to $1300 per hectare.[46] The point here is not that investment in public irrigation is inadvisable, though the evidence suggests a systematic tendency toward over-optimisim in projecting investment costs and benefits as well as a widespread sacrifice of

Table 2. Estimated Economic Benefits from Public Irrigation Systems Relative to Cost of Irrigation Supply

Country	Estimated Benefits as a Percentage of: Operation and Maintenance Costs	Total Capital & Recurrent Costs with: Moderate Capital Costs	High Capital Costs
Indonesia			
i) high estimate of benefits	1000	178	88
ii) low estimate of benefits	370	65	32
Korea[a]			
i) high estimate of benefits	370	71	49
ii) low estimate of benefits	278	55	38
Nepal	1000	135	82
Philippines	1428	233	102
Thailand	322	64	36

[a]These estimates are based on internal prices of rice, which are held far above world prices. If calculated on the basis of world prices of agricultural output, the estimated benefits of irrigation would be a much smaller fraction of costs.

Source: L. Small, et al., *op. cit.*, Table 5, p. 37

economic efficiency to other purposes. Rather, the point is that improvements in performance are essential if acceptable economic returns are to be realized on future irrigation investments.

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The inadequacy of current performance in large operating public irrigation systems has been widely recognized. Many experts have stated that efforts to improve them should take priority over new project starts, and investment priorities in international funding agencies and some national planning bodies have shifted. Efforts to improve performance include rehabilitation and modernization of physical structures and increasing attention to the management of irrigation systems.

The performance of many older irrigation systems is limited by the original designs, which cannot meet the needs of modern intensive agriculture. Although they give farmers some assurance against drought-induced crop failures, such systems cannot meet the peak water requirements of optimal cropping systems throughout the command area, and they cannot respond flexibly to farm demand for irrigation. Moreover, many systems, aged or inadequately maintained, have deteriorated to the extent that they cannot approach even original design performance.

Widespread and crippling management problems have been identified in public irrigation systems:[47]

- Responsibilities are fragmented among construction, operating, agricultural, and financial agencies, which do not coordinate to provide good services to farmers.
- Most government irrigation agencies are not accountable to the farmers they serve, either for employment or funds.
- There are usually no effective means for monitoring and evaluating the performance and effectiveness of the system.
- Irrigation agencies in many countries are staffed with poorly trained, supervised, motivated, and rewarded operatives.
- Many agencies are plagued by pervasive corruption and indiscipline.[48]
- Water users within sections of public irrigation projects, who are physically interdependent by virtue of a common water supply system, usually don't organize, cooperate, or participate effectively in operating and maintaining the system.

Varying attempts are being made to address these physical and managerial problems, including internationally financed projects, national programs, and new institutions, such as the International Irrigation Management Institute. These efforts and initiatives are, of course, valuable and important.

For the most part, management problems are symptomatic of the underlying conflicts in the political economy of public irrigation. But, many of the remedial projects and programs deal mostly with the symptoms, not the underlying conflicts. If performance in public irrigation is treated either as a mechanical or design problem, or as a management problem, and the more fundamental difficulties in the political economy of public irrigation are not resolved, efforts to improve performance will probably have limited success. A

*Management problems are **symptomatic** of the underlying conflicts in the political economy of public irrigation.*

broader approach that includes changes in incentive policies to promote greater efficiency within the entire system is more promising.

A fundamental problem in the operation of existing systems is that forces of self-interest and self-preservation encourage water users to subvert the physical design and operating criteria of public irrigation systems to get more water. Self-interest also biases irrigation agencies and water users against adequate maintenance and upkeep. Irrigators face an "assurance paradox" that encourages them to shirk their maintenance responsibilities. Irrigation agencies gain disproportionately by allocating resources to new projects, and suffer few sanctions (and sometimes enjoy benefits) if maintenance is poorly performed. Therefore, physical improvements, such as those financed by current rehabilitation projects, are unlikely to have substantial, lasting, beneficial effects on system performance—and may not long survive—unless there are changes in the implicit incentives that influence the self-interest and behavior of irrigation agencies and water users. Externally financed rehabilitation projects run the danger of becoming periodic remedies for deferred or neglected maintenance, funded on capital account.

By the same token, water users, their political representatives, and government irrigation agencies may all endorse the principles of equity and efficiency supposedly underlying the designs and operating principles of public irrigation systems. However, none of these groups realize their maximum advantage if equity and efficiency are achieved in practice, so all are busy in their own interests trying to overturn those

principles. Under these circumstances, "better management" is an elusive goal, since the dominant parties involved have weak, if any, interests in attaining it. Without fundamental changes in the incentives that motivate these parties, efforts to strengthen irrigation management probably won't substantially improve performance in public systems.[49]

To a large extent, the current emphasis on management as the critical problem in public irrigation reflects acceptance of the long-dominant engineering perspective. Most engineers, who still run virtually all irrigation agencies, conceptualize irrigation projects as hydraulic systems designed and built to operate in certain ways. If they don't actually operate that way in practice, then, according to the engineers, "they are not being managed properly." However, seen not as hydraulic but as socioeconomic systems, those same irrigation projects are designed to operate in quite a different way—in accordance with the principles of rent-seeking—and, in fact, they do so.

III. Rent-Seeking and the Functioning of Public Irrigation Systems: General Considerations

In almost all public irrigation projects, the value of water delivered to farmers far exceeds what they must pay to get it. The difference is especially pronounced in periods of peak water demand but is substantial for the whole crop year. This gap between what more water would cost farmers and what it's worth to them almost inevitably creates demands in peak periods that the project can't meet. The available water is rationed to users by various mechanisms in different systems: through contractual deliveries to irrigation associations; through the irrigation agency's operating rules and procedures; or, in loosely managed systems, through sheer unavailability of water to some users.

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The typical user, not the one with highly preferential access to water, would gladly take more water if he could get it. Extra water would be worth much more to him than the associated charges. His use is limited by the ration he commands, not by the government's charges for additional supplies. The difference between the value of additional water to the farmer (to the economist, its marginal value product) and what the system charges for it is an economic rent. Unlike an economic profit, rent accrues to the user not by virtue of superior efficiency and foresight in farming, but through the water allocation his land receives.[50]

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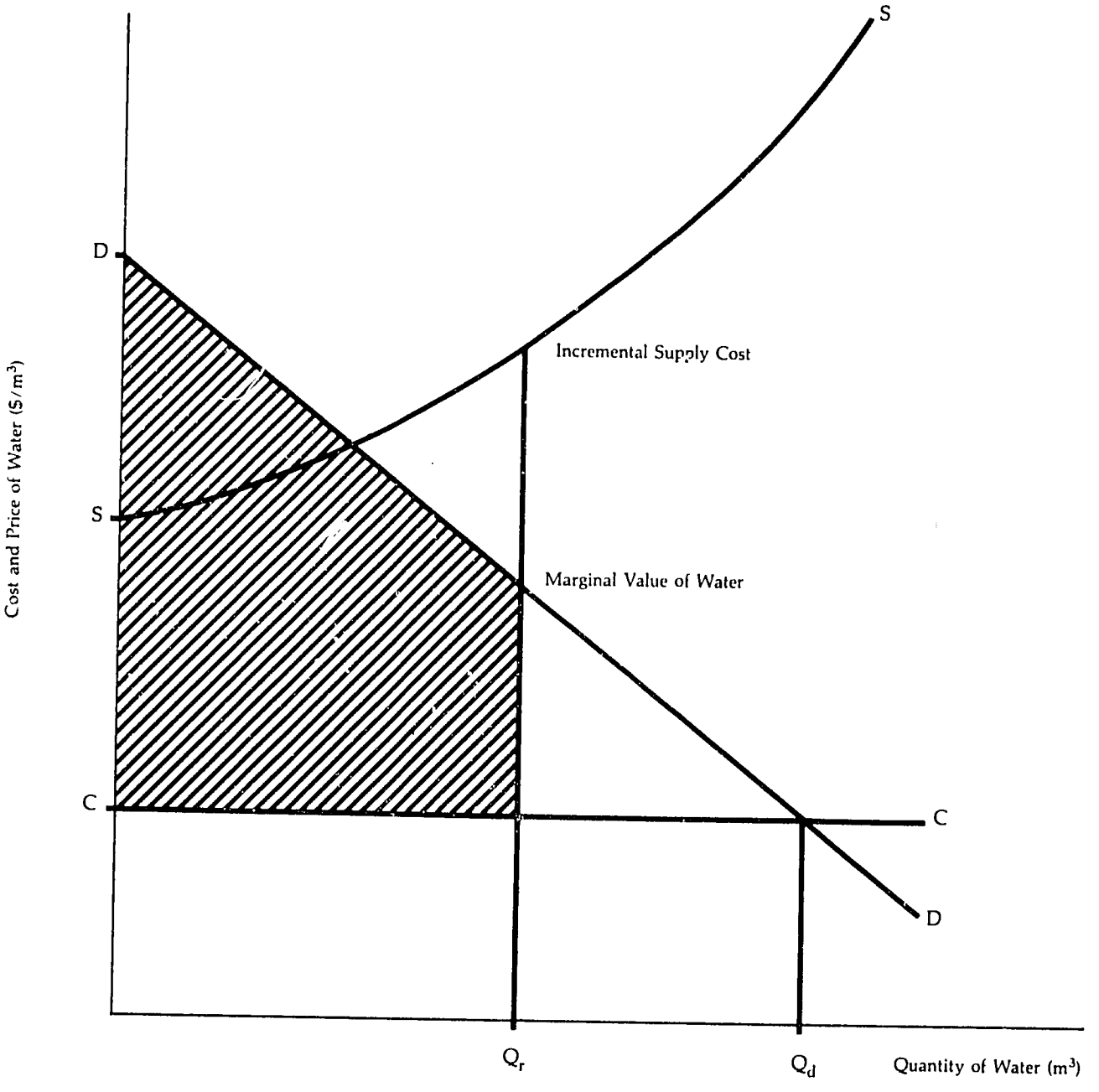
Figure 1 portrays this situation in a graph of farmers' demand for water (DD), the charge they must pay for it (CC), and the full cost of supplying it (SS). While the marginal value of water, underlying farm demand, is portrayed as declining as more is available for use in a given area, and the full costs of supply are assumed to rise, the charges per unit of water are shown as unvarying as more is used. In fact, in many countries charges are levied per unit of land irrigated, not per unit of water applied, and so charges decline as more is used. Ideally, of course, water charges would be set to cover incremental costs at a level of supply that meets all demands at that price (that is, where the demand and supply functions meet). With such charges, there is no excess demand, and farmers are discouraged from using additional water if the marginal returns are less than incremental supply costs. With charges set much lower at the subsidized cost (CC), the economic rent is the entire shaded area that reflects the difference between the value of water and water charges. The excess demand is portrayed by the difference between the amount of rationed water available (Q_r) and the amount demanded (Q_d) when water charges are low. The full costs of water supplied are portrayed as substantially above its marginal value, which corresponds to the data on actual benefits and costs presented above.

As Table 3 shows, economic rents are a large fraction of the gross value of irrigation water supplied by public systems in many countries. In fact, in all the countries for which data were available, both from WRI case studies and from other sources, total water charges represent only a small fraction of the benefits recipients receive from water allocations. Charges would have to

Figure 1. Economic Rents in Irrigation Supply



be increased many times over to recover from farmers what public irrigation water is worth to them.

Several implications are immediately evident. First, farmers strongly desire increases in water availability, even if the marginal value of that water in crop production is well below the cost of supplying it. Even though below cost, those marginal benefits still amount to much more than the charges farmers have to pay. Second, since most farmers' demands exceed their rationed supplies, increases in water charges would not begin to affect their demands, or their incentive to conserve water, until charges approximated the marginal value of water and rents were curtailed. This is the reason why studies exploring farmers' reactions to comparatively small variations in water charges have typically found no significant response.

Another implication is that any production benefits stem from increased availability of water, not from

Table 3. Economic Rents in Public Irrigation Systems: Irrigation Charges as a Percentage of Estimated Economic Benefits to Farmers

Country	Charges as a Percent of Farmer Benefits
	(%)
Indonesia[a]	
high estimate of benefits	8
low estimate of benefits	21
Korea[a]	
high estimate of benefits	26
low estimate of benefits	33
Nepal[a]	5
Philippines[a]	10
Thailand[a]	9
Pakistan[b] (Punjab Province, major irrigated crops) surface irrigation	6
Mexico	
high estimate of benefits	11
low estimate of benefits	26

[a] based on L. Small et al., *op. cit.*, Table 5, p. 37.

[b] based on M. A. Chaudry "Water Charges, Cost Recovery and Irrigation Subsidies in Pakistan."

[c] based on R. Cummings and V. Brajer, "Water Subsidies in Mexico's Irrigated Agriculture."

lower charges. If a little more water were somehow made available, farmers would use it to expand irrigated production, provided its price to them was below the net value of the additional output. Providing more water to them at a much lower charge, creating more rents, would make farmers richer but not change their willingness to use water productively. Any economic benefits that others derive from increased farm output—more rural employment, lower food prices, etc.—flow from making more water available, not from pricing it below its value to farmers. In fact, if under-pricing of water makes for inefficient irrigation systems, as the next sections show, agricultural output suffers, food prices are higher, and rural employment is less than it could be. In the vocabulary of benefit:cost analyses, the "secondary benefits" of irrigation might be positive, but those of irrigation subsidies might be negative. It is thus perfectly logical to advocate irrigation expansion and yet question the wisdom of irrigation subsidies.

Production benefits stem from increased availability of water, not from lower charges.

Finally, because excess demand for subsidized irrigation water requires some sort of rationing system, the large economic rents from keeping water charges low accrue to those who receive allocations. Allocations within irrigation systems are almost everywhere tied to specific parcels of land, either because only those lands are physically irrigable or favorably located to receive water, or because legal systems assign water rights to lands instead of persons, or because the rules of irrigation societies delimit the area eligible to receive water.[51] Therefore, while use of labor, capital, and other inputs can readily increase or decrease on specific parcels of land, the availability of public irrigation water is effectively fixed.

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It is not surprising that economic rents from low water charges are quickly capitalized back into the value of the land on which the water is available. If such land is sold, its price reflects the value of its access to low-cost water. If the land has superior access by virtue of its location near the head of the system, that too is reflected in its price.[52] If the land is rented out, the terms of tenancy capture the full productive value of the irrigated land for the owner, and do not pass on the subsidy embodied in low water charges to the tenant.[53] Even if farmers trade water rights among themselves, as they do throughout India, Pakistan, and Bangladesh when one farmer has a tubewell and his neighbor does not, the prices at which water rights are sold more nearly reflect irrigation's productive value to the buyer than its cost to the seller, which is often highly subsidized by government even though the tubewell is privately owned.[54]

Even with these subsidies, the differences between farmers' incentives to use private tubewell and public canal water are instructive. With tubewells, farmers can get more water at higher cost, either by pumping longer hours or by installing larger capacity wells and pumps. Using more water generates additional costs, and water

use is typically limited by its cost, relative to its value in production, not by its physical availability. There is no excess demand.[55] In most public canal irrigation, water charges are tied not to the amount of water farmers use but levied on the basis of the area irrigated, with some rate differentiation according to crop and season. Using more water on a given acreage costs the farmer nothing.

