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IRRIGATION MANAGEMENT IN PAKISTAN: FOUR PAPERS

by Douglas J. Merrey and James M. Wolf

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Summary: These four papers attempt to understand different facets of irrigation in Pakistan's Indus Valley. One paper looks at Pakistan's Provincial Irrigation Departments (PIDs), with attention to the implications of financial and staffing structures on O&M policy. The other three related papers analyze local level sociological and ecological processes that have important implications for irrigation system management and development policy at the macro level.

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PREFACE

Each paper in this report attempts to understand different facets of a paradox: despite massive economic development investments since the late 19th century, the Indus Valley region, now the heart of modern Pakistan, is one of the poorest areas of the world. Most of the development investment has been in irrigation, yet irrigated agriculture in Pakistan remains very low in productivity by all conventional measures in comparison with its apparent potential. Or, as many rural Pakistanis say, "In Pakistan we have everything - good soil, water, climate, and people. Yet we remain poor."

The paper by James Wolf analyzes the present level of financing OEM at the provincial level, and evaluates its adequacy. Based on a rapid reconnaissance during a consulting assignment, the paper is not intended to be comprehensive. However, it provides a useful foray into the issues, and raises questions that need further investigation. The author wishes to acknowledge W. L. McAnlis and W. Rusk who worked with the author on the USAID-sponsored study that provided much of the information contained in this paper. He also appreciates the constructive comments made by Don Humpal, Douglas Merrey, and Edward Vander Velde.

The three papers by Douglas Merrey analyze from slightly differing perspectives local level sociological and ecological processes that have very important implications for irrigation system management and development policy at the macro level. The research was supported by a Social Science Research Council Foreign Area Fellowship in 1976-77. The first paper was originally titled "Local level management strategies and the state in the Indus Food Machine" and was presented at the symposium, "Lands at Risk in the Third World: Local Level Perspectives." sponsored by the Institute for Development Anthropology and Clark University Cooperative Agreement with USAID on Human Settlements and Natural Resource Systems Analysis, 10-12 October 1985. The author is grateful for the useful critical comments by Mark Svendsen. Hugh Plunkett, Robert Wade, James Wolf, and Thomas Wickham. The second paper was originally written while Merrey was employed on Colorado State University's Water Management Research Project in Pakistan under United States Agency for International Development contract number AID/ta-c-1411. The author is grateful to Hugh Plunkett, Ashfaq Mirza, John Reuss, and Brian Spooner for helpful comments. The third paper was prepared for presentation at the Sixth Afro-Asian Regional Conference of the International Commission on Irrigation and Drainage, 9-16 March 1987. The author appreciates and, in some cases, incorporates comments by Hammond Murray-Rust and Edward Vander Velde.

Both authors wish to express their appreciation to the editorial and production staff at IIMI.

In mid-1986, the Pakistan branch office of the International Irrigation Management Institute was formally established, and James Wolf was named its Director. These four papers inaugurate the important research of IIMI's new office. We hope they will stimulate policy discussion as well as collaborative research on the critical problems of irrigation management in Pakistan.

Douglas J. Merrey and James M. Wolf
October 1986

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COST AND FINANCING OF IRRIGATION SYSTEM OPERATIONS AND MAINTENANCE IN PAKISTAN

James *M.* Wolf'

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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'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.

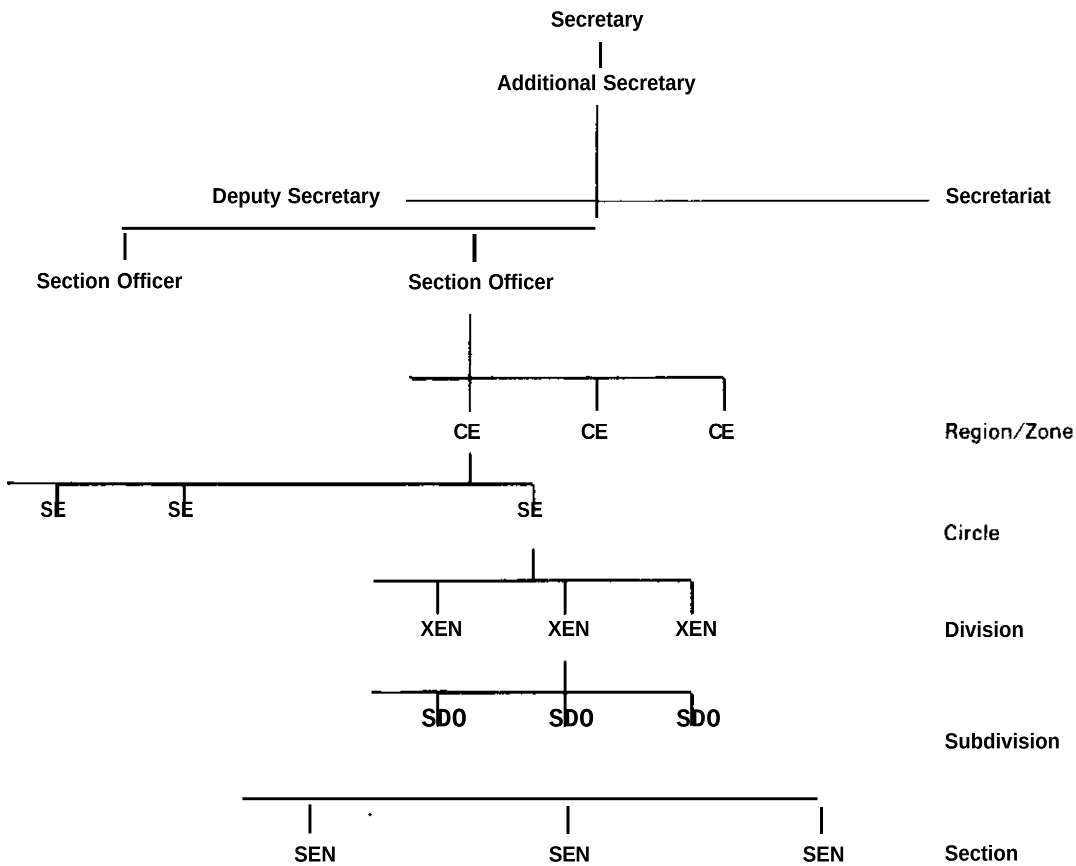
Whereas PID costs for surface water supply are largely for maintenance activities, PID costs for groundwater (tubewells) are about 75% operational - primarily electricity charges - and 25% maintenance, which includes repairs to motors, pumps, and wells.

