COST AND FINANCING OF IRRIGATION SYSTEM OPERATIONS AND MAINTENANCE IN PAKISTAN

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Introduction

Despite concern over poorly maintained irrigation systems and insufficient investment in operations and maintenance (O&M) for irrigation systems in most developing countries, there is little agreement about how much money is required. A review of 18 Asian Development Bank (ADB) appraisal reports for irrigation projects in Asia, covering the period 1969-78, revealed O&M estimates ranging from US$15 - US$120 per hectare (ADB 1980). This is not surprising given the variety of irrigation systems involved. What is surprising is the absence of published information on what is actually spent for O&M.

Funding for irrigation system O&M in Pakistan has not been adequate to maintain the Indus system in good working order. As a result, irrigation operations are adversely affected. Irrigation facilities, particularly canals and drains, have deteriorated to the point where the United States Agency for International Development (USAID), the World Bank, and the Government of Pakistan are jointly providing US$118 million to rehabilitate portions of the system in what is commonly termed "deferred maintenance." Under 1982 agreements that underpin the rehabilitation project, Pakistan's provinces agreed to step-up their funding for O&M. However, the level of funding needed to adequately maintain the irrigation system[2] was not clear then and is still not fully understood.

This paper presents 1983/84 costs of irrigation system O&M for Pakistan. It describes the facilities maintained by the Provincial Irrigation Departments (PIDs), details current organization and staffing levels, and discusses income sources and water charges. Lastly, it discusses certain O&M policy related issues.

Characteristics of Irrigation Systems

Historical. Although irrigation had been practiced along the rivers and streams of Pakistan for centuries, the Indus system today dates primarily from works constructed by the British between 1850 and 1947. and from works built post-partition and/or as a result of the 1960 Indus Waters Treaty. The first irrigation works were constructed to create employment opportunities for war veterans (Michel 1967). A second series of facilities were opened to encourage resettlement in areas that were largely uninhabited and thereby generate revenues from sale of state lands. A second objective was to maximize the command area and prevent famine by providing water to a large number of families.

The objective of projects constructed in the early 1900s was to generate revenue by selling water and taxing land, agricultural produce, and trade (Merrey 1983). Above all, projects were designed to keep administrative and operational staff requirements as low as possible. Systems were intended to provide "equitable distribution (of water) without any interference by the canal

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[2]Consultants were employed to identify past levels of expenditure as preparation for determining future needs. This paper is derived from the work (DAI 1984). which was performed under contract with USAID as part of Irrigation Systems Management Project No. 391-0467,

establishment - which is an important advantage to the irrigation community" (Clibborne 1924146). This *laissez faire* attitude toward canal operations, combined witn a design that required only minimal regulation, established the basis for today's relatively low involvement of government personnel in active system operations.

Scope of Government Responsibility. In Pakistan, irrigation system O&M is the responsibility of the Provincial Irrigation Departments (PIDs). PID responsibility begins after water is diverted from the dams and terminates at the outlets to some 89,000 watercourses which serve areas that vary in size from 80 - 280 hectares, and typically about 160 hectares. Compared to other Asian countries, this is a relatively large area to be served by a single outlet. In Thailand and Malaysia an outlet serves 50 - 80 hectares; Indonesia, 20 - 30 hectares; Sri Lanka, 12 - 16 hectares; Philip. pines, 10 hectares; Korea, 0.8 - 2 hectares; and Japan, 0.4 hectares. Thus, other factors being equal, irrigation department expenditures in Pakistan should be less than those in other Asian cquntries.

The costs reported in this study cover only those items for which the PIDs have responsibility (i.e., main system O&M). The Water and Power Development Authority (WAPDA) is responsible for planning and constructing storage and headworks facilities, and for O&M of major dams and power-generation works. Below the outlet, O&M is the responsibility of water users.

Facilities. PIDs operate and maintain three major types of facilities: irrigation canals, public tubewells, and drains and flood protection works. Besides these, PIDs also incur costs for maintaining and/or operating canal roads, small hydro facilities, small dams, barrages, and workshops, and for several modest facilities where research programs are conducted.