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In China, before irrigation pricing policy shifted recently toward a volumetric system, peasants derided the flat charges, with sayings such as "Use a little or use a lot, eight *mao* (ten Chinese cents) for every *mu* (one fifteenth of a hectare)."[56] In public irrigation systems, then, there is chronic excess demand, and use is limited by ration, not by the balance of costs and on-farm benefits.

The effect of such rents as those created by low irrigation charges on 1) those who receive them, 2) those who aspire to obtain them, and 3) those with power to confer them has been extensively studied. "Rent-seeking behavior" has been scrutinized in many areas of economic life, by observers from the time of Adam Smith to the present. The behavior itself and its consequences are by now well-known and predictable.[57]

Potential recipients of economic rents compete for them, not by outbidding rivals in the marketplace through superior economic efficiency and foresight, but by trying to control the people who allocate them.

Rent-seekers think that using the resource efficiently is much less important than gaining control of the allocation mechanism.

Political manipulation, intimidation, and corruption replace economic efficiency as ways to get ahead. Inevitably, most of the available rents are captured by those with power, influence, and wealth, and rent-seekers think that using the resource efficiently is much less important than gaining control of the allocation mechanism. In fact, the existence of substantial economic rents may encourage blatant inefficiency in resource use. Under U.S. water law, for example, if farmers or even States fail to put water to "beneficial use" (for example, to use it for irrigation), they can lose their rights to it. Rather than forfeit those rights, they have often constructed costly irrigation systems and used water much less economically than other potential users could.

Successful rent-seekers can well afford to spend a portion of their rents to safeguard, defend, and increase them.[58] These defensive expenditures finance organizational efforts, political contributions and lobbying, and activities or investments that strengthen rent-seekers' claims to the resources being allocated. Over time the mechanisms by which successful rent-seekers obtain their gains become extremely well entrenched and defended.

Those who control the allocation of rents, whether administratively or politically, are in a position of power relative to rent-seekers because they are dispensing rights to resources for which excess demand is chronic.[59] They typically find ways to appropriate a share of those rents for themselves—often through corruption and monetary gain, but also in other forms.[60] Politicians gain votes and contributions, and public agencies gain expanded budgets, staffs, and authority.

At a minimum, the power enjoyed by those who control the allocative mechanism and ration excess demands makes them less responsive to the needs of users. The prevailing attitude is "There is not enough to go around, so they must take what they get." In extreme cases, allocators adopt an exploitative attitude toward users. For example, operators of public sector SCARP tubewells in Pakistan have been known to find their wells broken or inoperable during seasons of peak water requirements and find themselves unable to make the necessary repairs until farmers pay them off.[61]

All who share in the rents—politicians, administrators, and users—have a shared interest in preserving and expanding the arrangements that benefit them. They combine to do this, finding ways to shift the costs of the system to other parties while keeping as much of the benefits as possible to themselves. Since parties to this coalition can then prosper whether or not total benefits exceed total costs, they typically press to expand the system beyond its economic limits. If the coalition is compact and well-organized, and its victims sufficiently diffuse and ill-informed, the economic losses rent-seeking coalitions can inflict, and their duration, can be staggering.[62]

IV. Rent-Seeking in Public Irrigation in the United States

The following analysis of the U.S. experience with public irrigation implemented through the U.S. Bureau of Reclamation highlights and illustrates these processes.[63] It is not intended as a balanced or comprehensive assessment of the achievements and shortcomings of reclamation activities in the American West. Rather, since the U.S. experience with rent-seeking in public irrigation has been extensively documented, it marks the trail taken later in examining similar phenomena in the Third World, which have not been so thoroughly explored.

"Pork barrel politics" in U.S. government water resource development programs is probably the best known example of rent-seeking in the public expenditure domain.[64] The effects described above have reached dramatic proportions in federally financed irrigation programs carried out by the U.S. Bureau of Reclamation. Yet, the lessons so painfully learned have not been applied to the same processes flourishing in other countries.

Early opponents of the proposed Reclamation Act at the beginning of this century prophesied with deadly accuracy that it was bound to become a drain on the Federal treasury for the benefit of agricultural interests. To counter this objection, the Act created what was intended to be a self-financing revolving fund to finance irrigation construction through ten-year, interest-free loans repayable by irrigation charges set by the Secretary of the Interior.

From this beginning, the subsidy element in Bureau of Reclamation projects has grown steadily under the pressure of huge project cost overruns and constant protestations by beneficiaries of their inability to pay. Additional revenue sources were funneled to the Reclamation Fund to make good funding shortfalls. Then, in 1914 Congress authorized 20-year repayment schedules with a five-year grace period, graduated installments, and moratoria in bad years. In 1926 the repayment period, still without interest, was extended to 40 years; in 1939 the grace period was lengthened to 10 years, and the principle formally adopted that charges should take into account farmers' ability to pay.[65]

Postwar inflation and the rise of interest rates made the forgiveness of interest charges on unpaid balances and the use of historical costs in calculating repayment obligations enormously important subsidies. Nonetheless, the Bureau of Reclamation found more ways to increase the transfer of rents to its constituents. When constructing new parts of huge projects with many components, such as California's Central Valley Project, the Bureau recalculated the 50-year repayment limit from the time of completion of the latest construction component, so that beneficiaries' obligations were repeatedly deferred. When constructing multipurpose projects, the Bureau assigned large shares of the costs to other revenue-generating purposes, such as hydro-electric power, and to such "non-reimbursable" accounts as flood control, for which the federal government is supposed to pay the bill.[66]

Farm groups, their political representatives, and the principal federal irrigation agency have thus combined to expand the subsidy in government reclamation programs from its modest initial amount to its present proportions. Although the subsidy differs in each of the Bureau's 140 completed projects with completion date, contract terms, and assessed farmer ability to pay, studies have shown that it averages about 83 percent of full project costs.[67] This amounts to $37.50 per acre-foot delivered, a total subsidy to the 146,000 farms that use Bureau water of over a billion dollars per year. Expressed as a capital sum—the present value of capital and operating expenditures less reimbursements, the subsidy averages $1450 per irrigated acre in 1985 prices—nearly $15 billion in total. At the time of the study cited above, the total subsidy was no less than 56 percent of the average market value of irrigated land in the reclamation project areas.

In most project areas, charges are considerably lower than the estimated marginal value of irrigation to farmers. Thus, the projects generate substantial economic rents, which can be estimated from Table 4.[68] The Black Canyon project, for example, generates economic rents of $117 for every acre irrigated.[69] At the same time, Table 4 indicates that in 11 of the 18 projects studied, the value of irrigation water used efficiently on a

Table 4. Economic Rents and Subsidies in Bureau of Reclamation Irrigation Projects in the Western United States

Irrigation District	Average Supply 1972–1976 (acre-ft/acre)	Actual Current Charges ($/acre-ft.)	Estimated On-Farm Water Value ($/acre-ft)	Estimated Full Supply Cost ($/acre-ft)
Black Canyon	5.2	1.41	24	15.77
Coachella	6.31	7.00	8	26.27
Columbia Basin East	4.19	4.19	20	41.16
Elephant Butte	2.14	6.45	67	24.43
Farwell	1.21	10.50	34	135.50
Glenn-Colusa	0.71	1.46	6	17.85
Goleta	1.84	59.24	35	263.12
Goshen	2.1	4.22	n.a.	22.96
Grand Valley	5.4	1.18	4	31.10
Imperial	5.82	4.75	10	11.00
Lower Yellowstone	1.8	5.28	35	34.62
Lugert-Altus	0.52	18.58	—[a]	143.19
Milk River	0.8	7.79	80	119.13
Moon Lake	1.13	1.75	3	7.047
Oroville-Tonasket	4.1	11.47	90	21.33
Truckee-Carson	3.38	2.19	72	33.46
Wellton Mohawk	6.96	4.80	31	29.58
Westlands	2.54	15.80	27	67.56

[a] Unable to cover any irrigation charges at assumed prices and yields

Source: Richard W. Wahl, "Full Cost Pricing Option," in Department of the Interior, Bureau of Reclamation, *Westwide Report on Acreage Limitation: Draft Environmental Impact Statement:* Appendix G; Washington D.C., Jan., 1985.

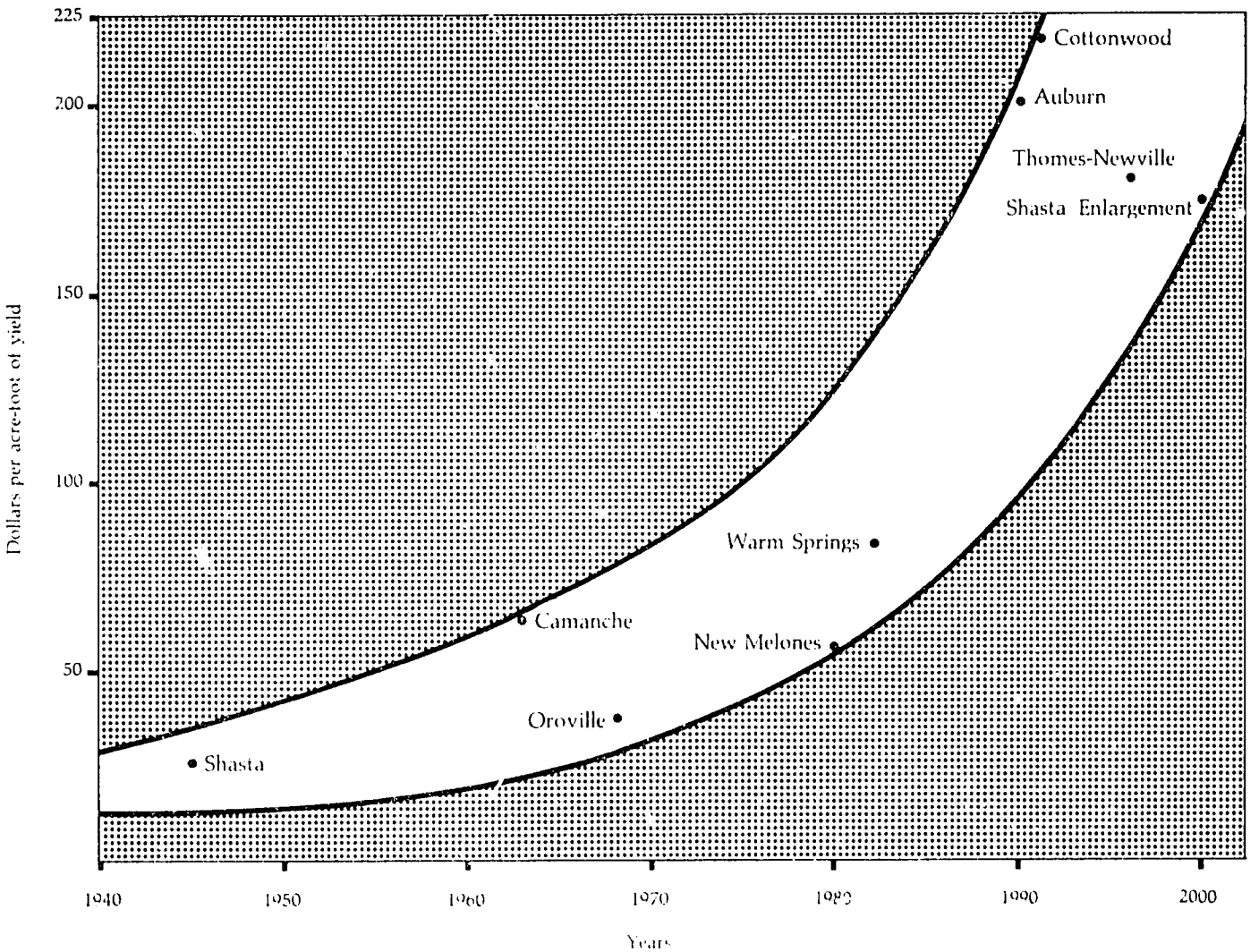
relatively large 640-acre farm, does not cover the full costs of its supply. In the gigantic Westlands project, which irrigates more than half a million acres, the estimated economic loss exceeds $120 per acre.

Nonetheless, because this coalition has won increased subsidies and shifted almost all the costs of federal irrigation onto others, farming interests and their political representatives lobby for further investment in even costlier irrigation projects that farmers would not, and could not, profitably finance themselves. Figure 2 illustrates this trend with data on the constant-dollar cost of providing additional irrigation water in California, from completed, current, and planned investments.[70] In California's Central Valley, farmers pay an average of $6.15 per acre-foot for federal water, less than 10 percent of its *average* supply cost, and consequently, have lobbied the Bureau of Reclamation to double the current supply by spending billions to construct such projects as the Auburn Dam (depicted in *Figure 2*). Recent estimates place the annualized capital costs of water from this project at $378 per acre-foot, far more than irrigation water is worth. Even with 50-year, interest-free repayment, the water would cost $50 per acre-foot. However, farmers avidly support the project since the Bureau averages project costs with those of other components of the huge Central Valley project: water charges would rise only by $2 per acre foot.[71] This is an egregious example of cooperation between farm groups, politicians, and the irrigation bureaucracy to secure additional rents through massive investments in wildly uneconomic projects.

Unfortunately, this is typical of federal irrigation projects under construction. A General Accounting Office study of six such projects found that full costs of supply would range from $87 to $130 per acre-foot and that the subsidies to users would range from 92 to 98 percent of these costs. After examining farm economics in those project regions the study concluded: "If water were priced high enough to recover the construction costs plus a 7.5 percent interest charge, the potential customers for irrigation water could not generate enough extra agricultural yield to pay for the additional expense required by irrigated agriculture. The projects we studied failed the pragmatic test of economic viability for the irrigation facilities."[72]

The lure of additional rents and the process of political log-rolling, whereby politicians support each other's claims for additional projects for their constituencies, supports and perpetuates faulty investment decisions.[73] Screening these investment proposals through benefit:cost analysis is widely recognized as a sham, despite periodic solemn reexaminations of methodology.[74] Without the assurance of actual reimbursement of investment costs by direct beneficiaries, benefit: cost analysis cannot withstand heavy political pressures from rent-seeking

Figure 2. Historical and Projected Costs of Water Supply Facilities (1980 Dollars)



Source: C.V. Moore and R.E. Howitt, "The Central Valley of California," unpublished paper prepared for the World Resources Institute, June 1985

coalitions. In the United States in 1982, even though the Bureau of Reclamation had long since exhausted the possibilities for economically viable new projects, there was a backlog of 71 projects under construction, and another 31 had been authorized, though no funds had been appropriated in that year. Already, $6.5 billion had been spent on new projects under construction, and with 4 percent annual inflation, the additional cost to complete them would escalate to $23 billion.[74] Delays and cost escalation due to the proliferation of projects have been substantial.