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

Souice 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 (1 1 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$1 18 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.

THE LOCAL IMPACT OF CENTRALIZED IRRIGATION CONTROL IN PAKISTAN: A SOCIO-CENTRIC PERSPECTIVE

Douglas J. Merrey[1]

> The body of accumulating knowledge on civilizational growth in the past (and in the present?) testifies to the instability rather than the stability of large-scale socio-natural systems and the increasing uncertainty, rather than control, resulting from technoeconomic growth (Bennett 1976:147).

Introduction

Investment in irrigation to increase agricultural production has been a very important economic development strategy in many regions of the world for thousands of years. In ancient times, large scale publicly constructed and mangged irrigation systems were fundamental to the existence of centralized states in Mesopotamia, China, India, Sri Lanka, Egypt, and Mexico. In modern times, both developed natiops and the poorer developing countries assisted by international donors are investing heavily in irrigation development. It is hoped that this will lead to higher agricultural production, development of industries and markets, generation of revenues for the state, and improved well-being for the beneficiaries. Although such investments in new construction continue, there is increasing concern among both developing country governments and international donors that the investments in irrigation are not providing economic returns at the rates assumed during project planning. Far more attention is therefore being given to questions of how to improve irrigation system management and productivity, and how to increase the rate of cost recovery from beneficiaries in response to the spiraling recurrent costs of irrigation systems.

One of the first efforts in modern times to use massive irrigation investments to promote economic development was the construction by the British of large scale irrigation systems in India, particularly Punjab. in the 19th and 20th centuries. The British were pioneers and developed many of the technical criteria used in irrigation design today. They were relatively successful in constructing very large irrigation systems in a timely manner without major cost overruns. Construction was financed by raising funds in private markets and paying off the investors using funds generated from high irrigation fees charged to the water users. Huge tracts of land in what is presently Punjab in Pakistan were transformed from sparsely populated deserts and herding grounds into heavily settled intensively cultivated areas. For several decades in the early 20th century, Punjab was a major exporter of food and fiber.

Pakistan today is among the poorest countries in the world, with a per capita income in 1982 of under US$400 (World Bank 1985). Agricultural productivity is very low by world standards or compared to its potential. From the late 1940s until the early 1980s, Pakistan had to import about 25% of its annual wheat requirements and as much as 90% of its cooking oils. The Government of Pakistan, with assistance from international donors, has been investing billions of dollars in upgrading, extending, and improving the irrigation system it inherited from the British colonial government, and such massive infusions of aid will continue for the forseeable future.

Until recently these investments were predicated on the assumption that the problems are primarily technical and thus purely technical solutions are required. With hindsight, there is widespread agreement that the return on these investments has been less than anticipated. Some

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recent development programs do address organizational issues but they are focused at the local level on promoting water users associations and involve very limited tinkering with the local organization of the system. This limited approach is unfortunate because it seems increasingly clear that the problems are fundamentally organizational and political and not exclusively - or even primarily - technical. Thus, as argued by Spooner (1984), a "socio-centric" theoretical approach which takes account of the centrality of human activity is essential if the problems are to be clearly identified and appropriate solutions formulated.

This paper[2] analyzes changes in local resource management strategies and the environmental impact of centralized irrigation management in the Indus Basin since the mid-19th century. These changes are viewed primarily as responses to increasing interventions of the state, and the co-opting through centralization of what had been local functions by higher level bodies. This in turn has led to an inability to respond to local level problems before they reach crisis proportions. To interpret the trends and identify key problems and issues, the paper draws upon a systems theory model of the evolution of the state that was originally developed by scholars interested in the demise of Mesopotamian civilization. The analysis provides the basis for a short critique of present development programs and for identifying several key research questions.