1. ***Irrigation canals.*** The irrigation network consists of 63,100 kilometers of unlined (alluvial) canals that command 14.25 million hectares (Table 1), of which 58% can be irrigated perennially and 42% can be irrigated only during the summer (kharif) season when the rivers are at peak flow. Canals vary from minors that carry 0.09 - 0.15 cubic meters of water per second (cumecs) and serve 2 - 3 watercourses to canals the size of rivers that transfer water between river basins and which have capacities up to 650 cumecs. Measured at the headworks, the canal irrigation system carries about 16 million hectare-meters (mhm) per year.

Table 1. Irrigation canals in Pakistan,

Province	Total Length (km)	Design Q (cumecs)	Command Area (million ha)
Punjab	36,481	4.288	8.321
Sind	21,192	3,544	5.101
NWFP	2.772	176	.446
Baluchistan	2.655	135	.384
Total	63.100	8.143	14.252

Source: 1982 and 1983 data from the PIDs

By design, the number of control structures in a canal was kept to a minimum; cross-regulators (checks) were installed only where necessary to control operating water levels for the headworks of "offtaking" channels. For example, in Sind the distance between regulators on main canals averages about 24 kilometers, about 16 kilometers on branch canals, and 32 kilometers on distributaries. The lowest point in the system for regulation is at the headworks of distributaries, which often carry 6 - 9 cumecs. In practice, regulating flows in distributaries is not common. When water supply is insufficient, a system of scheduled canal closures and rotational operations between distributaries is initiated. Thus, canals either run at full supply level (most of the year) or are shut down entirely. Gates were not installed at the outlets (called moghas) but were designed to pass a specified quantity of water at the normal full-supply level. Moghas act as proportional flow dividers, each taking proportionately less when the canal level is lower than normal, and more when the supply level is high. The theory is that the entire system, from the main canal head-works down to the last outlet on the last minor, will operate in balance - provided the head inflow is close to normal full supply and the moghas are in good condition.

This design obviates the need for operational changes common in many modern irrigation systems. Essentially. the canal system functions like a drain. Because the irrigation system was designed to supply only 0.25 litres per second per hectare, farmers must apply a relatively high degree of water management in order to irrigate their entire holdings. Needing few operational changes and having few structures means the system can deliver water with relatively little investment in O&M, except that for major barrages which are at the headworks of main canals.

2. ***Public tubewells.*** Beginning in 1959, Pakistan made major investments in a series of salinity control and reclamation projects (SCARPs) consisting of a battery of tubewells of 0.03 - 0.15 cumecs capacity. SCARPs were constructed by WAPDA but are operated and maintained by the PIDs at considerable cost. Tubewells are used for two purposes: water table control and, where groundwater quality permits, supplemental irrigation. There are almost 13,000 public tubewells. with the majority in Punjab (Table 2).

Table **2. Public tubewells in Pakistan.**

Province	Number	Discharge (mhm/yr)
Punjab	8.523	0.766
Sind	3.782	0.153
NWFP	688	0.033
Total	12,993	0.952

Source: 1982 and 1983 data from the PIDs.

Public tubewells produce an estimated 0.95 million hectare-meters of water per year. Outside PID responsibility. about 90,000 private tubewells located within the canal command areas pump an additional estimated 3.1 mhm/yr. About 110,000.other pumping schemes outside government irrigation commands produce about 0.24 mhm/yr.

3. ***Drains and flood control works.*** PIDs have responsibility for maintaining 15,079 kilometers of main, branch, and sub-branch drains (Table 3). Maintaining surface drains is a low priority. PIDs also maintain over 5,255 kilometers of flood protection works, including levees (bunds) along rivers, and training bunds and spurs that protect facilities such as bridges.