Underlying the inadequate returns to past and current investments is serious inefficiency in irrigation water use. Many irrigation districts in the West have senior rights to cheap federal water. Outmoded water laws in some states that restrict transfers to higher valued uses, or that even keep irrigators from using water they conserve to irrigate additional acreage, blunt incentives to use water more efficiently. Consequently, water use is generally inefficient – physically and economically—in Bureau of Reclamation irrigation systems.

In Western agriculture, only about 50 percent of water diverted is used for plant growth. Conveyance losses alone in Bureau projects are estimated at almost one third of diversions because, according to a survey in the 1970s, 85 percent of the Bureau's 14,000 miles of canals and 68 percent of its 23,000 miles of laterals were unlined.[75] On-farm losses are also large unless investments in advanced distributions sytems or land-levelling and

tailwater recovery are made. Where availability is assured and the cost of water low, neither irrigation districts nor farmers are motivated to make these investments to reduce water losses. A study of irrigation districts in Kern County, California, found close correlations (.64 for surface water systems) between the levels of water charges and of irrigation efficiencies.[77]

While most of these losses either recharge aquifers or reappear in downstream river flows, almost half of the seepage is lost to deep percolation, evaporation, and transpiration by weeds along canal banks. And aquifers and return flows are contaminated by salts, agricultural chemicals, and such toxic trace elements as selenium. Drainage and salinization are emerging as major problems in most heavily irrigated agricultural regions.

Moreover, cheap water is used for extremely low-valued uses. In 1981 over 30 percent of area irrigated with federal water was devoted to hay, alfalfa, and other pasture. Another 25 percent was planted to such grains as barley, sorghum, corn, and wheat. Various studies conclude that water used in this way can bear a cost of no more than $25-$40 per acre-foot, much less than its incremental cost of supply. Not only that, 45 percent of federally irrigated land in the West, and 59 percent in California, is used to grow crops that are officially in surplus and subject to other expensive federal programs to *reduce* production.[78] Only about 25 percent of the acreage grows fruits, vegetables, and specialty crops that might reasonably justify irrigation.

Low irrigation charges allow low-valued uses—this is clear from cropping patterns across districts where the level of irrigation charges differ. In Kern County, California, where charges for surface water varied from $6.68 to $51.07 per acre-foot, a much higher percentage of land was planted to orchards, vineyards, and vegetables where charges were high, holding constant soil type and distance from market.[79]

Throughout the West, federal government subsidies for irrigation have created large rents but have resulted in huge economic losses. Billions of dollars have been committed to projects that don't yield enough benefits to cover their costs, and that would not have been built if the beneficiaries had to pay for them. Millions of acre-feet of water are used to irrigate crops that aren't even worth the cost of bringing water to them, let alone the value of that water in rapidly growing western cities and industries.

Farmers who have successfully captured, defended, and increased the rents implicit in federal irrigation policy are among America's richest.

Farmers who have successfully captured, defended, and increased the rents implicit in federal irrigation policy are among America's richest. Only 6 percent of all farmers receive any Bureau of Reclamation water. Other irrigators, who pump groundwater or use water from local and state systems, pay five to ten times more per acre-foot of water. Dryland farmers are even worse off. Their average holding is smaller than that of irrigators (377 acres, compared to 886); the value of their equipment less ($330,000 to $788,000); the value of output sold smaller ($47,000 to $143,000) and their net profit also less ($1,034 to $11,395).

Furthermore, although the original and ostensible purpose of Bureau of Reclamation activity is to help the small farmer, most of the billion-dollar annual subsidy goes to a small number of large farms. In 18 sample projects studied by the Bureau of the Interior in 1981, the largest 5 percent of farmers, with operational holdings of 1280 acres or more, garnered one half of the total subsidy. By contrast, the smallest 60 percent of farms, of 160 acres or less, for whom all the benefits of federal irrigation projects were originally intended, received only 11 percent of the total subsidy.[80] Laws that were passed to ensure that only these small farms received the rents have been circumvented and ignored over the years; in 1982, they were finally repealed in the Reclamation Reform Act.

Although the original and ostensible purpose of Bureau of Reclamation activity is to help the small farmer, most of the billion-dollar annual subsidy goes to a small number of large farms.

Successful rent-seekers actively enter the political arena to influence key decisions and decision-makers.[81] For example, during the ten months before the important Reclamation Reform Act of 1982 was enacted, 34 Political Action Committees representing land and water interests in the West contributed over $500,000 to political office-holders and candidates. Members of the House-Senate Conference Committee on this legislation received $82,000 and the five Congressmen who represent the San Joaquin Valley in California, site of the controversial Westlands Project, received $91,000.[82]

These facts are well-known in the United States and widely recognized as symptoms of the search for rents in public irrigation. Political battles have been fought to change the system, with much expenditure of ammunition and some success. Appropriations for federal irrigation projects have fallen nearly 50 percent in real terms over the past decade, and a 10-year moratorium on new project authorizations has been in place. Any new project authorizations have been linked

to agreements with local interests to contribute a reasonable share of capital costs "up front." New Bureau of Reclamation contracts include significantly higher water charges. Albeit, policy changes to reform the rent-seeking process are being put in place.

Yet, neither the lessons of U.S. experience nor their policy implications are being applied to public irrigation systems elsewhere, where the same underlying problems and the same symptoms are evident. USAID, though supportive of efforts to improve irrigation management and performance in the Third World, accepts as a policy goal the collection of enough revenues to meet Operating and Maintenance (O&M) expenses. The World Bank's policies regarding cost recovery in the public irrigation project it supports call for the recovery of a reasonable share of capital costs as well, and it regularly includes conditions and covenants to that effect in its irrigation loan agreements. In practice, however, borrowing governments frequently fail to live up to those conditions by raising irrigation charges or taking equivalent steps, sometimes reneging repeatedly on successive World Bank irrigation loans. The World Bank rarely takes action. In most Third World countries, official policies call only for the recovery of O&M costs from beneficiaries. Yet, even these costs, which are typically only 10 percent or less of the total costs of major surface water irrigation systems, are rarely recovered.

This policy stance is an anomaly that would not long survive in other fields of public investment. Suppose, for example, that natural gas were priced to the consumer at the cost of operating and maintaining the gas pipeline. It takes an effort of imagination even to suppose that such a policy would be seriously proposed or entertained. The results would be 1) excess demand for gas and a cumbersome rationing mechanism, 2) substitution of gas for other energy sources and little interest in energy saving investments, 3) a perpetual clamor from consumers for the construction of more pipelines and the development of more gas reserves, 4) huge fiscal losses among gas supply agencies.

Of course, such a policy stance would never be adopted. For example, the World Bank's policies toward cost recovery in other fields of public investment, including even urban water supply, stress financial autonomy and full cost recovery by the supply agency—to ensure efficiency in resource use, to ensure discipline over investment decisions and operations, to prevent fiscal drains, and to ensure that those who are able and willing to pay do so. Irrigation stands as a notable, and costly, exception.

The next sections present details on the costs. They explain the linkages between rent-seeking and distortions in investment decisions, weaknesses in operation and maintenance, and inefficiencies and inequities in water allocation and use.

V. Links Between Inappropriate Incentives and Performance in Public Irrigation in the Third World

A. How Rent-Seeking Affects Public Irrigation Investment Decisions

When farmers make private irrigation investments out of their own resources, they calculate their expected benefits and costs and allow for risks. But farmers and their political representatives will ardently support publicly financed irrigation investments whether the overall economics are favorable or not, so long as they profit privately. An interesting illustration of this difference in attitude comes from the Philippines, where water-user associations must repay the government a part of the government's construction costs in communal irrigation systems. Farmers pressure government to eliminate planned structures they see as inessential and to ensure that material and equipment ordered for the project are actually used for that purpose, when the costs come out of their pockets.[83]

Usually, government irrigation agencies' capital budgets come from the general treasury, not from revenues produced by their projects. In a sample of countries in which the World Bank finances irrigation projects, revenues cover only 7 percent of project costs, on average. Even in countries where water charges do cover an appreciable fraction of capital costs, the funds typically return to the central treasuries and are not retained by the irrigation agencies. Naturally, irrigation agencies share farmers' strong interests in continuing high levels of investment, with much less regard for overall economic viability: it accords with their traditional role of expanding water supplies, and is the only way they can preserve high levels of staffing and spending.

Even external financing agencies, such as the multilateral development banks, are not dependent for debt service and repayment on the results of the specific projects to which they lend. At times, large, non-controversial projects that development assistance agencies could support have been scarce, and irrigation projects have accounted for a large, steady flow of new lending. Irrigation specialists within those agencies naturally prefer a high level of activity and engineering consultants and construction firms in the lending countries depend on it.[84] As a result, financial discipline over investment decisions in public irrigation systems is structurally weak, from farmer to international banker, because no party—except the general taxpayer—is seriously at risk. At the same time, because rents are so large, the pressures for new investment are strong.

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National budget and planning offices and development agencies attempting to screen out poor investments through benefit:cost analysis wield a frail weapon against rent-seeking pressures by local interests and irrigation bureaucracies. Projections of investment returns on major projects are inherently speculative: construction takes many years, and farmers' adaptations to use water supplies effectively takes many more. Optimistic assumptions about key parameters—the pace of construction, the cropping patterns farmers will adopt, the acreage that will be irrigated, the efficiency of water use, and the level of farm commodity prices—can make almost any project viable on paper. And it is a long time before those assumptions can be tested against actual experience.

In fact, major public irrigation investments cost more and take longer to complete than planned. When

completed, irrigated acreage, yields, and farm income usually grow more slowly than assumed.[85] Public sector SCARP tubewells in Pakistan provide a good example since they are quicker to implement than major surface systems and can be more readily evaluated. In current prices, all the tubewells installed represent a total investment of $650 million. Projected returns have not been achieved. Water deliveries and use of pumping capacity have been less than projected, and they have been declining over time. Cropping intensities average 115 percent rather than the projected 150 percent. Cropping patterns and yields have not changed to the extent anticipated. And water tables, after falling initially, have risen again in most SCARP project areas.[86] In the light of actual performance, initial projections appear to have been overly optimistic.

The attitudes of experienced administrators toward benefit:cost analyses of public irrigation investments range from skeptical to contemptuous. One evaluation from a man who held many senior irrigation posts in India for eleven years found that "Project reports are prepared by adopting an irrigation and cropping pattern which can bring about a favorable benefit:cost ratio, to make the project acceptable for the initial sanction. The final expenditure on the project, the area actually irrigated, and the cropping pattern adopted by the farmers have generally no relationship with the original projections."[87]

The main problem is not in the methodology of benefit:cost analysis, although non-market environmental costs have typically been slighted. The main problem is that, unlike in private investment decisions, neither financial responsibility nor the need to repay capital invested in the project imposes a check against inaccuracy and bias in the projected returns. Further, benefit:cost analyses are generally premised on efficient use of water and project facilities. But, since there are few incentives to induce this behavior, actual use is typically inefficient and analytical results are excessively optimistic.

Failure to finance public irrigation services from charges on the users creates yet another planning problem. Planning agencies are deprived of information about the services farmers are actually willing to pay for, and so, of information about the benefits they actually receive. This makes it more difficult to design projects to maximize net benefits or to judge the feasibility of proposed investments.

Bias in investment decisions springs from rent-seeking. Those who have them want more; those who do not want their share. Notions of equity are advanced to give priority to new projects to benefit additional areas over activities to realize maximum returns in areas already served with irrigation facilities. Political log-rolling creates coalitions to approve entire squadrons of new projects as they are paraded past the reviewing stand. When cost overruns begin and funds get tight, there are too many projects under way and too few resources to complete them or maintain them when finished. In the words of a senior Indian planner, "There is also the tendency for political power centres to view and demonstrate their performance in terms of the number of projects they are instrumental in getting approved and started, irrespective of whether the projects are sound and irrespective of the number which can be effectively implemented within the overall resource constraint."[88] Implementation schedules are then delayed, costs mount, and benefits are deferred.[89]

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In summary, the pursuit of rents in public irrigation systems leads to the three widely observed problems in investment planning and decision-making:

1. Investment programs are pushed beyond their economic limits and the economic analysis of investment proposals is undermined by optimistically biased predictions of anticipated costs and benefits. At levels of performance currently being realized, few new major public irrigation projects can be economically justified in any of the countries for which data are available.
2. Investment priorities are biased toward large new projects at the expense of improving existing systems, developing dispersed small-scale community-controlled irrigation facilities, and improving rainfed farming methods.[90]
3. The number of projects sanctioned and under way far exceeds the public funds available for implementing them. Available funds are doled out among projects, which prolongs construction periods, inflates construction costs, and delays the realization of benefits.[91]

B. How Rent-Seeking Affects the Design of Public Irrigation Systems

Similar pressures affect the design of irrigation systems. Trade-offs are inevitable between extension and intensity in designing irrigation systems within budgetary constraints—between design features that improve the controllability, reliability, and adequacy of water supplies, and features that extend lower-quality service to a larger area. In general, these trade-offs mean choosing between higher (capital and operating) costs per acre served, and irrigating a larger area. Rent-seeking biases these choices toward extending the area commanded too far beyond that which can be adequately served.

The best economic balance reflects both internal and external margins: for any area served, "quality" can be increased until the additional costs outweigh the expected additional agricultural benefits; and for any standard of "quality," the area to be irrigated can be expanded until the marginal costs exceed the marginal benefits. Ultimately, storage or diversion capacity or the reliable water supply available sets an economic limit to the size of a project.

It is often argued that the optimum use of water is to spread it thinly over a large area. However, when farmers themselves invest in private irrigation facilities, they choose much more reliability and availability than most public irrigation systems provide. Throughout the Indo-Gangetic plain, for example, farmers invest in their own tubewells even in canal command areas. They willingly pay much more per acre-foot for tubewell water than they do for canal water so they can have enough water when they need it. Nonetheless, the returns on investments in private tubewells are much higher than those on public surface irrigation systems, or even on public tubewells—which, despite similar technology and theoretical economies of scale, provide less reliable and adequate service.[92]

In some semi-arid areas, such as Northwest India, public irrigation systems provide minimal service in part because they were intended to protect against drought.[93] But, when public investments are highly subsidized, there is also a strong equity motive for distributing water as widely as possible instead of concentrating a large subsidy on a small area and a few recipients. Political support is also broadened by extending the command area and promising at least some rents to a larger number of beneficiaries.