Pakistan's **Irrigation System**[3]

The Indus Basin is a huge plain crossed by the Indus, Jhelum, Chenab. Sutlej, Ravi, and Beas rivers. The climate is arid to semi-arid, with low and extremely unreliable rainfall, thus necessitating some form of irrigation as a basis for stable agriculture. Since implementing the Indus Waters Treaty in 1960, Pakistan has used water from the three western rivers (Indus. Jhelum, Chenab). while India diverts most of the flow of the other three. The flood plains are subject to monsoon flooding. The higher land between the rivers was covered by grassy and woody vegetation before the construction of the canals, but today it is intensively cultivated.

The British began planning canal projects even before formally annexing the Punjab in 1849. The first canal - the Upper Bari Doab - began irrigating in 1861. Thereafter, the British continued building increasingly sophisticated and large-scale canals until the end of their rule. Since 1947. Pakistan with the aid of international donors has remodeled, expanded, and integrated the systems. Aside from several new canal projects, the Mangala and Tarbela dams have been constructed, and huge link canals completed to carry water from the western to the eastern river beds and canals. These are today components of the largest single integrated irrigation system in the world. About 63,000 kilometers of canals and distributaries carry water to about 90,000 watercourses, irrigation channels under farmers' control that carry water to farmers' lateral ditches and to their fields. About 14 million hectares are irrigated by the system.

The system uses barrages, a device to divert water from the rivers into the canals. These are designed for continuous operation at or near full capacity. The amount of flow cannot be regulated on demand except within very narrow parameters. However, flow may be interrupted during floods or for canal repair. Water flows continuously from canals into distributaries, then through ungated concrete modular outlets *(mogha)* into watercourses, and finally into farmers' ditches and fields.

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[2]This paper was inspired by two papers by Susan Lees (1974a and b), in which she took a similar approach to analyzing local trends in water resource management in Oaxaca, Mexico; in one paper (1974b) she notes specifically the similarity of processes in the Indus Basin.

[3]This section is based on the brief description of Pakistan's irrigation system in Merrey (1982). See also Merrey (1983) and Michel (1967).

The mogha is designed to deliver a fixed quantity of water when the canal is flowing at full capacity based on the area commanded. Although there is great variation in area irrigated and number of farmers, each watercoursecommands about 225 hectares cultivated by about 50 farmers. The Provincial Irrigation Department (PID) is responsible for operating and maintaining the system downward from the barrages to the mogha. The watercourse is legally the responsibility of the farmers who own land in the command area.

Each farmer has the right to a quantity of water proportional to the size of his land holding. Usually each farmer is allotted a period of time on a weekly rotation basis to take his share of water. Although these rotations were originally established by the farmers, most have been replaced by formal rotations devised by the PID. Farmers get water for a fixed period every week regardless of crop water requirements. Although water trading is illegal under formal rotations, it is common. The system was deliberately designed by the British to command the maximum area possible (about 140 hectares per cubic meter/second, or 0.21 liters per second/hectare) with a minimum of management necessary up to the mogha. Despite major remodeling at the macro level, canals are still operated according to principles established by the British.

This description does not convey the magnitude of the engineering achievement that supports Pakistan's irrigated agriculture, sometimes referred to as the "Indus Food Machine." The early British engineers were proud of their work, and that pride continues in Pakistan's PIDs. Nevertheless, severe problems plague the system.

Waterlogging and salinity problems date back to the first large canal constructed by the British in the mid-19th century. Despite research, the British never seriously addressed this issue. They found it cheaper or more profitable to expand the system rather than embark on major efforts to solve problems.

Following Independence in 1947, Pakistan discovered itself to be a food deficit country and had to import large quantities of wheat during the next **38 years**.[4] Studies during the 1950s and 1960s[5] clearly showed that the irrigation system faced a major crisis. Estimates suggested that 20,000 - 40,000 hectares were going out of production annually from waterlogging and salinity. Indeed. the system's productivity has remained low compared to its demonstrable potential and compared to other countries with similar conditions.

The combination of low productivity, food deficits, severe waterlogging and salinity, and Pakistan's general poverty have led to massive investments by donor countries since the 1950s to improve the irrigation system. For example, the United States Government's total investment up to 1977 was about one billion dollars. Investments have been made in dams, link canals, and large public tubewells to provide vertical drainage in waterlogged and saline areas. Referred to as the Salinity Control and Reclamation Program (SCARP), these wells have had some impact in controlling the water table and increasing cropping intensity by making more irrigation water available to farmers. But the program has proven so costly that questions are now being raised about continuing it.'

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[4] Pakistan has produced enough wheat to satisfy internal demand in only 2 of the past 38 years. Recently, the country has had to import US$ 250 million of wheat during a period whan it could not sell its surplus cotton (remarks by a senior official from the Government of Pakistan. 1985).