Maintenance Practices. Canals were designed with slopes and sections in regime to minimize scouring and silt deposits. But even though the irrigation systems carry a substantial load of silt which is discharged through the moghas and deposited on irrigated lands, major silt cleaning efforts are required each year. Annually, about 20% of the canals are scheduled for cleaning but lack of funds reduces this percentage. Perennial canals are maintained during a 2 - 3 week closure between December and early February, and consists primarily of silt removal and bank shaping. Non-perennial canals are normatly shut down from mid-October to mid-April to provide a more flexible schedule of silt clearance and general maintenance. PIDs generally contract out silt removal and other labor-intensive maintenance activities.

Table 3 Surface drainsand flood control works

Province	Design Capacity (cumecs)	Total Length of Drains (km)	Flood Control Works (km)
Punjab	991	6.068	2.431
Sind	280	6.677	2,346
NWFP	104	2,173	230
Baluchistan	11	161	248
Total	1,386	15,079	5.255

Source: 1982 and 1983 data from the PIDs.

Silt accumulation reduces channel cross-sectional area, which means that operating water levels must be raised to maintain design flows. A higher operating level leads to reduced freeboard, more bank overtopping and breaching, and generally increased maintenance costs. It also increases the flow through moghas at upstream locations, depriving farmers in the lower portions of the system of their fair share of the water and thereby creating a potential for equity problems between top-end users and bottom-end users.

During periods of peak water delivery, very little direct operation of the system is required and the major work effort is directed toward maintaining canal banks. Additional patrolling and maintenance is done to guard against overtopping or breaching of the banks. Emergency repairs often involve farmers and small contractors as well as PID personnel.

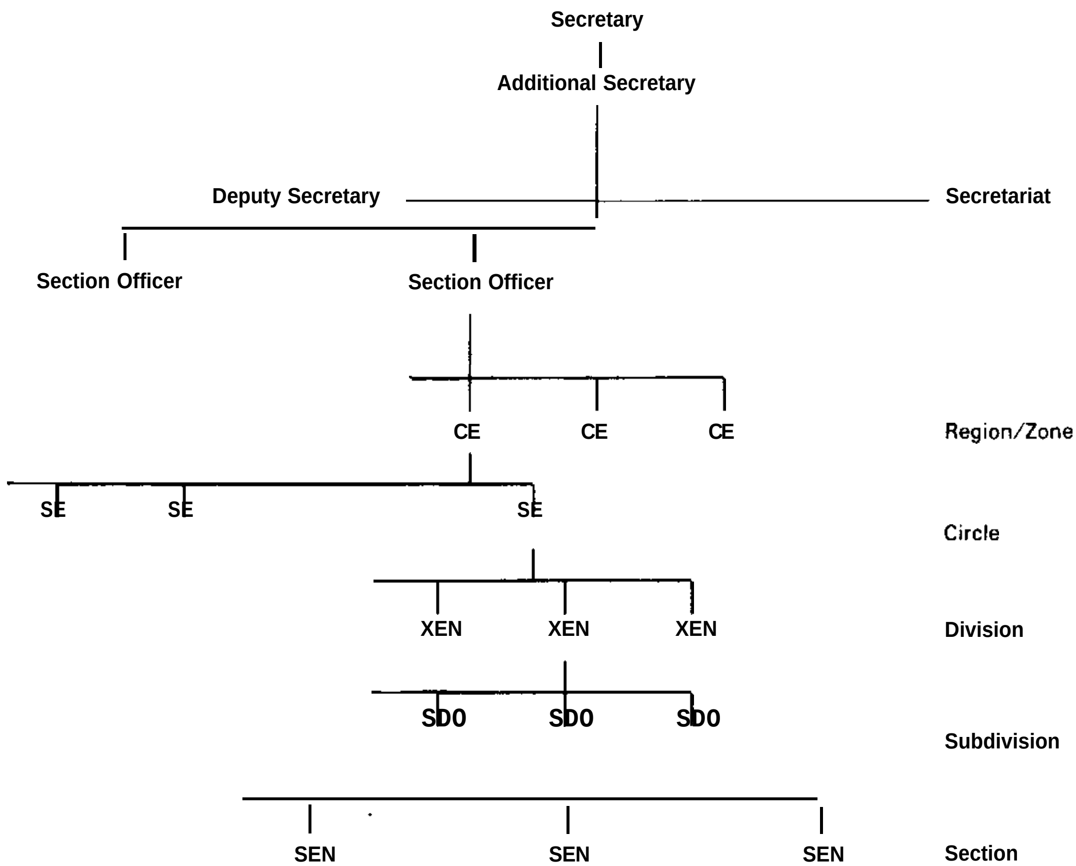
Whereas PID costs for surface water supply are largely for maintenance activities, PID costs for groundwater (tubewells) are about 75% operational - primarily electricity charges - and 25% maintenance, which includes repairs to motors, pumps, and wells.