The bias toward extensive, low-quality service in public systems is reinforced by the low valuation of water implied by its low price relative to capital and operating costs. Despite the evidence of private irrigation systems, designers hesitate to make the expenditures needed to reduce water losses and to permit more precise application of water with less wastage, because its low valuation makes those expenditures seem extravagant. According to the president of the International Commission on Irrigation and Drainage, "Modern [irrigation] technologies are unlikely to penetrate the developing world until a more reasonable tariff structure is adopted for water."[94]

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If it seems implausible that irrigation designers might undervalue water in agriculture simply because its price is low, evidence lies in the operation of multipurpose schemes when releases for power generation conflict with the need to store water for irrigation, or vice versa. In North India, although it was clear that agricultural losses from water shortages in critical periods far outweighed the losses from higher-cost electricity generation (or even outages), more revenues were provided by power sales than by water charges. Releases from the large Bhakra dam for years were dominated by power demands. According to one report, "Perhaps the most important factor in deciding the scheduling of releases [from Bhakra] are the financial returns from power relative to those from irrigation. . . . The engineers operating the system are under great pressure to make it appear as financially successful as possible. In this situation, irrigation understandably may receive secondary consideration."[95]

The costs of bias toward the extensive margin have been enormous. Failure to line canals has led to excessive seepage loss, which—especially in areas where groundwater has become saline—reduces irrigation supplies. Combined with failure to provide adequate drainage where needed, it also has led to widespread waterlogging.[96] Failure to invest in adequate control structures has greatly reduced the benefits from public irrigation systems. For this reason, recent projects to upgrade existing systems demonstrate opportunities for significant output gains and favorable rates of return.

If investments had to be financed out of realized benefits, there would be no incentive to expand the command area unduly or to exaggerate the area potentially irrigable. Revenues that could be collected from farmers in marginally irrigable areas would not cover service costs, and overly optimistic planning assumptions would just plunge irrigation agencies into financial losses. Pressures to overextend the command area at the expense of high-quality service arise because farmers do not pay supply costs and enjoy substantial rents even from suboptimal levels of service. Incentives for irrigation agencies to go along arise because these agencies don't bear the losses from faulty investment decisions and invalid planning assumptions.

Further distortions follow from these initial biases in project design. Farmers in head reaches of command areas typically consume more water than planned irrigation efficiencies allow—often establishing these water-use patterns even before tailreach facilities are completed. The rents available stimulate head-reach farmers to appropriate as much water as possible by planting large areas to crops with high water requirements, such as rice and sugarcane. (These entitlements to generous irrigation supplies are then often firmly nailed in place by investments in sugar- and rice-processing mills.)

Supplies available to tail-reach farmers are often too scanty and unreliable to induce them to make the expected investments in field channels and land preparation that would enable them to use public irrigation supplies. Therefore farmers often fail to construct and maintain tertiary and farm-level distribution networks. This dissonance between the assumptions underlying the design of irrigation systems and the actual incentives farmers face contributes to the frequent discrepancies between planned and actual acreage served.[97]

Moreover, the system generates its own momentum. Because water is chronically short in the tail reaches and is less than promised to those constituencies, demands for further investments to increase water supplies remains high. As the International Irrigation Management Institute puts it, "Water shortage in an existing irrigation project may result in pressures to develop new sources of water. These pressures are likely to be greater if the water users do not expect to pay for the cost of the investment, and could lead government agencies to make uneconomic decisions."[98]

Other distortions in project design that follow from the search for rents are more straightforward. Because the advantages of location at the head of distributories are so substantial, large and powerful landowners influence irrigation authorities and water user associations to locate outlets near their fields, whether doing so is hydraulically efficient or not.[99] In the Philippines, a study found 40 percent of outlets in the Upper Pampanga River system inappropriately located, forcing many farmers in areas missed by the distribution network to cut directly into the canals if they wanted to get any water.[100] As with other distortions, this would be much less likely to happen if access to public irrigation were limited mainly by its cost rather than its physical availability.

C. How Rent-Seeking Affects the Operating Efficiency of Irrigation Systems

Severe operating and maintenance problems, which greatly reduce performance and benefits, have been diagnosed in public irrigation systems in many countries.[101] Many systems are operated so that the availability of water to farmers has little to do with the seasonal patterns of their irrigation needs. Even in systems that aren't designed to deliver water on demand or on schedules tuned to crop needs, water deliveries are irregular and unpredictable, so farmers can't even plan their field operations to match the irrigation supplies they are likely to get. It's not just fluctuations in river flows that make irrigation supplies uncertain. Even in the long-established *warabandi* rotation schedule used in canal systems in North India and Pakistan, which were instituted to ensure farmers a regular, periodic source of supply,[102] most farmers are in the dark about when water can be expected. Distributories and watercourses operate with different rotation periods, and distributories don't always receive their full supplies in low-flow periods, so farmers can't predict their turns in advance over the season. Moreover, according to one detailed study, although the information was supposed to be public knowledge, "No farmer questioned about it had seen a channel rotation schedule in several years."[103] The risk that there could be a stretch of water dearth long enough to destroy or severely damage the crops makes farmers very reluctant to spend heavily on inputs that could raise yields.

Again, irrigation availability is almost always highly uneven throughout the command area, despite official policy that water should be allocated equitably. Careful studies of irrigation systems in Sri Lanka,[104] the Philippines,[105] and Thailand[106] document this maldistribution and its adverse effects on overall productivity. While some differential water use between head and tail is economically rational because conveyance losses and costs make deliveries of water to tail regions relatively expensive, studies show that usually water reallocations toward tail farms would raise total agricultural production.[107]

Within the overall water misallocation that comes from the superior access of head regions, operating rules are frequently bent to accommodate the more powerful users, with destructive effects not only on efficiency but also on discipline, trust, and credibility throughout the public system. Robert Wade's studies in South India found "the rule of law constantly abrogated by the power of money."[108] But a study of North India provides the fullest statement of the process and its consequences:

> *"Throughout the Sarda system it is the general rule that the strong, the powerful, the well-connected, the local bullies dominate the use of irrigation water. They get water first and tend to take as much of it as they please. Only after they are satisfied do they permit the mass of ordinary, unimportant, petty cultivators to have access to it. . . . In practice, therefore, there are two kinds of water service on the Sarda canal: a superior service to the few—the strong—and an inferior service to the many—the weak . . . The big people can take the risk of developing a style of cultivation in which they are quite dependent on canal water. They get the canal water first, and they can be quite sure they will get it every crop season. The mass of ordinary cultivators have no such assurance. . . . In fact, they have to conduct their affairs as though the supply of canal water was problematical, an intermittent blessing to be welcomed when it comes, but not to be counted on."*[109]

These quotations should not create the impression that irregularities are an Indian phenomenon. They are widespread. They are reported in almost all countries in

which public irrigation systems are important.[110] A comparative study of irrigation management concluded that "Wherever water supplies are scarce and uncertain, the large farmers within a watercourse are much more likely to abuse their position by taking what they can at the expense of their poorer and weaker neighbors . . ."[111]

Maintenance problems are also widespread in public irrigation systems around the world. Maintenance on the main system is slighted, both because too few funds are collected or allocated for the work and because available funds are misused.[112] Farmers also fail to keep up their watercourses, so that even more water is lost before it reaches the field. Sluices, gates, and outlets that control the flow of water also soon fall into disrepair, are broken, altered, or bypassed. In Pakistan, for example, a study by the Water and Power Development Authority found that two thirds of the outlets to field channels were drawing more than their authorized full supply. Only 10 percent of the outlets in head regions were drawing less, compared to 30 percent at the tail.[113]

These operating problems are to a substantial extent attributable to the search for rents. In public irrigation systems, where users will take whatever water they can get, operators do not see themselves as selling a service, but rather as allocating a scarce resource. This is in contrast to markets that limit resource use by price, in which suppliers would often willingly sell more, if they could, and try to woo additional customers in many ways. In public irrigation systems, because demand is rarely short, operation is typically regarded as a problem of maintaining supply.

Given this supply orientation, system operators naturally pay too little attention to the conditions and determinants of agricultural demands that they typically cannot fulfill. This in part explains their failure in many countries to monitor and evaluate system performance closely from the standpoint of agricultural effectiveness.[114] Consequently, managers of public irrigation systems are too little informed and influenced by input and feedback from farmers and agricultural specialists.

Unresponsiveness to user satisfaction is aggravated by the policy in many countries that water charges collected from farmers are not retained by the irrigation agency and used for operation and maintenance, but are absorbed in the general treasury. In most states in India, for example, the Revenue Department assesses and collects irrigation fees. Operation and maintenance expenses (including salaries) are funded from public expenditure budgets. Operators and managers are not financially accountable to the users, and the test of finding out whether farmers are willing to pay for the service provided is never performed.

In community irrigation systems and some national systems in which irrigation authorities get their money for operation and maintenance from farmers (including the Philippines, Korea, and China) comparative studies find that the staffs of the irrigation agencies are more responsive to farmer needs and more eager to solicit farmer participation.[115] Conversely, when farmers have more control over the operation of systems, they are more willing to contribute to its upkeep. For these reasons, Sri Lanka has initiated a new policy of dedicating revenues collected from farmers to the operation and maintenance of public irrigation systems, phasing out the government's budgetary contribution over a period of years.

Even within a single country, significant differences in operation can be observed between government-controlled and communal irrigation systems. Typically, the latter are run by operators employed and paid by the community and maintained by contributions from water users. In the operation of many communal irrigation systems, concern for the regular and equitable distribution of water has been longstanding, even in such countries as Indonesia and Nepal, where the operation and maintenance of government systems have been inadequate.[116] Moreover, in those countries, irrigators who would not think of paying for the operation and maintenance of government systems willingly contribute to the upkeep of communal systems, over which they exercise collective control.

System operators who have some power over the allocation of scarce irrigation water are also favorably situated to extract from farmers a part of the rents cheap water conveys, through extortion and corruption. It is not surprising, given the pressures they face, that they do so.[117] This abuse is widely recognized by irrigation authorities, though usually only alluded to obliquely in published documents and edited out of project reports.[118]

In addition to the inequities this produces, it undermines the functioning of irrigation systems. First of all, it destroys farmers' trust in the impartial functioning of the system, without which they are naturally reluctant to abide by its rules or contribute to its upkeep. Farmers' willingness and ability to cooperate in group irrigation systems is a scarce and valuable resource that is dissipated by perceived unfairness and partiality.

Second, though sometimes informal payments to operating staff reflect additional operating costs (for example, to bring water far down the canal in dry periods), rent-seeking by operating staff distorts water allocations and exacerbates uncertainties about the availability of water. Operators have reportedly opposed and circumvented efforts to publicize the operating rules and schedules of the system because publicity makes irregularities easier to detect and limits their discretion to reallocate water in exchange for favors. In extreme cases, operators deliberately create uncertainty about water availability, either by spreading rumors about likely shortages or by simulating breakdowns in the distribution system to raise farmers' anxieties and facilitate extortion.[119]

Farmers in public irrigation systems face what is known as an assurance paradox, similar to a "prisoner's dilemma." Collectively, they would be better off if all abided by the system's operating rules and contributed to its maintenance. But, any single farmer would be better off if he shirked his obligations and took more than his share of water. On the other hand, he would be much worse off if he abided by the rules and nobody else did. The frequent result is that rules and cooperative behavior break down unless strong community traditions and sanctions protect against antisocial behavior. Without assurance that operators will impartially enforce the rules and run the system, conditions soon deteriorate into the "populist anarchy" that now exists in many public irrigation systems. Without trust and mutual restraint, water-user associations, whose key role is increasingly recognized, are impossible to create and sustain.[120]

Unlike in the true "prisoner's dilemma," important asymmetries set head and tail reaches apart in public irrigation systems. Farmers in the head reaches can much more easily take more than their share of water, with little to fear from those downstream. For this reason, they benefit less from cooperating in a water-user association, and they have only the system operators to deal with. The consequences are well illuminated by the findings of a study in Sri Lanka: "Farmers with the least water problems preferred having a government officer handle water management and were least disposed to suggest giving responsibility to a *vel vidane* (a traditional community-appointed water manager); farmers with the most serious water problems were quite negatively disposed toward government officers and strongly favored having *vel vidane*."[121]

In these ways, efforts by users and operators to corner the rents afforded by public irrigation sabotage system operations. In many public irrigation systems, a downward spiral of performance results. Unresponsive and unreliable service for most farmers reduces their willingness to cooperate, pay irrigation fees, or contribute to system upkeep. Their lack of participation and support, in turn, depresses performance and maintenance.[122] Irregularity, uncertainty, favoritism, exploitation, and corruption are promoted. Efficiency and equity suffer. "Better management" is hardly a sufficient answer if it skirts the underlying problems. While efforts to strengthen institutions through better monitoring, organization, and training are necessary and important, they can have only limited impact unless the destructive pressures of rent-seeking are removed.

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Although rent-seeking behavior seriously affects the operation and maintenance of public irrigation supply, until relatively recently most discussions of irrigation efficiency—especially in the context of irrigation financing—focussed on water use on the farm. There, too, enormous scope for improvements has been observed in most countries. Widespread evidence shows that throughout much of the world, on-farm water use efficiencies, both technical and economic, are low in public irrigation systems. Low-value field and fodder crops are irrigated. Water conservation technologies and practices are widely ignored. Conveyance and applications losses in watercourses and fields are high. Within canal command areas, head farmers plant crops with high water demands and use more water per acre than necessary, while on tail farms production and yields are curtailed by water risk and actual water stress.[123]

Whether higher water charges would prompt farmers to use water more efficiently has been long debated. Many economists (and others) insist that higher charges are necessary if on-farm efficiency is to improve significantly. For example, M.E. Jensen, National Program Leader on Water Management and Salinity, Agricultural Research Service, U.S. Department of Agriculture, states, "The efficiency with which water is used is linked to its cost to the user or the value placed on water. Water, as a primary resource needed for food production, should not be provided at little or no cost to agricultural users. Free or low cost water leads to waste, and additional or indirect costs like those resulting from waterlogging and salinity."[124]

Analytical studies, based on programming models of irrigated farms and canal command systems, imply that water allocation based on volumetric pricing or an approximation leads to substantially higher net farm incomes and higher water use efficiency than other allocational systems as water becomes increasingly more scarce.[125] These analytical results are supported by some actual evidence that irrigation water is used with greater economic efficiency when its user cost is higher.[126] The extent of this evidence is limited since in few public irrigation systems have charges been raised to a level near the marginal value of water. However, the evidence from experience in Californian irrigation districts has already been cited. In Mexico, also, in those irrigation districts in which irrigation charges vary with the amount of water consumed, water use efficiencies are significantly higher than in those districts in which flat rate charges are fixed—so that farmers pay nothing for extra water.[127] In parts of China that have already converted to higher, volumetric,

irrigation charges, even skeptical observers concede that farmers have begun to use water more economically and the increased revenues have allowed better system maintenance.[128] Consequently, there is ample reason to expect that on-farm water use efficiency, as well as the operation and maintenance of systems above the farm outlet, will be substantially improved if financial incentives reflect the true scarcity value of water and rent-seeking is reduced.