[5] The most important are the "Revelle Report" (White House 1964) and Lieftinck et al. (1969). More recent development strategies are set out in WAPDA (1979). which has been endorsed by all the major donors (see Peterson 1964). Johnson (1982) discusses these reports.

'See Johnson (1982). The number of private tubewells has expanded to an estimated 200,000 (Peterson 1984)

In addition to continuing SCARP programs and constructing new canals such as the Chashma Right Bank, donors have recently invested large amounts in watercourse improvement programs, rehabilitation of major canals (deferred maintenance), and the Command Water Management (CWM) scheme, which is an integrated rural development activity focused on irrigated agriculture. Present donor pledges total over USS1.15 billion, not including a left bank drain project and a new dam on the Indus (Peterson 1984:9-10).

In order to implement these large projects, the Water and Power Development Authority (WAPDA) was established in 1958. Several foreign advisory reports since then have recommended even more centralized planning and management for better coordination (White House 1964:179-84; Lieftinck et al. 1969:186-91). Based on such recommendations, donor pressures, and the bureaucracy's own predilections, all of the policies and solutions to Pakistan's irrigation problems since Independence have shared the same characteristics: "an orientation toward purely technical solutions, designed and implemented from the top down, with the financial and advisory aid of foreign organizations, and an assumption that the 'experts' know best what the problems are and how to solve them" (Merrey 1982:91). The most fundamental problem has not been addressed how should the Indus irrigation system be organized and managed?

Processes of Evolution: A General Systems Model

The problems characterizing Pakistan's irrigation system are not unique, and the experience of other hydraulic societies suggests that concern about these problems is. not misplaced. Similar problems have had profound consequences for large scale irrigation systems in the past. The dependence on a centrally managed canal irrigation system was as characteristic of ancient Mesopotamian civilization as it is of modern Pakistan. Despite technological innovations like power-driven tubewells and reinforced concrete dams, the same mechanisms, processes, and pathologies characterize the organization and development of both modern and ancient large systems.

Conventional wisdom once said there was a direct relationship in ancient civilizations between successful irrigated agriculture and the presence of a strong stable central government (Wittfogel 1957; Adams 1974; Jacobsen 1958). Only when government controls weakened did the irrigation system and the whole agricultural regime collapse.

This argument was recently reversed. Gibson (1974:7) argued that, "on the contrary, in Mesopotamia the intervention of state government has tended to weaken and ultimately destroy the agricultural basis of the country." Based on studies of a contemporary group in southern Iraq (Fernea 1970). as well as on archeological data, Gibson hypothesized that the cyclical rise and fall of kingdoms in Mesopotamia from the 4th century BC to the present is not related to the breakdown of administration (this occurs later in the cycle of decline). Instead, the cause can be attributed to state-managed irrigation projects that increased waterlogging and salinity and undermined long-term agricultural productivity, and, more deleterious, to government intervention at the local level which violated the fallowing essential to maintaining agricultural productivity. This intervention had the same origins in Mesopotamia as it has Pakistan: rising demand for food by growing urban populations and the need for revenues by the state.

Whitcombe's (1972) study of the disastrous impact of British irrigation schemes and agricultural policies in the Ganges River Valley (present-day Uttar Pradesh) shows that Mesopotamia is not an isolated case. The Ganges, Mesopotamian, and Pakistan systems share many features, which suggests these may be analyzed under one theoretical approach.

Flannery (1972). building on Rappaport (1969 and 1.971) and others, suggested a useful model based on systems theory to describe the evolution of the state. Flannery (ibid.:409) points out that human societies may be regarded as one class of living system, and the state as a very complex system whose complexity can be measured by two processes: the degree of segregation, which is the "internal differentiation and specialization of subsystems," and the degree of centralization, which is the "linkage between the various subsystems and the highest order controls in society." An explanation of the rise and decline of a state would focus on these two processes and their consequences. Furthermore, Flannery distinguishes among "processes." "mechanisms," and "socio-environmental stresses." He suggests that processes and mechanisms are universal characteristics of complex systems, while socio-environmental stresses which select for these processes vary over time and space.

This paper focuses on one of Flannery's processes (centralization), one mechanism by which centralization occurs (linearization), and two system pathologies (meddling and hyperintegration) which, in conjunction with socio-environmental stresses, lead to progressively greater stress and instability of systems.

Systems respond to stress by breaking down or changing (evolving); new institutions or control levels may emerge (segregation), or higher-order controls may be extended and strengthened (centralization). A mechanism by which these processes occur is linearization (ibid.:413), in which lower order controls are repeatedly or permanently by-passed by higher order controls, usually after the former have failed to maintain relevant variables within the proper **range.**[7] An example offered by Flannery is when central authorities take over local irrigation regulation from local institutions.