Characteristics of the Irrigation Bureaucracy

Structure and Size *of the Provincial Irrigation Departments*. PIDs are large, hierarchically structured, and labor-intensive organizations, and their responsibility for irrigation water delivery is correspondingly highly centralized. In each province, PIDs receive water from the dams and deliver it to the moghas without relinquishing control to any other intermediary water agencies. The contrast in management responsibility with some other large gravity flow systems is sharp. For example, while Punjab irrigates 8.32 million hectares through a single entity, California delivers water to 3.8 million irrigated hectares through a decentralized network of 244 water districts (DWR 1983).

Figure 1 is an organizational chart for a PID. The chief executive officer is the Secretary, who is assisted by a secretariat. Next in line are one or more Chief Engineers (CE). depending on the size of the department. A CE usually supervises three to six Superintending Engineers (SE), each with a supporting staff. The organization under the command of an SE together with the area served is called a "Circle." The Circle is divided into Divisions (usually 3-5). with each Division under the authority of an Executive Engineer (XEN). Reporting to XENs are Sub-Divisional Officers (SDOs), positions normally held by Assistant Engineers. The day-to-day field work is carried out at the divisional level and below. All levels above the Division provide administration or support.

Figure 1. **Organizational chart for a provincial irrigation department**



Notes: **CE - Chief engineer; SE - Superintending engineer; XEN - Executive engineer; SDO - Sub-divisional officer (assistant engineer); SEN - Sub-engineer. All levels above division are administrative or support staff; those below are field staff.**

Without exception, all grades from Assistant Engineer and above require an engineering degree. Most of the officer positions are held by civil engineers, although there are a few mechanical and electrical engineers assigned to specialized functions, such as SCARP projects and major workshops. Expertise and degree training in management, finance, or economics are not substitutes for the engineering degree if one is to occupy any position of authority in the PIDs.

Pakistan's irrigation bureaucracy is enormous. The Punjab PID has more than 50,000 employees. In contrast, the United States Bureau of Reclamation currently has about 7,500 employees. More than 80.000 individuals were employed by the four PIDs in 1983/84 (Table 4). In aggregate, this is about one employee per watercourse or one employee per 88 - 216 irrigated hectares, depending on the province. Bottrall (1981) notes that the ratio in other Asian countries ranges from one employee per 122 - 496 irrigated hectares.

In Punjab. almost 40% of the total work force is assigned to canal irrigation, followed by 26% who work with tubewells, 15% in the special revenue group (whose function is to assess water charges). and 6% who work with drainage. The remaining 13% is assigned to administration or to a number of less labor-intensive categories such as dams, flood control, hydrology, hill torrents, land reclamation. waterlogging and salinity, workshops, research, design, stores, water treaty, and water allocation.

Table *4*. Staffing levels for Provincial Irrigation Departments.