VI. Impetus and Impediments to Reform

Efficiency and environmental considerations all show the need for fundamental changes in the way public irrigation systems are financed, but there are formidable obstacles to these changes. The toughest is the strongly defended interest of those farmers who now command billions of dollars in annual rents from irrigation services provided by governments at a fraction of their value. These interests are stoutly protected in political arenas. Local, state, and provincial governments in agricultural regions, key legislative committees, and political parties all respond to irrigation constituencies.

Agencies that build and operate public irrigation systems also support the *status quo* and resist cuts in their authority, budgets, and activities. They respond more readily to arguments for additional projects to expand supply than to the need to restrain water demands and raise the efficiency of existing projects. Generally, they resist increases in irrigation user charges that would reduce rents because those rents ensure continuing strong demand for more irrigation projects and give irrigation agencies influence over their farming clients.[129]

Paralleling these interests, ingrained attitudes and assumptions also resist change. Farmers and others who have long enjoyed cheap water feel entitled to it. Some, who have bought irrigated farmland at prices incorporating the capitalized value of irrigation subsidies, feel they have bought and paid for a supply of cheap water. Some societies invoke basic principles that water is a God-given gift, though the distinction between charging for the use of water and for the cost of irrigation systems is blurred. Even in communities where resistance is less deep-rooted, people feel that "water is different" and cannot or should not be bought and sold like other resources.

To make matters worse, farmers in many countries now deeply distrust public irrigation systems and operators—usually for good reasons. Farmers have experienced unreliability, irregularity, and corruption. Despite their demonstrated willingness to pay for good irrigation services, they can be counted on to resist paying much more for public irrigation services unless they are convinced that they will get their money's worth. In the Philippines, for example, the collection rate of assessed water charges is more than twice as high, 77 compared to 38 percent, in public irrigation systems that have been newly rehabilitated and improved.[130]

Skeptics contend that higher water charges, even if adopted over severe political opposition, would be ineffective. They argue that unless fees can be calibrated to on-farm water use through volumetric water charges, incentives to use water more efficiently would be weak. However, the costs of metering water use in technologically primitive systems serving thousands of tiny farms with fragmented holdings are said to be prohibitive. Moreover, the argument goes, even were water metered, higher charges would convey no additional incentives to farmers to conserve water unless on-farm deliveries were responsive to farmers' demands. As it is, irrigation deliveries are not responsive to farm demand in most public systems in Third World countries; rather, farmers decide how best to use an arbitrary allotment of water—and are already motivated to use it efficiently, whatever its price, when its availability is limited.[131]

There are other objections: even if supplies were flexible, charges are now so low that they would have to rise many times over before rents were eliminated and the limits of farmers' willingness to pay approached. Such increases are said to be politically impossible, while the changes that are possible would have little effect because as long as rents are large, use continues to be rationed by availability rather than cost. Finally, it is argued, full cost recovery from farmers would be inappropriate because most of them are poor or near the poverty line and because there are indirect beneficiaries from public irrigation projects—urban food consumers, rural farm laborers, traders and processors of agricultural products—who should bear some of the costs so that water use won't be excessively discouraged.

A final objection is that, in many existing systems, performance and benefits to farmers are so low that attempts to recover anything like full supply costs would seriously reduce the use of available irrigation

resources. Most farmers would regard such collections as additional impositions unrelated to improvements in irrigation availability or performance.

These objections, while serious and substantial, are too pessimistic about the potential gains that are possible if incentives are corrected through irrigation charges and related measures. Those who raise them ignore the important improvements in irrigation performance that would result if rents and occasions for rent-seeking were reduced: better investment decisions, improved system design, more satisfactory operation and maintenance. Moreover, most of the objections are overstated.

In inefficient systems in which benefits to farmers could not cover total costs even if plausible improvements in performance were realized, it would still be desirable to make beneficiaries responsible for the *incremental* costs of rehabilitation and modernization undertaken to improve service and water availability. This would impose an effective economic test on those investments, ensure that the incremental costs of

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supply were reflected in farmers' incentives, and reduce the scope for further rent-seeking. Even if no such investments were contemplated, setting charges in existing systems to reflect marginal irrigation benefits would be a large improvement over current practice.

The feasibility of such changes has been underestimated. Volumetric metering of water may be much more economic in many systems than supposed. In Egypt, for example, where canals are below field grade and water is lifted into field channels, the costs of metering have been estimated to be $1-$7 per acre, a small fraction of the $200-$300 full cost of supplying irrigation water. It would not take a great savings in water to justify the additional cost of metering, and modelling studies based on Egypt's irrigation system suggest that as water scarcity increases, allocation by volumetric pricing becomes increasingly more advantageous.[132] Few serious economic studies of metering developing-country irrigation systems have been conducted, though the principles and methodology are well-established from studies of metering urban water consumption and electricity use.[133] It is merely asserted that metering is uneconomic, despite the fact that some developing countries, including Morocco, Tunisia, Mexico, and China, do charge for water volumetrically with good results.

The fundamental question here is whether irrigation water is a salable commodity, or whether the costs of segregating and measuring one party's individual use are so high that water must be treated as a public good.

The evidence from private irrigation systems is overwhelming that individual use can be measured and segregated accurately enough to allow charges to be levied and enforced, and markets in irrigation water to function.

When posed in this way, the answer is obvious. The evidence from private irrigation systems is overwhelming that individual use can be measured and segregated accurately enough to allow charges to be levied, property rights in irrigation water to be defined and enforced, and markets in irrigation water to function. In Spain, markets in irrigation water have functioned more or less continuously for the last 700 years.[134] Similar markets work in many other countries, both developed and developing. In communal irrigation systems in Nepal, marketable water "shares" are assigned in proportion to financial participation in construction and maintenance of the systems, just as ditch companies in California do.[135] Private tubewell water is widely sold by tubewell owners to neighboring farmers in India, Pakistan, and Bangladesh.

All this experience demonstrates that individual water use can be measured well enough, at low enough cost, to support property rights, transactions, and charges. When water is distributed by rotation, as it is

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in many countries all over the world, the number of irrigation "turns" or the amount of time farmers receive water is the basis for distribution and charges. This is a simple approximation to volumetric pricing, if there is some consistency among parcels in flow rates, a condition that irrigation design improvements can promote.[136]

In Pakistan, in project areas where the distribution system has been rehabilitated and management

strengthened, the government is basing charges on the number of turns a farmer receives in a rotation or the total irrigation time. Similar mechanisms are in place in the Indian state of Gujarat, and in some Irrigation Districts in Mexico.

Allocation systems that assign farmers rights to *shares* in a variable irrigation supply, as is done in Peru also,[137] promote efficient water use because when the supply is unusually low, the cost per unit volume of water is high. Moreover, evidence indicates that when water is scarce or its price high, the price elasticity of demand is near unity.[138] Since when price elasticity is unity, revenue remains constant whatever the quantity sold, this suggests that the value of a unit share in an irrigation system would be nearly invariant as supply fluctuated. Farmers can rationally buy irrigation shares even when supply is uncertain. Therefore, *volumetric water charges can be levied in developing countries, but strict volumetric pricing is not necessary to create effective incentives for efficient water use.*

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Though it is true that pricing can do little to improve the efficiency of on-farm use if supply is completely arbitrary and inflexible, at least favored farmers can increase their supplies to fulfill the demands that low water charges stimulate. Unauthorized diversions, bribery of operators, and alterations of outlets are common ways of getting more water. Favored and favorably located farmers get ample water in many systems and use it wastefully. Higher charges would encourage such farmers to conserve water.

Moreover, trading irrigation turns among farmers along a watercourse, or even across watercourses if there are effective water-user associations, can induce farmers to value water at its marginal opportunity cost.

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Water transactions are common in private and communal irrigation systems, but are usually discouraged within public irrigation system command areas. In rotational systems, farmers trade irrigation turns informally, though it is officially discouraged. Such trading is an appropriate way to reduce inefficiencies in water distribution by reallocating supplies to farmers to whom it is worth most. If combined with measures to absorb rents, such as land taxes, betterment levies, or area-based water charges, irrigation trading can effectively substitute for volumetric water charges. Trading provides appropriate incentives for water conservation at the margin, while cost-recovery measures place financial responsibilities on beneficiaries and so reduce rent-seeking impulses.

That irrigation projects have indirect beneficiaries does not alter the case for pricing water at its full cost to users. A distinction must be made between the secondary benefits of irrigation and those of irrigation subsidies. The former stem from the additional production that irrigation permits, which may give rise to new jobs and incomes in related sectors. However, as pointed out earlier, irrigation subsidies *per se* result in no additional output or employment. They just transfer resources from taxpayers to favored farmers, and are mostly capitalized back into the value of irrigated farmland.[139] Since subsidies create rents, and rent-seeking reduces the efficiency of public irrigation systems substantially, they reduce output and employment, with *negative* secondary effects.

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In any case, except for such physical externalities as the recharge of aquifers (a positive side-effect unless waterlogging results) or the salinization of downstream river flows (a negative side-effect), the secondary benefits of irrigation are no different from those associated with any other productive input. While adjusting water charges is one possible way to deal with the environmental side-effects of irrigation, there is no special case for pricing water as an agricultural input on different principles than for other agricultural inputs.

In particular, equity considerations are a shaky basis for special treatment. Although irrigation subsidies in many Third World countries represent transfers to agricultural sectors that are penalized by taxes, tariffs, and exchange rates, *within* the rural sector these subsidies mostly benefit the relatively well-off.[140] First of all, they generally benefit landowners because they are capitalized backward into land values or accrue to the landowner. And, in most countries, the distribution of irrigated land is quite unequal. Most of the subsidies benefit a small fraction of farmers who own most of the

land, as in the United States. In older systems, landowners in the head reaches have prospered from years of favorable access to irrigation water, and, as shown earlier, the larger farmers have also been able to influence the allocation system to obtain superior access to water. It is indicative of their ability to capture rents that in several countries delinquencies in paying irrigation charges are more frequent among larger, richer, more powerful farmers than among small and poorer farmers.[141]

Since such better-off farmers also devote more of their acreage to cash crops and—partly because of assured water supplies—use more purchased inputs per acre, they also benefit disproportionately from the heavy subsidies many Third World governments provide to users of chemical fertilizers and pesticides, tractors, and agricultural credit. Even water charges in many countries discriminate in favor of the cash crops grown disproportionately on large farms.[142] For all these reasons, the distribution of subsidies within irrigated regions favors the larger farmers.

As a group, farmers with irrigation are substantially better off than others in the rural sector—landless households, for example, who make up a sizable fraction of the rural population. Most irrigation projects have been built to bring water to relatively fertile plains and valleys, which were more productive anyway. In such cases, irrigation has just widened the advantage over dryland farming areas, and neither irrigation charges nor land taxes have come close to equalizing the net income farmers can get from irrigated and dry lands.[143] In Mexico, for example, net income per acre is three times higher on the 10 percent of farmland that is irrigated.[144]

For all these reasons irrigation subsidies confer additional advantages on those within the rural sector most able to pay for services. In India, the aggregate value of irrigation subsidies and subsidies to fertilizer used on irrigated land is of the same order of magnitude as *total* farm income on unirrigated land.[145] In Indonesia, the situation is similar: the annual subsidy to irrigation is about as large as the overall difference in net farm income per acre between irrigated and unirrigated paddy fields.[146]

When water is scarce, full cost pricing results both in the highest total farm income and the most even distribution.

So, there is no conflict in this issue between efficiency and equity. Irrigated farms as a group are relatively well-off. And within irrigation systems, numerous studies show that when water is scarce, full cost pricing results both in the highest total farm income and the most even distribution.[147] In other words, tail-end and small farmers generally do better if all farmers compete on an equal footing—paying the full delivered cost of water supplies—than under other distribution rules.

Despite all the defenses, the forces for change are strong and are already creating new patterns of financial responsibility. The worldwide fiscal crisis is forcing governments, in the North and the South, to make painful cuts in public investment and operating budgets and to re-examine subsidies to the relatively well-off. Governments in many countries have acted forcefully to shift irrigation costs onto beneficiaries. In Peru, Mexico, Sri Lanka, Pakistan, the Philippines, and elsewhere, governments have changed policies to ensure that users will assume financial responsibility for the operation and maintenance of irrigation works. China has recently raised irrigation charges and affirmed that central government funds will be restricted for new project construction and devoted to improvements in irrigation performance. Moreover, some countries have begun to emphasize the role of local communities and the private sector, where feasible, in irrigation management and development Between 1980 and 1983, Bangladesh transferred 43 percent of deep tubewells and 56 percent of low-lift pumps to private ownership and operation.[148] The Government of Pakistan has recently decided to rely on private investment in tubewells to maintain water table depth in areas where aquifers are not too saline for irrigation use; it is also transferring public sector SCARP tubewells, which have performed badly, to cooperatives and farmer associations.

Governments and international financing agencies are less willing to commit to large new project starts and have shifted investment priorities sharply toward improving existing systems. The rising real costs, the environmental impacts, and the performance problems are impossible to ignore. Moreover, declines in oil prices and farm prices have independently reduced the economic viability of large multi-purpose projects. From 1981 through 1983, when oil prices were high, well over half the benefits in such projects could be predicted to flow from power generation, and this alone could justify the costs of large dams, such as those planned in the Amazon basin. This is no longer the case. Farm output prices are also much lower than in the 1970s and can no longer be projected at the high levels used to justify many relatively costly projects.

Pressures on governments and lending agencies are strong, and they signal the end of the era in which central governments will pay the bill for more and more irrigation supplies to be used with little regard for efficiency and environmental consequences.

VII. Strategies and Recommendations for Change

The coalition of farmers, their political representatives, and government irrigation supply agencies is so strong that it has been called "the iron triangle." Since these successful rent-seekers resist change in the arrangements that have served them well, strategies for change must either circumvent this coalition by emphasizing private sector irrigation development where it is feasible or break it by imposing greater financial responsibilities, from the top down, on irrigation interests. Rents can only be squeezed out of public irrigation systems step by step—by imposing a repayment obligation for new irrigation and rehabilitation investments on each level of financial authority from national governments to international financing agencies, from provincial governments and irrigation agencies to the national treasury, from water-user associations to irrigation agencies, and finally from individual farm beneficiaries to their water-user associations. If an agency must repay funds transferred to it from a higher level of authority and pay for services it has received, then—like it or not—it must exert pressure on agencies below to do the same.

If an agency must repay funds transferred to it from a higher level of authority and pay for services it has received, then—like it or not—it must exert pressure on agencies below to do the same.

In the United States, for example, budgetary authorizations for new water projects have been made conditional on substantial initial cost-sharing contributions from state governments where projects are to be located. This has the effect of forcing local interests to ask themselves whether the likely benefits are worth the expenditures (their own) and where the money to pay for the projects will come from (if not from the beneficiaries). In general, imposing a reimbursement requirement on an agency at one level enlists its interest in ensuring that the proposed expenditure has high priority and will be a worthy use of its financial resources. When those resources are limited, this policy also pushes agencies to place the same reimbursement requirements on the agencies it serves.