Linearization may lead to evolutionary change but it may also lead to new problems (ibid.). For example, linearization often destroys the intervening controls which buffer one subsystem from the perturbations of another. Such internal changes may lead to systemic pathologies which subject the system to further stresses leading to progressively greater centralization - "the process is one with many positive loops." Pathologies include meddling, which means "to subject directly to a higher order control the variables ordinarily regulated by lower order controls," and *hyperintegration,*[8] which refers to the over-integration of a system. This is a highly centralized and therefore potentially very unstable condition which results from the breakdown of the autonomy of subsystems and their tight integration, such that change or perturbation in one rapidly and directly affects the others (ibid.:420). Thus, in this multi-variant model,

> we might see the state evolving through a long process of centralization and segregation; brought about by countless promotions and linearizations, in response not only to stressful socio-environmental conditions but also to stress brought on by internal pathologies (ibid.:414).[9]

Flannery's intention was to contribute to developing a generative model for the origin and evolution of state systems. However, the model's relevance is not limited to ancient civilizations. For example, Lees (1974a and b) used Flannery's and Rappaport's models to discuss the increasing involvement of the government of modern Mexico in local irrigation systems in the Valley of Oaxaca. Government intervention (meddling) in formerly independent local irrigation systems led to increased agricultural productivity in the short run but also to insensitivity to local conditions.

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[7] **Flannery 11972) does not consider a Situation in which higher levels of the system change the expectatiosn *or* standards for iudging lower order controls (e.g., when the State presses for rapid increases in production).**

[8] **Flannery (1972) uses both "hyperintegration" and "hypercoherenece."**

[9] **"Promotion" refersto a process where an institution may rise to a higher level in a control hierarchy or a new institution may emerge from one of the roles of an existing institution.**

hyperintegration among the various subsystems. Lees suggested that the system was potentially unstable, and increasing environmental degradation as a result of the state's intervention would lead to diminishing returns from investment in hydraulic development. The short-run response to this degradation (mainly decreasing availability of water) has been further centralization: higher order controls have been strengthened as increasingly sophisticated and expensive technology has been required to extract more water from the environment. However, this centralization, as in Mesopotamia, leads to further degradation; "centralization will not correct the disturbance to the system but may exacerbate it" (Lees 1974b:174).

Lees observed that so far only short-term processes are observable in the contemporary Oaxaca system. Since the Indus Basin system has been in operation for only 130 years. relatively little time has passed from an evolutionary standpoint. Nevertheless, the system has grown rapidly and trends are emerging. The mechanisms, processes, and pathologies that constitute Flannery's model appear to characterize Pakistan's irrigation system. Therefore, analyzing the problems from the perspective of a systems model should provide important insights.

Because my original research focused on a particular village community in historical perspective, data are available on local management strategies and social organization. To date, however, there has been little research on the larger bureaucratic organizations that control the irrigation system. Thus, the remainder of this paper analyzes local level data using Flannery's (1972) system's model, and raises questions about the larger system to be addressed through further research.

Changing Resource Management Strategies in Gondalpur[10]

The Pre-Canal Period. Gondalpur (a pseudonym) is a village located about five kilometers from the Jhelum River, on the Chaj Doab, the interfluve between the Jhelum and Chenab Rivers. Politically, Gondalpur is in southern Gujrat District (Punjab) and borders Sargodha District. Since 1904, its land has been irrigated by water from the Lower Jhelum Canal (LJC). Although there are many colony villages[11] in the region, Gondalpur is an older village that predates the canal system. Historically, this region has been a backwater and not a center of political or cultural developments in Punjab.

At the time of the first British survey in 1857, Gondalpur had 67 inhabitants. Subsistence was based primarily on about 100 head of cattle, supplemented by agriculture on about 19 hectares of rainfed cultivation, with an additional 7.3 hectares irrigated by a recently constructed Persian wheel well.[12] The inhabitants were recent settlers on this land, though some claimed to trace their genealogy many generations back to a founder whose name is the real name of the village today. The cattle herders on the uplands had very close symbiotic relations with the people in the flood plains, where settled populations practiced intensive irrigated agriculture, and where a number of small towns were located.

On the active flood plain, which is flooded during the summer monsoon, wheat and other crops were cultivated on the residual moisture during the winter. On the less active portions of the flood plain, the water table was fairly high (9 - 15 meters), and there were a large number of Persian

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[10]This section is based on data presented in Merrey (1983: Chap. IV-VI).

[11]New settlements created as part of the canal development project in which people from East Punjab were settled.

[12]A persian wheel well is a continuous chain of pots or buckets for raising water from a well using animal power.

wheel wells used for irrigation. There were also inundation canals which carried summer flood waters to land away from the rivers, enabling an irrigated summer crop on the inactive flood plain. The wells were owned by individuals or small groups of people; the inundation canals were generally constructed and managed by local landlords with control over the requisite capital and manpower. However, the British survey in the middle of the 19th century, which followed a long period of political and economic uncertainty. indicated that most of the inundation canals were not operational. Gondalpur itself is located on the crest separating the upland from the flood plain. Its one Persian wheel well was marginal because the water table was almost too low (17 meters) for the lift technology of the period.