Position or Pay Equivalent	Numbers of Staff			
	Punjab	Sind	NWFP	Baluchistan
Secretary	1	1	1	1
Chief Engineer	13	7	1	1
Superintending Engineer	47	26	7	10
Executive Engineer	145	87	20	17
Sub-divisional Officer	574	246	64	49
Sub-enginear	2.312	873	208	177
Sub-total. Officers	3.092	1,240	301	255
Other Staff	47,185	22.466	4.731	2.859
Total Staff	50.277	23,706	5,032	3.114
Area (ha)/Employee	166	215	88	123

Source PID and non-development budget (NDB) figures for 1983/84

Source of Income to PIDs

Recurrent and Non-Recurrent Budgets. PIDs receive funding for recurrent or operational expenditures through Provincial Finance Department allocations contained in the non-development budget (NDB)[3]. The NDB is the only source of revenue to support direct O&M costs, salaries and administration associated with those expenditures, and administration of the irrigation bureaucracy.

Each year's budget allocation to the PIDs is based upon the physical characteristics and inventory of the irrigation facilities against which are applied "yardsticks" developed by the PID and sanctioned by the Finance Department. For example, the Punjab PID receives US$600 per year for each kilometer of main and branch canal with a discharge greater than 300 cubic meters per second. Allocations for other categories of canals also depend on length and discharge capacity. SCARPs draw allocations on the basis of number of wells, discharge, and pumping lift. Flood control and drainage works are rated on the basis of length (in kilometers) and bed width, barrages and headworks on discharge capacity, dams per individual facility, and buildings per criteria set by the Buildings Department. Thus, the basis for budget allocations is rigidly fixed and based on formulas most of which were developed decades ago.

NDB budget categories are divided into broad groupings such as repairs and maintenance, operations (in the case of tubewells), machinery and equipment, salaries and allowances, utilities, and other staff-associated budget items. Because the allocation is not for a specific job nor by functional category (e.g., canals and tubewells). the breakdown is not conducive to job-cost accounting. However, it does allow PID managers broad scope in using funds for a variety of O&M functions.

PIDs also receive funding from the Provincial Annual Development Plan (ADP) for development works, new construction, or non-recurrent project-related expenditures. The current irrigation system rehabilitation project that funds deferred maintenance is "budgetarily" a non-recurrent item, and funding for it is channeled to the PIDs through the ADP.

Water Charges. Water charges are based on cropped area and on the type of crop. For example, water charges for sugarcane and orchards are more than three times those for grains and pulses that

[3] A four-year review (1980-84) of NDB allocations to the PIDs in each of Pakistan's four provinces provided the basis for cost information presented in this paper

use less water. The rate for water delivered from tubewells and lift schemes is double that for gravity canals. Water charges are assessed against the cropped area of each field at the beginning of the growing season. At the end of the season, adjustments are made for crop failures. Water charges average between USS5.00 and US$7.50 per hectare/crop, and it is estimated that water charges represent about .6% of the net income per hectare derived from crops produced.

In the early development of the irrigation network, farmers who owned lands that benefitted from irrigation were expected to pay for the costs of operating, maintaining, and repairing the system. As a result, irrigation proved to be a lucrative government activity. In 1927/28, one-third of the Punjab provincial revenues were derived from irrigation department profits (Merrey 1983:130). Receipts from water charges generally exceeded O&M expenditures but, in the early 1970s, PID expenditures for O&M escalated sharply because PIDs were forced to assume the operating costs of SCARP tubewells. Presently, cost recovery from water charges falls far short of O&M requirements. Expressed as a percentage of O&M expenditures, revenues from water charges were: Punjab, 62% (1983/84); Sind, 49% (1982/83); and NWFP. 24% (1982/83).

PIDs participate in assessing water charges through their cadres of revenue officials. However, collection is the responsibility of the Revenue Departments. Monies raised through water charges pass into the provincial treasuries along with other tax revenues, thereby losing their distinctive source identification. PID budgets are allocated by provincial governments as part of the normal budgetary process. Because provincial treasuries are the direct source of PID funds and not water charges directly, PIDs are accountable upward to the administrative authority, the provincial governor. In contrast, if water charges were collected and retained by the PIDs as their primary source of financing, there could be increased PID accountability downward to the farmers. Lack of accountability to the farmer/water-user affects the perceived quality of service, because PIDs can be fully accountable without interacting with farmers who, in turn, can perceive the service they receive as less than satisfactory.