This can be an effective strategy. When the national government of the Philippines made the National Irrigation Agency (NIA) responsible for repaying of foreign borrowings incurred for new irrigation projects, NIA began to scrutinize investment proposals for foreign financing more carefully. When the Philippine government eliminated budgetary grants to the NIA for operation and maintenance of existing systems, making it dependent on user fees, the irrigation agency became more interested in farmers' concerns and participation in management, and more interested in the formation of water-user associations that can help collect irrigation charges from farmers.[149]

What happened in the Philippines is not an isolated experience. China has successfully transferred financial responsibility for internationally financed irrigation investments to provincial authorities and followed the principle of local autonomy for operation and maintenance expenses. Recent changes in water policy in China have stressed the responsibility of local governments for the full costs of water resource development. In Korea and other countries where irrigation authorities depend on farmers for revenues through water charges and cannot finance their operating expenses from budgetary allocations, observers have found that irrigation agencies tend to be more responsive to their clientele.[150]

Irrigation authorities in some countries have used intermediate institutions to transfer financial responsibility downward to farmers. In Gujarat State in India, the irrigation agency sells water volumetrically in bulk to cooperatives, which distribute it and collect fees from their members. These arrangements leave the problem of water distribution and metering to local organizations, which are best able to monitor performance and they enlist local group pressure to maintain adherence to rules and discourage "free riders."

Multilateral and bilateral development assistance agencies have a critical role to play in forcing financial responsibility downward to the beneficiaries since they are at the end of the financing chain. At present, despite recurring calls for greater cost recovery from beneficiaries, they are not playing this role effectively. Their calls have met with limited success. Loan conditions and covenants related to cost recovery and water charges have been only weakly enforced and have frequently been violated. Multilateral development banks, such as the World Bank in Indonesia, continued to make new irrigation loans despite the borrowing government's failure to make good on cost-recovery commitments made as conditions to previous irrigation loans.[151]

If financing for irrigation investments is provided through grants, or if financing is through loans, but repayment obligations are against general government revenues rather than the receipts of the irrigation agency, the chain of financial responsibility is broken right from the beginning, making it more dificult for recipient governments to press for reimbursement from beneficiaries.

Part of the problem may be that aid agencies have tried to jump right from one end of the chain of financial responsibility to the other (that is, farmers' payment of water charges) without paying attention to intermediate links in the chain. They have not stressed the financial responsibility and autonomy of irrigation agencies as quasi-utilities, which they almost invariably have done with public sector entities in other sectors. They have thus failed to enlist the interest of agencies in the middle of the chain in recovering costs from farmers.

Aid agencies' policies on financing irrigation development contrast with those toward other public sector industries, another reflection of the "water is different" syndrome. USAID policy, for example, has as its goal only that recipient countries recover operating and maintenance expenses from farmers—a minor fraction of total irrigation costs. This policy implicitly accepts substantial rents and rent-seeking. The World Bank calls for recovery of operating and maintenance expenses, plus a reasonable share of capital costs assignable to irrigation. However, World Bank policy objectives in irrigation differ substantially from those applied to other sectors, such as energy, telecommunications, and even urban water supply. There, World Bank policies put considerable emphasis on creating autonomous, financially viable entities capable of making rational investment decisions and mobilizing the funds needed to service debt and contribute to future investments, in addition to meeting operating and maintenance costs. The Bank lends directly to operating entities in these sectors, which assume debt service responsibilities. They are expected to levy tariffs and charges related to the costs of providing services so as to discourage excess consumption and waste. Why these objectives and policies are not equally applicable to public sector irrigation lending is not clear.

World Bank policy objectives in irrigation differ substantially from those applied to other sectors, such as energy, telecommunications, and even urban water supply.

These strategic considerations for improving irrigation system performance by reducing the scope for rent-seeking behavior give rise to a number of specific recommendations:

RECOMMENDATIONS

A. Steps to Increase Financial Responsibility in Irrigation Systems

1. International development agencies should adopt in irrigation lending the same general policies and policy objectives that apply to other public sector utility sectors, with the same emphasis on financial autonomy, viability, and full-cost pricing of services.

These agencies should lend directly to entities responsible for irrigation supply where possible and work with central governments in borrowing countries to pass financial responsibility for irrigation investments through to irrigation entities, state and provincial governments, and water users. Possible mechanisms include establishing domestic financial intermediaries financed by loans from the central government and international agencies, which would in turn lend to local irrigation project developers, both public and private. Another promising mechanism is to require local authorities to provide substantial initial financial contributions to proposed investments, perhaps financing their "up-front" contributions through borrowings on domestic capital markets.

2. National governments should work out methods to initiate bulk water sales through contracts with water-user associations and cooperatives, as irrigation agencies do in Mexico, India, China, and other countries. Bulk sales will probably involve both organizational efforts to strengthen water-user associations and structural modifications in existing irrigation systems. For example, creating intermediate storage at the head of distributories makes it easier to meet delivery commitments when water availability fluctuates, and installing meters in secondary channels facilitates volumetric sales in bulk.

B. Steps to Strengthen Incentive and Cost-Recovery Mechanisms

3. Both national governments and development agencies—including research institutes, foundations, and official aid agencies—need to work harder to develop and diffuse innovative techniques for levying user charges, collecting irrigation rents, and valuing water at its marginal opportunity cost. Successful experiences in some countries can serve as the basis for expanded efforts.

For example, promising and proven ways of raising and collecting user charges should be adapted and promoted. These mechanisms include changing existing policies or laws, where necessary rescinding uniform state-wide or nation-wide irrigation charges and basing charges instead on the costs of individual projects. Charges should be indexed to prices of principal irrigated crops so that fees will adjust automatically to inflation and fluctuations in agricultural conditions. Charges should be collected, where possible, in conjunction with other transactions between farmers and public or quasi-public agencies so as to reduce collection costs. Where rotational systems for distributing water are used, irrigation agencies should establish charges based on the number of "turns" or the total irrigation time, thus approximating volumetric charges.

4. Thorough studies should be made in individual countries of the economics of metering irrigation systems, including consideration of low-cost approximations and metering of intermediate delivery points. The benefits of these options should be evaluated in the context of complementary changes in water pricing and the operation of irrigation systems that would promote greater efficiency in water use.

5. Where equity and poverty alleviation are truly important in the design of innovative cost-recovery mechanisms, or where additional water supplies are to be made available, governments should consider "lifeline" irrigation charges, whereby cultivators receive a baseline supply (one or two waterings) at current low rates and are charged a much higher fee for additional deliveries.

6. Among innovative systems of cost recovery, hybrid systems should be explored that combine betterment levies, land taxes, and area-based irrigation charges to absorb rents and recover costs with provisions for *water trading*, which would encourage farmers to value irrigation water at its marginal opportunity cost. National and international support is warranted for improvements in land registration and valuation and in the administration of tax collection so that rural land values can be more successfully taxed.

Steps to broaden the scope for water trading and voluntary exchanges among farmers and water-user associations in public irrigation systems can promote more efficient water use. In those systems where head reaches can reduce water application significantly with negligible effects on yields, or where waterlogging and salinity are problems, water trades between head and tail reaches could offer significant gains and few, if any, losses to third parties. The feasibility of water markets in Third World countries is proven by their long and widespread existence in community irrigation systems. Laws and regulations discouraging water trading in public irrigation systems should be reevaluated and revoked unless clearly justified. Irrigation authorities should support water trading by recognizing and implementing private contractual agreements involving the exchange of water rights, where such rights exist.

C. Broadening the Focus of Policy Reforms in Irrigation

7. Structural adjustment loans from the multilateral development banks and other efforts to reform agricultural price policies should invariably include, as part of the package of policy reforms, changes in irrigation financing to absorb the rents in public irrigation systems and to reflect the incremental costs of irrigation supplies. These increases in farmers' costs should be considered together with policy changes to reduce implicit taxes on farm output.

8. Besides these steps to reduce rents and establish appropriate price policies in public sector irrigation systems, national governments and development agencies should strongly promote and support efforts to increase the private sector's role in irrigation development. Within the limits of its technical and financial capabilities, private irrigation development ensures that beneficiaries bear the costs of irrigation development, that suppliers of irrigation services are responsible to their clients, and that future investments will face the test of reimbursement from project benefits.

Governments in such countries as India, Pakistan, and Bangladesh that have invested extensively in tubewells, lowlift pumps, and other small-scale irrigation facilities should be supported and encouraged in initiatives to sell off these installations to farmers, cooperatives, and entrepreneurs.

High priority in future water resource development plans should be given to programs that support private sector irrigation development. One option is support for credit programs, on realistic terms, to finance new small-scale irrigation works and the rehabilitation of traditional irrigation systems by community organizations, cooperatives, and individual businessmen. Another option is public investment in

rural electrification, where economically feasible. Electricity rates for agricultural users can be used to regulate pumping, both to prevent depletion of aquifers and to encourage conjunctive use of groundwater and surfacewater supplies. Associated with this, programs to survey groundwater resources and monitor use, to create institutional and legal mechanisms to protect quality and regulate withdrawals, are essential.

9. Irrigation authorities should encourage water-user associations in public irrigation systems to take over local distribution networks, and purchase water in bulk for resale to association members. In Sri Lanka, for example, some main canal systems supply series of large tanks, from which water-user associations distribute water to community members.

D. Policy Reform in the Rehabilitation and Modernization of Existing Systems

10. The last five years have seen a rapid increase in programs and projects intended to improve the performance of existing public irrigation systems—through physical rehabilitation and modernization and through attention to management problems. Elimination of rent-seeking behavior through reform of irrigation financing is a necessary condition if these efforts are to succeed. At the same time, these programs provide a critical opportunity to introduce new financing arrangements. Farmers willingly pay for reliable and responsive irrigation services. In Pakistan, for example, farmers in the On-Farm Water Management Project have been willing to contribute cash and labor to rehabilitate and modernize their distribution systems.

New investments in existing systems provide opportunities to improve the controllability, adequacy, and reliability of services. Water losses can be greatly reduced. Structures can be designed to increase control over flows, to facilitate the approximate measurement of water flows, and to store water at intermediate delivery points. Inexpensive changes in scheduling water releases and rotations, and publicizing those schedules, can greatly reduce farmers' uncertainty about deliveries. The high prospective rates of return for these projects, and the fact that they will serve farmers who already enjoy the benefits and rents of public irrigation, justify a full reimbursement test on these investments.

These improvements should therefore be inseparably linked to farmers' acceptance of new financial responsibilities. Rehabilitation of existing systems, or sections of systems, should be started only after agreements have been reached with water-user associations to recover costs. Governments and international agencies should give priority in rehabilitation projects to proposals that local interests and water-user associations have put forward and for which they are willing to assume financial responsibility. Financing agencies should facilitate such projects, but not go ahead without a demonstrated local willingness to pay.

11. Designs of rehabilitation projects should take into consideration the goals of local control, measurability of discharges, and reliability of service, along with other objectives. Critically needed are detailed analyses of the feasibility of various metering options, of intermediate storage, and of other mechanisms to increase local control over deliveries.

12. Rehabilitation and modernization projects should include, wherever possible, provisions for contractual arrangements for water deliveries between irrigation agencies and water-user associations, whereby farmers will gain more reliable and adequate services in exchange for realistic payments related to the full cost of those services. In Huangxian County in the People's Republic of China, for example, an irrigation service company was formed to contract with farmers to provide assured volumes of water in exchange for higher fees.[152] Pilot projects should be sponsored in other key countries to explore variations on such contractual arrangements, including contractual distinctions between firm, guaranteed deliveries and contingent supplies (at different costs to users), compensation to farmers for failures by irrigation agencies to meet contractual delivery obligations, and adequate sanctions on farmers and water-user associations for failure to meet financial obligations.

VIII. Recapitulation

The political economy of public irrigation systems leads to poor use of water and invested capital. Pervasive rent-seeking, which stems from the divorce of benefits from financial responsibility, distorts investment decisions, the design and operation of irrigation systems, and patterns of water use. The consequences are inefficient, inequitable, fiscally disastrous, wasteful of increasingly scarce water, and environmentally harmful. While the rent-seeking phenomenon is legendary in public irrigation systems in the United States, it is being underemphasized in the rest of the world. Those concerned with irrigation development are trying to "work around it" to improve the performance of public irrigation systems by physical rehabilitation and efforts to strengthen management. These efforts, while also critical, are unlikely to succeed unless the incentive issues are squarely faced. Much can be done to correct incentives by placing financial responsibility on beneficiaries. Successful models exist, and now is an opportune time for change.

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Notes

1. Montague Yudelman, "Forty Years of Experience," (Nairobi, Kenya: ICIPE) forthcoming.

2. William Gasser, "A Survey of Irrigation in 8 Asian Nations," US Dept. of Agriculture, Economic Research Service, *Foreign Agriculture Economic Report, No. 165* (July 1981).

3. Yudelman, *op.cit.*

4. Peter Oram et al., "Investment and Input Requirements for Accelerated Food Production in Low Income Countries by 1990," *IFPRI Report No. 10* (Washington, D.C., 1979).

5. Ronald Cummings and Victor Brajer, "Water Subsidies in Mexico's Irrigated Agricultural Sector," report prepared for the World Resources Institute (November 1985).

6. Ian Carruthers, ed., *Aid for the Development of Irrigation* (Paris: OECD, 1983).

7. J. Thakur and P. Kumar, "A Comparative Study of Different Irrigation Systems in Western Uttar Pradesh, *Indian Journal of Agricultural Economics.*

8. Carruthers, op. cit. Also, A. Bottrall, "Comparative Study of the Management and Organization of Irrigation Projects," *World Bank Staff Working Paper No. 458*, Washington, D.C. (1981).

9. Paul Faeth, "Determinants of Irrigation Performance in Developing Countries" (Washington: US Dept. of Agriculture, Economic Research Service, International Economics Division, December 1984).

10. The World Bank, *Tenth Annual Review of Project Performance Audit Results, Volume Two: Sector Reviews* (Washington: The World Bank, August 1984).

11. Sadiqul Bhuiyan, "Irrigation Technology for Food Production: Expectations and Realities in South and Southeast Asia," paper presented at the conference on Water and Water Policy in World Food Supply, Texas A&M University, May 26-30, 1985, p.11.

12. Leslie Abbie et al., "Economic Returns to Irrigation Investments in India," *World Bank Staff Working Paper.*

13. Muhammed A. Chaudry, "Water Charges, Cost Recovery, and Irrigation Subsidies in Pakistan," unpublished report prepared for the World Resources Institute, Washington, D.C. (1985).

14. Li Jinchang, Wang Yanxiang, and Liu Wen, "Resource Pricing for Sustainable Development," unpublished paper prepared as part of a collaborative project between WRI and the Technical Economic Research Commission under the State Planning Council of The People's Republic of China, Beijing, 1985.