Local resources were controlled at the local level during the pre-British period. In Gondalpur, and indeed in most of Punjab, there were no large scale public works such as state-controlled canal systems. Although empires based in Lahore sometimes were able to extract tribute from the Gondalpur area through local centers of power, but this was probably not done consistently even during the height of the Mughal Empire.

With the extension of direct British rule, all this changed. The British carried out detailed surveys of land, people, and resources, and demarcated land into individual revenue villages *(mauza)*. Within each mauza individual holdings were demarcated in order to clearly define and record responsibilities for payment of land revenue to the state. This process of defining and assigning rights is called ***settlement.*** The settlement process in Gondalpur created a village community with a legal basis where none had existed before. It created a brotherhood of land proprietors sharing an official genealogical charter, and provided brotherhood members with individual rights of land. The differential possession of land rights and the exclusion of a significant portion of the community from such rights created a totally new basis for social relationships and social differentiation. It also initiated the process of centralization because a higher level and rather remote entity (from the point of view of Gondalpur's residents) took over the right to regulate land use. As part of this process, land not assigned to individuals became government land and the government then restricted the right to graze cattle or cultivate on its land. This centralization of control over land use rights, in conjunction with other factors, had a profound impact on local resource management strategies.

The restrictions on use of land not one's own and assignment of land rights to specific individuals or the state, along with other changes at the time (e.g., relative peace, increases in interregional trade, population growth), led to a shift in the uplands from semi-nomadic cattle herding supplemented by casual agriculture to a great expansion in rainfed agriculture and attempts to expand irrigated agriculture. Before the end of the 19th century, two more Persian wheel wells had been constructed in Gondalpur, although one of them never worked well because of the low water table. As part of this process, tenancy relationships became more formalized, and about 50% of the land was cultivated by tenants by about 1900.

More serious in the long run, speculators began purchasing, land in anticipation of the canal being built. This occurred during a period in the 1890s when there was a series of local droughts and epidemics, forcing villagers to sell land in order to survive. As a result, on the eve of the introduction of canal irrigation, over half of the land in Gondalpur was controlled by town-based landlords living outside of Gondalpur. Overall, the contrast between the upland and flood plain adaptive strategies had nearly disappeared, with the rapid population increase and the agricultural intensification on the uplands. However, upland agriculture, being primarily rainfed, was far more unstable and uncertain than flood plain cultivation.

On the flood plains, there was also a process of agricultural intensification, through construction of more Persian wheel wells and more inundation canals. The British made it public policy during this period to encourage private investment in such improvements, including inundation canals. One can say, then, that until about 1900 in this region, water resources continued to be locally managed and controlled, as a matter of public policy and fact. However, as a state whose finances were dependent on revenues from cultivated land, the British colonial government had centralized control over land, providing specific rights to certain persons over specific plots of land, and reserving a large portion of the land completely under government control.

The ***Post-Canal Period.***[13] Construction of the Lower Jhelum Canal (LJC)[14] was begun in 1897, and completed in 1917. Irrigation began along the upper reaches of the canal in 1901. In 1904, Gondalpur began receiving irrigation water. Today the net command area of the WC is about 628,000 hectares. Maximum design discharge at the head (Rasul Barrage) is 151 cubic meters per second (cumecs) or about 0.24 liters per second/hectare. Actual discharges vary widely by season and year, and often exceed the maximum when sufficient water is available (Bottrall 1978:4-8).

Developments during the decades before 1904 had prepared the residents of Gondalpur and its region for irrigation, because the response was immediate - within just a few years - the area cultivated in the village more than doubled and all of it was irrigated. The immediate impact of the introduction of canal irrigation was not radical. Rather, it intensified trends already evident during the pre-canal period: increasing dependence on agriculture with a continuation of a mixed rather than a mono-cropping strategy, a shift from grazing to stall feeding animals using fodder crops and residues from grain crops, an increasingly complex and hierarchical community social structure, and retention of a basically subsistence orientation toward farming. The laner occurred despite the (forced) necessity of growing more cash crops to pay land revenue, irrigation fees, various . illicit charges levied by the bureaucracy, and to buy a basic necessities.

However. the eventual impact of the introduction of canal irrigation was profound, radically changing the environment, local social structure, resource management strategies, and relationship of the villagers with institutions and forces outside the community. Of these, the impact of changes on land and water control in the flood plain and the uplands, appear to be responses primarily to increasing centralization through linearization and pathological tendencies toward meddling and hypercoherence.

Despite post-Independence legal changes ostensibly designed to protect tenants' rights, and two anempts at land reform, there have been no drastic changes in land laws during the 20th century which have a major impact on land use in Gondalpur, with two qualifications. One is that the threat of land reform laws has led large landlords to move tenants around more, lest they develop squatters' rights, and, in recent years, some tenants have been turned into daily wage laborers or annually engaged agricultural servants on land directly managed by the landlord. The other partial exception is the impact of land consolidation laws. The government attempted to implement a land consolidation scheme in Gondalpur in 1977, with very mixed results.