Because present water charge rates are considered low compared to the farmers' ability to pay, one frequently discussed solution is to raise water charges to close the gap between recovery and expenditures. Another proposal is to relieve the PIDs from the responsibility and costs of O&M for SCARP s, and to turn tubewell operations over to the private sector. This may be a valid approach for some areas of Punjab where groundwater quality is good, but it is less appropriate where water pumped from SCARP tubewells is too saline for irrigation. Under such conditions, farmers will **not** assume responsibility for the wells.

Expenditures for Irrigation System O&M

Allocation for *O&M*. Allocations for all PID activit'ies were broken into five categories: canals, public tubewells, surface'drainage and flood control. establishment, and other. An analysis of expenditures by category and province is presented in Table 5. Although a four-year period was analyzed, dollar figures in the table are only for 1983/84. After 1980/81, expenditures for irrigation O&M increased annually by about 20 - 22%. double the rate of inflation. Increases were a response to agreements between Pakistan and the World Bank for the irrigation rehabilitation project which mandated greater expenditures for O&M.

Depending on the province, 50 - 60% of a PID's budget goes for repair, maintenance, or operations of canals and tubewells. From 30 - 40% goes to establishment, or to those salary, allowance and administrative costs associated with operation of the bureaucracy. Staff salaries and allowances range from 28 - 33% of the PID budget.

Table 5. Expenditure and percentage allocations to the PIDs for O&M.

	Punjab		Sind		NWFP		Baluchistan	
	US$	%	US$	%	US$	%	US$	%
Canals	12.1	16	11.4	37	4.4	39	3.4	54
Public Tubewells	43.9	45	5.6	18	1.7	14	-	
Drainage & Flood Control	3.6	3	3.4	4	1.4	15	0.3	4
Establishment	30.4	36	17.3	36	3.0	32	2.4	39
Other	0.3	*	3.6×	5	-	-	0.2	3
Total	90.3	100	41.3	100	10.5	100	6.3	100

* less than 1%; × includes major allocations for O&M of three large barrages on the Indus which serve as the headworks for the irrigation system in Sind. Expenditures for 1983/84 allocations; data in US$ millions (Conversion rate, Spring 1984: US$1.00=Rs 13/40). Percentages are averages of four years. 1981-84. Approximately 75% of "Public Tubewell" expenditures are for electricity, and 25% for repair and maintenance of pumps and motors. "Establishment" includes salary and allowances. administration of the headquarters units. buildings, transport, telephone, and utilities. "Other" includes small dams, research, design, and land reclamation. Source: data from the PIDs.

In three provinces, expenditures for canal maintenance were greater than for tubewell operation. Punjab differs from the other provinces in that it uses its SCARP tubewells primarily for irrigation not drainage, and thus operates its wells for more hours than dces Sind or NWFP. Consequently, expenditures for electrical charges for tubewell operations and repairs and maintenance to pumps and motorlaccounts for 45% of the Punjab PID budget. If a fair portion of the establishment cost pool is allocated to tubewells, their O&M consumes 56% of the PID budget[4].

Between 1970/71 and 1982/83, the Punjab PID increased expenditures for tubewell O&M at an annual rate of 67%, or more than ten times the rate of expenditures for other forms of O&M which increased at *6%* per year over the same period Because Punjab encountered sharply escalating cost obligations for O&M of SCARP tubewells, and Finance Department allocations have not kept pace, the Punjab PID diverted funds from other portions of its O&M budget which were forced to operate on residual funds. Thus the SCARP tubewell program has had an unintended impact upon canals, surface drains, and flood control works leading to an accumulation of deferred maintenance.