15. Leslie Small et al., "Regional Study on Irrigation Service Fees: Final Report" (Kandy, Sri Lanka: International Irrigation Management Institute, January 1986).

16. Ronald Cummings & Victor Brajer, "Water Subsidies in Mexico's Irrigated Agricultural Sector," report submitted to the World Resources Institute, Washington, D.C. (November 1985).

17. Robert Repetto, "Irrigation Charges and Subsidies in the United States," unpublished World Resources Institute paper, (August 1985).

18. B.D. Dhawan, "Irrigation's Impact on the Farm Economy," *Economic and Political Weekly* XX (39), 1985; A124-128.

19. The World Bank, *Mexico: Irrigation Subsector Survey* (Washington, D.C.: The World Bank), Annex 3, p.5.

20. R. Rangley, "Irrigation and Drainage in the World," paper presented at the seminar on Water and Water Policy in World Food Supply, Texas A&M, May 1985.

21. Li Jinchang et al., "Resource Pricing for Sustainable Development," *op.cit.*

22. Research to this effect is available for many countries. See, for example, H. Murray-Rust et al.,

"Productivity and Equity in Gal Oya Left Bank: A Sri Lankan Irrigation System," in N. Pant, (ed.) *Productivity and Equity in Irrigation Systems* (New Delhi: Ashish Publishing House) 1984. Also, D.F. Tabbah & T.H. Wickham, "Effects of Location and Water Supply on Water Shortages in an Irrigated Area," in *Irrigation Policy and Management in Southeast Asia* (Los Baños, Philippines: International Rice Research Institute) 1987; R. Chambers, "Men and Water: The Organization and Operation of Irrigation," in B.H. Farmer, *Green Revolution?*, (Boulder, Colorado: Westview) 1977; M.C.J. Cruz, *Social and Institutional Factors in Differential Access to Canal Irrigation: A Study of a Philippines Communal System;* unpublished Ph.D. Thesis, University of Wisconsin, 1983.

23. R. Chambers, *op. cit.*, note 19, p. 356.

24. N.D. Jayal, "Emerging Patterns of the Crisis in Water Resource Conservation," in J. Bandyopadhyay, *India's Environment: Crisis and Response* (Dehra Dun: Natraj) 1985.

25. The World Bank, *World Development Report 1982* (Washington, D.C.: The World Bank) 1982, p. 62.

26. Ian Carruthers, *op. cit.*, p. 70.

27. The World Bank, *Pakistan: Subsector Report: Public and Private Tubewells: Emerging Issues and Options* (Washington, D.C.: The World Bank) November 1984.

28. The black fly vector for river blindness breeds in fast-flowing waters, and it is sometimes thought that dams reduce breeding grounds. However, spillways provide excellent breeding grounds, and blackflies have successfully bred at the Volta Dam, the Kainji Dam in Nigeria, and the Owen Falls Dam on the Nile. E. Goldsmith & N. Hildyard, *The Social and Environmental Effects of Large Dams*, Wadebridge Ecological Center, London, 1984, pp. 85-86.

29. For example, the Aswan Dam led to a proliferation of insect pests, such as the cotton leaf worm *(spodoptera littoralis)*, the great moth *(polychrosis botrana)*, and the cornstalk borer *(chilo agamemnon)* into Upper Egypt where they were previously unknown. *ibid.*, pp. 67-71.

30. G.E. Pelts, *Impounded Rivers: Perspectives for Ecological Management* (New York: Wiley & Sons) 1984. See also E. Goldsmith & N. Hildyard, eds., *The Social and Environmental Effects of Large Dams*, 2 vols. Wadebridge Ecological Center, UK, 1986.

31. S. Chandran Nair, "Wasting Wealth of the Western Ghats," in J. Bandyopadhyay, *op. cit.*

32. Peter Rogers, "Fresh Water" in Robert Repetto (ed.), *The Global Possible*, Yale University Press, New Haven, 1985.

33. For example, it has been estimated that in Pakistan, where waterlogging and salinity are widespread and severe, reducing water losses in the Indus Canal system from 50 to 30 percent would match the contribution to irrigation supply of three Tarbela Dams, each costing $3 billion. Chaudry, *op. cit.*

34. Muhammed A. Chaudhry, *op. cit.*

35. Cummings and Brajer, *op. cit.*

36. DEVRES, Inc., *Irrigation Pricing and Management: Annex 4: The Philippines*, report submitted to USAID, Washington, D.C. (September 1985).

37. USAID, *Irrigation Development Options and Investment Strategies for the 1980s: India*, Report No. 6, Water Management Synthesis Project (Washington, D.C.: USAID) July 1981.

38. Rangeley, *op. cit.*

39. Small et al., *op. cit.*: Rangeley, *op. cit.*; Faeth, *op. cit.*

40. Small et al., *op. cit.*, p. 38.

41. M.A. Chaudry, "Economics of Alternative Irrigation Water Allocation and Pricing Rules in Pakistan," unpublished Ph.D. dissertation, Colorado State University, 1985.

42. Chaudry, "Water Charges, Cost Recovery, and Irrigation Subsidies in Pakistan," report prepared for the World Resources Institute.

43. The same is true of investments in public SCARP tubewells, which the government proposes to phase out in regions where groundwater is suitable for irrigation. Performance of SCARP projects has fallen far short of expectations, and the few *ex post* analyses of returns on investment show them to be inadequate.

44. Burness et al., "The 'New' Arizona vs. California," *Natural Resources Journal*, XXII (3), 1982.

45. Cummings, *op. cit.*

46. The World Bank, *Mexico: Irrigation Subsector Survey* (Washington, D.C.: The World Bank) January 1983, Annex 1, p. 1; Cummings, *op. cit.*

47. For example, A. Bottrall, "Comparative Study of the Management and Organization of Irrigation

Projects," *World Bank Staff Working Paper, No. 458*, Washington, D.C., 1981; D. Bromley, "Improving Irrigated Agriculture: Institutional Reform and the Small Farmer," *World Bank Staff Working Paper, No. 531*, Washington, D.C., 1982; I. Carruthers, *Aid for the Development of Irrigation*, OECD, Paris, 1983; K. William Easter, University of Minnesota, "Recurring Cost of Irrigation in Asia: Operation and Maintenance," report submitted to USAID, Washington, D.C., July 1985.

48. The most thorough study is R. Wade, "The System of Administrative and Political Corruption: Canal Irrigation in South India," *Journal of Development Studies*, XVIII (3), 1982; 287-327. See also, N.V. Jagannathan, "Corruption, Delivery Systems, and Property Rights," *World Development*, XIV (1), 1986, 127-132; R.P. de los Reyes, "Stereotypes and Facts in Irrigation Management," *Irrigation Policy and Management in Southeast Asia* (Los Baños, Philippines: International Rice Research Institute) 1978. In general, according to an authority on irrigation systems, "Illicit payments constitute a major impediment to efficiency, although this is seldom mentioned in donors' evaluation reports." I. Carruthers, *op. cit.*, p. 22.

49. This was succinctly put by one World Bank study: "Proposals for management improvement will fail if they do not take account of informal interests and the patterns of incentives and pressures they create." R. Heaver, "Bureaucratic Politics and Incentives in the Management of Rural Development," *World Bank Staff Working Paper, No. 537*, Washington, D.C. 1982.

50. In most countries, entitlements to water in public irrigation systems are attached to land, not to persons, and the entitlement's value is capitalized into the price of the land. Should a farmer *buy* land entitled to cheap public irrigation services, he very likely pays for the rents he receives.

51. There are interesting exceptions. In Maharashtra, to promote equity, rights to receive irrigation water have been assigned to landless households, enabling them to trade water with farmers for economic benefits. R. Chambers, "The Organization and Operation of Irrigation Systems"; B. Farmer, *op. cit.*

52. R. Repetto, "Time and the Choice of Techniques: A Study of Irrigation Programmes," Chapter 4 in *India's Development Programmes*, Harvard Economic Studies, Number 137 (Cambridge: Harvard University Press) 1971.

53. This has been found true both in developed and developing country systems. For the US, see B.D. Gardner and R.G. Huffaker, "Distribution of Economic Rents when Irrigated Farmland is Leased: The Case of Imperial Valley, California," National Technical Information Service, Report 1-07-81-V0201, Washington, D.C., 1983. For India, see E.J. VanderVelde, "Local Consequences of a Large-Scale Irrigation System in India," in E.W. Coward, Jr., *Irrigation and Agricultural Development in Asia* (Ithaca: Cornell University Press) 1980, p. 323.

54. In Bangladesh, for example, when the government greatly reduced its subsidy for operators of shallow tubewells and low lift pumps, the price at which their operators sold surplus water to their neighbors rose far less than proportionately, indicating that sellers had been charging close to what the water was worth to the buyer all along. S.R. Osmani and M.A. Quasem, *Pricing and Subsidy Policies for BanglaDesh Agriculture*, BanglaDesh Institute of Development Studies, Dhaka (August 1985), p. 160.

55. Inappropriate subsidy policies can alter this conclusion. In Uttar Pradesh, for example, where electricity prices are heavily subsidized, especially for agricultural users, *electricity* demand exceeds supply, and in peak demand periods is often unavailable for many hours in the day, so that tubewells equipped with electric motors cannot be run.

56. Lester Ross, *Environmental Policy in China*, Chapter Three: "Water Policy and Natural Hazards," unpublished manuscript, Dept. of Political Science, Purdue University.

57. Recent surveys of what is now a large literature with many applications include D.C. Colander, ed., *Neoclassical Political Economy: The Analysis of Rent-Seeking and DUP Activities* (Cambridge, Mass.: Ballinger) 1984; R. Tollison, "Rent-Seeking: A Survey," *Kyklos*, XXXV (4), 1982; J.M. Buchanan, R. Tollison, and G. Tullock, eds., *Toward a Theory of the Rent-Seeking Society*, Texas A&M, 1980. For an early general statement, see A.O. Kreuger, "The Political Economy of the Rent-Seeking Society," *American Economic Review*, LXIV (3), 1974; 291-303.

58. Examples are legion. Long apprenticeships and difficult licensing requirements to enter occupations preserve higher earnings for those already in them by discouraging applicants. Onerous procedures for applying for research grants from the National Science Foundation or the National Institute of Health serve as much to deter applicants as to ensure the value of the research ultimately performed. In the business world, when foreign exchange or locally produced steel are underpriced and administratively rationed, businessmen are

known to build more production capacity than the market requires to increase their claim to the scarce resource.

59. Martin Weitzman contrasts business behavior in product markets, where monopolistic competition ensures that business would like to sell more at the given price if it could, with its behavior in labor markets where labor's declining marginal product ensures that it does not want to hire additional workers at the current wage, although it could. He points out that few firms coddle their employees the way they coddle their customers. M. Weitzman, *The Share Economy* (Cambridge: Harvard University Press) 1984.

60. Jagannathan, *op. cit.*

61. A. Bottrall, "Management and Operation of Irrigation Schemes," C. Widstrand, ed., *Water and Society: Conflicts in Development* (New York: Pergamon) 1978.

62. See Mancur Olsen, *The Rise and Decline of Nations* (New Haven: Yale University Press) 1982 for a strong presentation of this process.

63. For a broader and more complete treatment of water policy issues in the U.S., see Mohamed T. El-Ashry and Diana C. Gibbons, *Troubled Waters: New Policies for Managing Water in the American West*, World Resources Institute, Study No. 6, Washington, D.C., October, 1986.

64. See, for example, H. Ingram, "Patterns of Politics in Water Resource Development," *Natural Resource Journal*, XXI (1), 1971, p. 102-18; S. Hanke, "The Political Economy of Water Resource Development," *Transactions of the 38th North American Wildlife and Natural Resource Conference*, Washington, D.C., March 1979; B.D. Gardner, "Water Pricing and Rent-Seeking in California Agriculture," and R. Rucker & P. Fishback, "The Federal Reclamation Program: An Analysis of Rent-Seeking Behavior" in T. Anderson, ed., *Water Rights: Scarce Resource Allocation, Bureaucracy, and the Environment* (Cambridge: Ballinger) 1983.

65. It is instructive that nowhere, not even in the world's richest agricultural regions, such as California's San Joaquin and Imperial Valleys, do farmers have the ability to pay for public irrigation water—not even when they are paying several times as much in the same regions for irrigation water from other sources. Part of the reason, of course, is that irrigation subsidies are quickly capitalized into the value of irrigated *land*, and largely disappear for those who buy, rent or mortgage such land.

66. For details on hidden subsidies in Bureau of Reclamation operations, see National Wildlife Federation, *Shortchanging the Treasury*, Washington, D.C., 1984; Natural Resources Defense Council & California Rural Legal Assistance Foundation, *Turning Off the Tap on Federal Water Subsidies, Volume I: The Central Valley Project $3.5 Billion Giveaway*, San Francisco, 1985; D.R. Franklin & R.G. Hagemen, "Cost Sharing with Irrigated Agriculture: Promise vs. Performance," *Water Resources Research*, XX (8), August 1984; 1047-1051.

67. See U.S. Dept. of the Interior, Bureau of Reclamation, *Draft Environmental Impact Statement on Acreage Limitation: Westwide Report, Appendix F: Calculations for Full Cost Pricing Option and for Value of Subsidy;* and *Appendix G: Full Cost Pricing Option*, Washington, D.C., January 18, 1981. For a similar conclusion, see Congress of the United States, Congressional Budget Office, *Efficient Investment in Water Resources: Issues and Options*, Washington, D.C. August 1983.

68. U.S. Dept. of the Interior, Bureau of Reclamation *op. cit.*, Appendix G, p. 19.

69. The rent per acre-foot is $22.59 (the $24 value of water less its cost to the farmer of $1.41), and an average of 5.2 acre-feet is applied to each acre irrigated.

70. C.V. Moore & R.E. Howett, "The Central Valley of California," paper prepared for the World Resources Institute Arid Lands Project, 1985.

71. Natural Resources Defense Council, *op. cit.*, p. 28.

72. U.S. General Accounting Office, *Federal Charges for Irrigation Projects Reviewed Do Not Cover Costs*, Washington, D.C., March 1981, p. 40.

73. W.E. Martin, H. Ingram, and N.K. Laney, "A Willingness to Pay: Analysis of Water Resource Development," *Western Journal of Agricultural Economics*, July 1982, 133-139.

74. According to one authority on U.S. water policy, "Benefit cost analysis is often used to clothe politically desirable projects in the figleaf of economic respectability." H. Ingram, *op. cit.*, p. 114.

75. U.S. General Accounting Office, *Water Project Construction Backlog—A Serious Problem With No Easy Solution*, Washington, D.C., 1981.

76. U.S. General Acccounting Office, *More and Better Use Could Be Made of Billions of Gallons of Water by Improving Irrigation Delivery Systems*, Washington, D.C., Sept. 1977.