As !he WC was extended, most of the government owned land was allotted to settlers from East Punjab, effectively eliminating the remaining grazing areas. In Gondalpur itself, as mentioned above, over half the land was acquired by absentee landlords during the decade or so before irrigation began." Much of the area acquired by absentees was prime land during the pre-canal period because it was relatively low, being located on the periphery of the inactive flood plain. This area was particularly valuable because well irrigation was possible, though just barely, since the water

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[13] This section is based on data presented in Merrey (1983: Chap. VII-IX).

[14] The LJC is one of the anonymous cases in Bottrall (1981).

[15] By the late 1930s a few villagers had re-acquired about half of this land, all from one landlord. Today about a quarter of Gondalpur's land is owned by non-residents.

table was higher than in the rest of the village lands. More important, the area caught runoff from the rains, facilitating the successful cultivation of crops based on rainfall. Ironically, within about 25 years of the introduction of canal irrigation. most of this land became severely waterlogged, and somewhat saline. Today. although only a portion of this area is officially classified as waterlogged, much of it is in fact not very productive. A major portion is still owned by absentee landlords, and cultivated by very poor tenants who cannot make a living on this land. I return to this below.

A major consequence of the implementation of the WC was the complete loss of local control of water. On the other hand, compared to the pre-canal period, the quantity and predictability of water increased manyfold which enabled a shift from rainfed agriculture with some well irrigation to a largely irrigated regime. However, given the design of the system, with minimal latitude for manipulating water supplies except at the headwork (still within very limited parameters), the supply of water to the local users depends on decisions made at the headworks by the Executive Engineer. His decisions are based primarily on instructions from Lahore and the available water supply in the Jhelum River, and not on conditions or demand for water in the command area. The system is a supply- rather than a demand-driven system; that is, whatever water is available is distributed according to fixed procedures. The objective of these procedures is to spread water as equitably as possible over as large an area as is possible regardless of crop water requirements or farmers' demand at any point in time.

Very detailed data are available on cropping patterns since the beginning of canal irrigation in Gondalpur. While there have been adjustments in the relative importance of particular crops, and the addition of new crops such as rice and sugar cane in recent decades, the overall management strategy has not changed greatly. Gondalpur farmers, like most Punjab farmers, pursue a mixed cropping strategy, avoiding dependence on a single crop. During the summer (monsoon) season, the major crops in the early decades of canal irrigation were bajra (spiked millet), then a staple grain, but now primarily a fodder crop, cotton (a cash crop), and miscellaneous fodder crops. Today, paddy has become extremely important as a cash crop, as has sugar cane. During the winter season, wheat is the major crop (for cash in the past, primarily subsistence now). along with mustard, spinach, clover, and alfalfa (all used as fodder crops).

Cultivators' first priority is fodder for their cattle, followed by wheat for their own subsistence, and finally a cash crop in order to buy necessities and pay taxes and fees. Farmers use rotations and manuring to maintain soil fertility, but in 1977 at least they used minimal amounts of commercial fertilizer.

From the beginning, the intensity of agriculture along the LJC and in Gondalpur has been greater than the design intensity. Whereas the system was designed on the assumption that only 75% of the total command area would be irrigated in a year, from the beginning the actual sown area was around 96% and the harvested area was 85%. When supplementary water from the SCARP tubewells became available in 1965, the average cropping intensity for Gondalpur went to 140%. However, it dropped to 120% by 1975-76 because of increased waterlogging again.

Because the timing and quantity of water supplied is relatively fixed, and cannot be influenced by the cultivators, farmers attempt to match their cropping pattern to the water supply. Using rules of thumb, they plan the mix and area of their crops based on what they think they can irrigate during the season. They tend to stretch water at peak times and often under-irrigate; during periods when the crops need less water than supplied, they over-irrigate in an attempt to store extra water in the root zone. Both over- and under-irrigation are considered to be among the major causes of the waterlogging and salinity problems faced by Pakistan today. To oversimplify, over-irrigation contributes to waterlogging by raising the water table; under-irrigation contributes to salinization by leading to movement of salts upward in the soils through capillary action and evaporation, and by failure to leach salts downward below the root zone (Lowdermilk et al. 1978[II]:56).

When the canal was opened in 1904, the Persian wheel wells were immediately abandoned. This was generally true throughout the Punjab region, and has been reported as a key impact in 19th century Uttar Pradesh as well (Whitcombe 1972). In addition, the British and modern Pakistan governments as a matter of policy incorporated all the inundation canals into the larger system. These former inundation canals are now operated on a non-perennial basis: they receive water during the summer (monsoon) season when water in the system is plentiful.

The whole area was thus made completely dependent on one massive canal which was operated by engineers who resided over 200 kilometers from the tail of the system, and responded to commands from further up the system more than to demands and conditions communicated from below. The implementation of the WC is a clear case of centralization through linearization in which local control centers were by-passed as a higher level of the state took over control of the water supply.