At the other extreme in PID priorities is the allocation of resources for surface drainage. Less than 4%, or USS0.42 - USS0.62 per hectare, is spent on maintaining suface drainage although inadequate drainage at depths less than 1.5 meters affects over 2.4 million hectares. Pakistan is currently investing in a major drainage artery - the Left Bank Outfall Drain - but this is a development and not an O&M expenditure.

There is little support within the Provincial Finance Departments for raising PID allocations for O&M. The fact that water charges have been set low and recoveries through water charges do not meet expenditures is an argument used to slow the rate of increase in allocation for O&M.

Cost of Irrigation Services. The cost of irrigation services including water delivery, flood control, drainage activities, and establishment was computed on the basis of 1983/84 NDB allocations to

[4] Commenting on the failure of the SCARPs to achieve drainage objectives. the lead editorial in the Pakistan Times (11 October 1984) surmised that the tubewells "drained crores (tens of millions) of rupees and little else."

the PIDs. The command area and water delivery statistics were furnished by the PIDs. O&M costs for SCARP tubewells and for the portion of establishment costs associated with tubewell operations have been separated from O&M costs for canals, drains, and flood control works. Table 6 shows the cost of irrigation services for canal and tubewell deliveries.

***Table* 6. Cost of irrigation services for canals and tubewells.**

Province	Canals	Tubewells	Overall
		US$ per hectare/year	
Punjab	4.81	22.77	10.74
Sind	6.30		7 76
NWFP	18.50	49.77	23.31
Baluchistan	20 73	n/a	20.73
		US$ per heciare-meter	
Punjab	0.09	1.00	0.19
Sind	0.09	0.75	0.10
NWFP	0.32	0.99	0.38

Source: 1983/84 data from the PIDs.

In 1983/84, Pakistan spent USS148.4 million dollars or USS10.34 per hectare for O&M for its irrigation systems. For the "average" hectare, approximately USS3.72 was spent on salary, allowances, and administration, leaving USS6.62 to be spent principally on operation of public tubewells or on repairs and maintenance of canals, tubewells, drains, and flood control works.

In the major irrigated areas, Punjab and Sind, the costs associated with providing canal irrigation water are extremely low, US$0.09 per hectare-meter respectively - about one-third to one-quarter of that in NWFP where irrigation works are much smaller. Annual expenditures for canal O&M including establishment costs were US$900 and US$1,490 per kilometer of canal for Punjab and Sind, respectively. Low expenditures can be attributed to several factors: 1) irrigation O&M responsibility that is limited to above the outlet and below the headworks; 2) the size and scale of major delivery channels; 3) the design of the system that requires few, if any, operational changes; and, paradoxically, 4) an inadequate level of maintenance activities which has led to an accumulation of deferred maintenance needs.

The annual cost to operate a public tubewell in Punjab was US$6,250; in Sind it was US$2,010. The difference in cost is attributable to longer operating hours per well in Punjab. Public tubewell supplied water costs of USS0.75 - US$1.00 per hectare-meter versus US$0.09 - 0.32 per hectare-meter for canal-supplied irrigation water. On a volume basis, tubewell water is four times the cost of canal water in NWFP, 8 times the cost in Sind. and 16 times the cost in Punjab. However, in most locations public tubewells have a dual purpose: drainage plus water for irrigation. Thus, it is not strictly correct to compare canal water costs with those of public tubewells for irrigation supply alone. Furthermore,. the fact that many private individuals have made investments in tubewells is an indicator that farmers realize additional benefits and thus are willing to incur additional costs in order to operate and control deliveries from their own wells.

The cost data presented here are accurate for Pakistan. However, any attempt to make cross comparisons with other studies or to apply these data to other locations should be approached with caution because of the physical differences in the irrigation systems, and differences in the institutional structures, methods of cost accounting, and wage rates between countries.

Implications and Conclusions

The preceding review highlights several important policy-related issues that can be mentioned both by way of summary and to generate further analysis and comment.