77. B.D. Gardner, *op. cit.* Also, on the Texas High Plains, where rising energy prices and declining water tables have raised the costs of pumping water from the Ogalalla Aguifer, farmers have adopted water-conserving cultivation practices, sprinkler and furrow irrigation systems, and have made land-forming investments to reduce losses. R.D. Lacewell & J.G. Lee, "Land and Water Management Issues: Texas High Plains," paper prepared for the World Resources Institute, August 1985.

78. Natural Resources Defense Council, *op. cit.*, p. 17.

79. B.D. Gardner, *op. cit.*

80. Dept. of the Interior, Bureau of Reclamation, *op. cit.*

81. For a recent account, see M. Reisner, *Cadillac Desert* (New York: Viking Penguin) 1986.

82. C.V. Moore and R.E. Howitt, *op. cit.*

83. L. Small et al., *Regional Study on Irrigation Service Fees: Final Report; Annex Six: Financing Irrigation Services in the Philippines* (Sri Lanka: International Irrigation Management Institute) 1986.

84. Carruthers, *op. cit.*, p. 96. There is nothing exceptional about professionals in any field believing in what they do, and wanting to maintain a high level of activity. Economists, politicians, and lawyers, for example, would be unlikely to desist from their activities just on the demonstration that they were often counterproductive.

85. S. Bhuiyan, "Irrigation Technology for Food Production: Expectations and Realities in South and Southeast Asia," paper presented at the conference on Water and Water Policy in World Food Supply, Texas A&M University, May 26, 1985.

86. The World Bank, *Pakistan: Subsector Report: Public and Private Tubewell Performance: Emerging Issues and Options* (Washington, D.C.: The World Bank) 1985.

87. Syed Haashim Ali, "Planning and Implementation of Measures to Ensure Productivity and Equity under Irrigation Systems," in N. Pant, ed., *Productivity and Equity in Irrigation Systems* (Dehra Dun: Natraj) 1985.

88. A. Vaidyanathan, "Report on Identification, Appraisal, and Evaluation of Agricultural Projects," *Indian Journal of Agricultural Economics*, XXXIII (4), 1978, 282-283.

89. The effects of these delays on rates of return in capital-scarce economies can be severe. For details, see R. Repetto, *Time in India's Development Programmes*, Harvard Economic Studies No. 137 (Cambridge: Harvard University Press) 1971.

90. Technologies increasingly available, such as quick-maturing, drought-resistant cultivars and moisture-conserving cultivation practices, offer substantial potential returns to investments in dryland farming. See G. Levine, "Irrigation Development and Strategy Issues for the Asian Region," paper prepared for USAID, Water Management Synthesis Project, Washington, D.C., 1981. Also, J.S. Bayer, "Water and Plant Productivity," paper presented at a conference on Water and Water Policy in World Food Supply, Texas A&M, 1985.

91. According to a report by the Government of India's Public Accounts Committee cited in a recent review of irrigation management, not a single major or medium irrigation project has ever been completed on time in the history of independent India. DEVRES, *Irrigation Pricing and Management: Main Report*, submitted to USAID, Washington, D.C., September 1985, p. 40.

92. L. Abbie et al., "Economic Return to Investment in Irrigation in India," *World Bank Staff Working Paper, No. 536*, Washington, D.C. 1982; I. Carruthers & R. Stoner, "Economic Aspects and Policy Issues in Groundwater Development," *World Bank Staff Working Paper, No. 496*, Washington, D.C., 1981.

93. Some economic historians now argue that investments in railways did more to reduce famines in India than investments in irrigation did by allowing shipments of food from surplus regions to those where the monsoon had failed. But, another reason why irrigation command areas were made so large relative to the firm water availabilities during periods of peak irrigation demand was that the systems depended mainly on diversions from highly seasonal rivers so they had little storage capacity. Canals were designed to carry a great deal of water during the wet season and to operate by rotation during periods of low flow.

94. R. Rangeley, "Irrigation and Drainage in the World," paper presented at the conference on Water and Water Policy in World Food Supply, Texas A&M, May 1985, p. 19.

95. R. Reidinger, "Institutional Rationing of Canal Water in Northern India: Conflict Between Traditional Patterns and Modern Needs," *Economic Development and Cultural Change*, XXIII (1), 1974, p. 89.

96. Where an accessible freshwater aquifer permits extensive private tubewell development, as in much

of the Indus Basin, the public canal system in effect provides a certain "baseload" irrigation supply while recharging the aquifer, while private tubewells provide irrigation supplies to meet peak demands. This mitigates the costs described above. See S.H. Johnson & J.O. Reuss, "Economics of Changes in Irrigation Management in Pakistan," *Water International*, IX (2), 1984, 66-71; S.H. Johnson & J.O. Reuss, "Economic Results of Simulated Changes in Pakistan's Irrigation System," *Water Resources Research* XX (5), 1984; 629-634; and G.T. O'Mara, "Issues in the Efficient Use of Surface and Groundwater in Irrigation," *World Bank Staff Working Paper, No. 707*, Washington, D.C., 1984.

97. One way to create appropriate incentives for farmers to use temporarily available irrigation supplies, predicated on the development (discussed below) of contractual relationships between irrigation agencies and water-user associations, is to distinguish "firm" from "contingent" classes of service, with different charges for temporary or unreliable water supplies. See Harald D. Fredericksen, "Organizing for O&M and Charges for Service," unpublished World Bank memorandum, Washington, D.C., August 21, 1986.

98. L. Small et al., *Regional Study on Irrigation Service Fees: Final Report* (Sri Lanka: IIMI) 1986, p. 11. The same process operates in the United States. State governments tend to grant permits to a volume of water greater than what is, in fact, available. Because the more junior water rights are worthless unless additional supplies are developed, support is generated for additional dams and diversion projects. The process is limited only by what the federal government is willing to spend. A.G. Cuzan, "Appropriators vs Expropriators: The Political Economy of Water in the West," in T. Anderson, *op. cit.*

99. R. Reidinger, *Canal Irrigation and Institutions in North India*, unpublished Ph.D. dissertation, Duke University, 1971, for an example from Haryana and Rajasthan.

100. R. Barker, E.W. Coward, Jr., G. Levine, and L.E. Small, *Irrigation Development in Asia: Past Trends and Future Developments* (Ithaca: Cornell University Press) 1984.

101. There is a burgeoning literature on the subject. See A. Bottrall, "Comparative Study of the Management and Organization of Irrigation Projects," *World Bank Staff Working Paper, No. 458*, Washington, D.C., 1981; U.S General Accounting Office, *Irrigation Assistance to Developing Countries Should Require Stronger Commitments to Operation and Maintenance*, Washington, D.C., August 1983; M. Svendson, D. Merrey, W. Fitzgerald, "Meeting the Challenge for Better Irrigation Management," *Horizons*, March 1983.

102. These systems intentionally provided for little discretionary control by irrigation staff, by including few control structures and establishing rigid rules for water distribution—partly, it seems, to minimize opportunities for rent-seeking. See R. Reidinger, *op. cit.*, p. 84.

103. Reidinger, *op. cit.*, p. 103.

104. H. Murray-Rust et al., "Productivity and Equity in Gal Oya Left Bank: A Sri Lankan Irrigation System," in N. Paul, *op. cit.*, p. 103.

105. M.C.J. Cruz, *Social and Institutional Factors in Differential Access to Canal Irrigation: A Study of a Philippines Communal System*, unpublished Ph.D. dissertation, University of Wisconsin at Madison, 1983.

106. T.H. Wickham and A. Valera, "Practices and Accountability for Better Water Management," *Irrigation Policy and Management in Southeast Asia* (Los Baños, Philippines: International Rice Research Institute) 1978, p. 68.

107. M.A. Chaudry, *Economics of Alternative Irrigation Water Allocation and Pricing Rules in Pakistan*, unpublished Ph.D. dissertation, Colorado State University, 1985. If head reaches are so water logged that yields are reduced, reallocating water to the tail can raise production in *both* regions. See R. Chambers, *To the Hands of the Poor: Water, Trees, and Land*, paper prepared for the Institute of Economic Growth Silver Jubilee National Seminar, Delhi, April 30, 1984.

108. R. Wade, "Irrigation Reform in Conditions of Populist Anarchy," *Journal of Development Studies*, XIV (2), 1984, p. 298.

109. D. and A. Thorner, "The Weak and the Strong on the Sarda Canal," *Land and Labour in India* (Bombay: Asia Publishing House) 1962.

110. For the Mexican case, for example, see R. and E. Hunt, "Irrigation Conflict and Politics: A Mexican Case," in T. Downing and M. Gibson, eds., *Irrigation's Impact on Society*, (Tucson: University of Arizona Press) 1974. For a Sri Lankan example, see H. Murray-Rust et al., *op. cit.*, p.106. For the Philippines, R.P. de los Reyes, "Stereotypes and

Facts in Irrigation Management," in International Rice Research Institute, *op. cit.*, p. 197.

111. A. Bottrall, *op. cit.*, p. 27.

112. R. Wade, "The System of Administrative and Political Corruption: Canal Irrigation in South India," *Journal of Development Studies*, XVIII (2), 1982.

113. The World Bank, *Pakistan: Command Water Management Project: Staff Appraisal Report*, Washington, D.C., April 1984, p. 8.

114. K.W. Easter, *Recurring Cost of Irrigation in Asia: Operation and Maintenance*, Final Report for USAID, Washington, D.C., July 1985.

115. L. Small et al., *op. cit.*, p.iii; J. Nickum, "Irrigation Management in China: A Review of the Literature," *World Bank Staff Working Paper, No. 545*, Washington, D.C. 1982; R. Wade, *Irrigation and Agricultural Politics in South Korea* (Boulder, Colorado: Westview) 1982.

116. For material on Indonesia, see DEVRES, Inc., *Irrigation Pricing and Management: Annex 5: Indonesia*, report to USAID, Washington, Sept. 1985. For further material on Indonesia and Nepal, see L. Small et al., *Regional Study on Irrigation Service Fees: Annex 3: Financing Irrigation Services in Indonesia*, and *Annex 5: Financing Irrigation Services in Nepal* (Kandy, Sri Lanka: Int'l Irrigation Management Institute) 1986.

117. R. Wade has described those pressures very clearly in "The System of Administrative and Political Corruption: Canal Irrigation in South India," and "Irrigation Reform in Conditions of Populist Anarchy."

118. See Carruthers, *op. cit.*, p. 22, and Bottrall, 'Management and Operation of Irrigation Schemes," in C. Widestrand, ed., *Water and Society: Conflicts in Development* (New York: Pergamon) 1978.

119. For a description of this process in public tubewell operation, see Bottrall, *op. cit.*, 324-325.

120. R. Wade, "Trust as a Factor in Canal Performance," The World Bank, Agriculture and Rural Development Dept., Operational Policy Staff, Discussion Paper, Washington, D.C., April 1985.

121. H. Murray-Rust et al., *op. cit.*, p. 108.

122. K.W. Easter, *op. cit.*, p. 14.

123. For an overview, see Manzur Ahmed, "Water as a Constraint on World Food Supplies," paper presented at the Conference on Water and Water Policy in World Food Supply, Texas A&M, 1985.

124. M.E. Jensen, "New Technology Related to Water and Water Policy—Engineering," paper presented at a conference on Water and Water Policy in World Food Supply, Texas A&M, May, 1985.

125. R. Young & R. Bowen, "Economic Effects of Alternative Methods of Charging for Irrigation Water: A Case Study of Egypt," Colorado State University, n.d.; M.A. Chaudry, *Economics of Alternative Irrigation Water Allocation and Pricing Rules in Pakistan*, unpublished Ph.D. dissertation, Colorado State University, 1985.

126. B.D. Gardner, *op. cit.*

127. G. Schramm & F. Gonzalez V., "Pricing Irrigation Water in Mexico: Efficiency, Equity, and Revenue Considerations," *The Annals of Regional Science*, March 1977, 15-35.

128. Lester Ross, *op. cit.*, p.235.

129. R. Wade, "The System of Administrative and Political Corruption," *op. cit.*, p. 316.

130. Easter, *op. cit.*, p. 38.

131. Leslie Small et al., *op. cit.*, p.iii.

132. R.L. Bowen & R.A. Young, "Allocative Impacts of Alternative Methods of Charging for Irrigation Water," in K.W. Easter & D.E. Welsch, *Irrigation Investment and Management Policies for Developing Countries* (Boulder, Colorado: Westview Press), forthcoming.

133. See R.N. Middleton, R.J. Saunders, and J.J. Warford, "The Costs and Benefits of Water Metering," *Journal of the Institute of Water Engineers*, November 1978, 111-122.

134. A. Maass, *And the Desert Shall Rejoice* (Cambridge: MIT Press), Ch.4. Maass's study of the *huerta* of alicante, where irrigation shares are traded among farmers, suggests as well that the system works more efficiently than those of other allocation systems, both in normal and drought conditions.

135. L. Small et al., *op. cit.*, p.44.

136. See H. Plusquellec, "Interdependence of Design and Water Management in Irrigation Projects," Ted Davis, ed., *Increasing Agricultural Productivity:*

Proceedings of the Third Annual Agriculture Sector Symposium, World Bank, Washington, D.C., 1982.

137. DEVRES, *op. cit.*, p.45.

138. Chaudry, *op. cit.*, p.22.

139. DEVRES, *op. cit.*3, p.69.

140. DEVRES, *op. cit.*, p.75.

141. DEVRES, *op. cit.*, Annex IV, "The Philippines," p.28. Also, Easter, *op. cit.*, p.19.

142. In Pakistan, for example, based on crop-specific irrigation charges and typical water-consumption rates, the subsidy has been estimated at Rs. 10 per acre of wheat, Rs. 28 of sugarcane. Chaudry, *op. cit.*, p.42.

143. S. Hirashima, "Poverty as a Generation's Program," in J. Mellor and G.M. Desai, *Agricultural Change and Rural Poverty*, Johns Hopkins Press, 1985.

144. The World Bank, *Mexico: Irrigation Subsector Survey*, (Washington, D.C.: The World Bank) June 1983.

145. P.K. Rao, "Irrigation Water Pricing and Cost Recovery: India," paper prepared for the World Resources Institute, December 1985.

146. L. Small et al., *op. cit.*, Annex II, Table 19.

147. Bowen and Young, *op. cit.*; Maass, *op. cit.*; Chaudry, *op. cit.*

148. Q. Shahabuddin, "Irrigation Water Charges, Subsidies, and Cost Recovery in Bangladesh," report prepared for the World Resources Institute, September 1985.

149. DEVRES, *op. cit.*, Annex 4; L. Small et al. *op. cit.*, Annex 6.

150. R. Wade, *Irrigation and Agricultural Politics in South Korea* (Boulder, Colorado: Westview).

151. World Bank, Operations Evaluation Department, *Bank Lending Conditionality: A Review of Cost Recovery in Irrigation Projects*, Washington, D.C., June 25, 1986.

152. Lester Ross, *op. cit.*, p.231.

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