1. SCARPs have eroded PID ability to perform other maintenance functions, especially in Punjab. Divesting tubewells to the private sector is seen by many as a solution in areas with fresh groundwater. But unless private well operators improve operating efficiency and provide more timely and reliable water supplies, divestiture is likely to fail because private individuals will not assume O&M costs that have proven so burdensome to the PIDs. The SCARP Transition Pilot Project is designed to test the feasibility of divestiture.

Given the extent of Pakistan's drainage problems, decisions must be reached between alternatives in three areas: a) vertical vs. horizontal drainage facilities, b) SCARPs vs. open or tile drains, and c) low capital/high O&M costs vs. high capital/low O&M costs. Because of such factors as pumping salt-laden groundwater without adequate provision for disposal to the ocean, the marked increase in energy costs, and the impact on residual maintenance caused by the SCARP program, a return to horizontal drainage may be the most economical and effective approach in the long run. A thorough review is warranted.

2. Because provincial governments provide O&M funding and not water charges directly, PID accountability is upward to the governor and not downward to the farmers. Similarly, PID responsibility is to deliver water to the 89,000 outlets, and not to the 3.6 million farmer water-users. PIDs can be fiscally accountable and fully responsible in their work and yet have minimal interaction with farmers, who often feel that the irrigation service they receive is not satisfactory.

Irrigation operations and farmer perceptions could be improved simultaneously by bringing PIDs into closer contact with farmers by extending PID responsibility beyond the outlet ("reach down"). This could be achieved by increasing the number of moghas and thereby reducing the size of outlet service areas. An alternative approach ("reach up") is to strengthen water user groups so that farmer representatives could eventually interact with the PIDs regarding O&M issues. Water users are already organizing along many watercourses in Punjab and Sind. An extension of the "reach up" approach could be to test the utility of a farmer-controlled intermediary water agency at the distributary level. The PID could wholesale water to the agency which would then sell it to farmers. The agency would be responsible and accountable to the water users for O&M functions.

3. Common to all these approaches to irrigation management is a need for more interaction and better communication between farmers and the PIDs. Such interaction is required if flexibility in main system water delivery scheduling is a future objective of irrigation planning, particularly because increased flexibility is seen by many as a prerequisite for better agricultural performance from the Indus irrigation system.

System design changes will also be necessary to obtain more flexibility. A program could be devised to permit action research on scheduling canal water deliveries that are more in line with crop water requirements. This would require increased canal capacities in two or three minors and along a series of adjacent watercourses so that accommodations in surface water delivery scheduling might be tested on a pilot basis.

4. Pakistan spends US$150 million dollars per year for O&M and has a deferred maintenance program of US$118 million dollars spread over 5 years. This investment will correct some of the principal deferred maintenance deficiencies. It is conceivable that doubling annual O&M allocations could restore the irrigation system to design level. With increases in allocations of that magnitude, O&M expenditures would still be low (about US$20 per hectare/year) when compared with similar expenditures reported for other countries in Asia. Pakistan's expenditures for

O&M can be kept relatively low because of a) the design of the Indus irrigation system, and particularly the scale of major canals; b) the fact that few operational changes are required; and, c) the practice of delivering water only to outlets which serve large areas. But these same factors which keep O&M expenditures low are also the key water constraints to increasing the productivity of irrigated agriculture. The design and management of the system intercedes, causing insufficient capacity, apparent lack of flexibility in main system management, and inability to make operational changes in the pattern of irrigation delivery.

What will be the impact of better system maintenance upon agricultural productivity? Probably, not much. Low productivity is unlikely to be corrected by doubling O&M expenditures. O&M preserves the capacity of the irrigation system as it was designed and is currently used. Increased investment in O&M doesn't address inherent design and management limitations which, along with a lack of agricultural inputs, more directly constrains agricultural performance. Thus, while better O&M is needed and increased financial support is justified, neither is a substitute for improvements in design and management. Nevertheless, with a major new dam scheduled for completion in the 1990s and the potential to extend irrigation to new areas, Pakistan should now be experimenting with design innovations and changes in operation of the Indus system.