Environmental Stress: Responses to Waterlogging and Salinity

Since Independence, waterlogging and salinity have come to be recognized as the most dangerous menace facing the irrigation system of Pakistan. However, the problem has a long history. Within a few years of its opening in the 19th century, the Western Jumna Canal in Uttar Pradesh was threatened by waterlogging and salinity. This became a major concern in the 20th century as canal irrigation expanded. In some areas, including the Chaj Doab itself, the problem was serious enough to threaten the viability of the canals. A Waterlogging Inquiry Committee began examining the problem in the mid-1920s. and the British experimented with various technical solutions. These included drainage, lining canals, restricting canal supplies and closing canals, and the first attempt at vertical drainage through tubewells on the WC itself.

There is considerable controversy over the actual extent and modern trends of waterlogging and salinity. In the late 1970s. some authorities claimed as much as 50% of the canal-irrigated area of the country had a water table of less than three meters and was thus waterlogged or potentially waterlogged, and as much as a third of the country's irrigated land was "strongly saline or sodic" (Malik 1978; Lowdermilk et al. 1978[II]:56-63).[16]

The causes of waterlogging and salinity are complex, involving both environmental factors and the design and operation of the canal system. A very flat terrain with low gradients combines with very heavy rains during the summer monsoons to create drainage problems that are difficult to solve. Design and operation factors include the absence of linings in main canals and the newer link canals, even in porous soils or where the canals are elevated above the ground, inadequate drainage facilities at all levels, and farmers' irrigation practices (which are responses to the design and operation of the larger system).

By the 1920s waterlogging had become a serious problem on the WC. In the area around Gondalpur the water table rose by as much as 18 meters above the pre-canal depth, to within less than a meter of the surface in some areas. Gondalpur and a neighboring village had several hundred hectares of land thrown out of production from waterlogging. The Mona Drain, which began functioning in 1928, was expected to drain this area. The water table had stabilized before

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[16] **The Punjab government estimates that seepage from the large link canals is causing the loss of 607 -** 810 **hectares per day to waterlogging - this would amount to 221,000 - 296,000 hectares per year. if correct (remarks by a senior official from the Government of Pakistan. 1985).**

the installation of the SCARP II tubewells in the mid-1960s. and operation of these tubewells is said to have lowered the water table in the area one to two meters where it has again allegedly stabilized. However, the quality of the water being pumped was declining by the late 1970s. and the whole SCARP program was facing severe Cost and management constraints (Johnson 1982).

The Gondalpur records reflect the impact of waterlogging, and the solution was to close the canals as of the early 1920s. During the 1920s and 1930s, the area defined in the records as rainfed (i.e., not receiving irrigation water) expanded slowly from about 3% of the total cultivated area in the first 5 years of irrigation to over 50% in the early 1930s. It dropped slowly thereafter to around 5% of the total cultivated area in the mid-1970s. It seems most likely that the high percentage of rainfed land in the 1920s and 1930s was the result of waterlogging and canal closures. The official figures on waterlogged and saline land in Gondalpur during this period were approximately 120 hectares or about a third of the total cultivable land in Gondalpur. However, these figures are suspect. Waterlogging was sufficiently serious that at least five land owning families were given new land in southern Punjab under a government scheme to compensate people whose land was put out of production by waterlogging and salinity.

The records indicate that the impact of waterlogging and the conversion of land to rainfed by the government (by reducing and stopping canal water supplies) combined with the worldwide depression in the 1930s to drastically reduce the productivity and incomes of Gondalpur farmers. The total annual estimated wheat produced in the village fell by 78% between the 1909-1917 average and the 1933-36 average. Whereas selling 33% of the wheat crop was sufficient to pay the annual irrigation and land revenue taxes in 1909-17, by the 1933-36 period these taxes were equivalent to 157% of the cash value of the wheat crop.

The official response to the waterlogging crisis in the Gondalpur area in the 1920s and 1930s illustrates several points. First, one of the consequences of over-centralization, especially in the absence of any effective communication upward in the system, is an inability to identify and respond to localized problems until they become crises. Thus, it was not until there was standing water on large tracts that had previously been cultivated that the government recognized the problem. Part of the solution was to build a drain, a necessary but insufficient action by itself. Another part of the solution was to reduce or stop canal irrigation supplies to large areas, including areas that were not waterlogged, thus reducing the productivity of a very large area and the incomes of many people.

This response is a clear case of the impact of hyperintegration. When a system is hyperintegated, disturbances or crises in one part of the system have negative impacts on other parts and that system becomes more vulnerable and unstable. In the case of Gondalpur, the system survived in the short run, but at the expense of a large (but indeterminable with present data) number of cultivators who had become dependent on the LJC.[17]

The official figures give the impression that waterlogging and salinity in Gondalpur declined during the 1940s and 1950s. However, there is a wide gap between the official figures for waterlogged and saline land and farmers' perceptions of the extent of these problems in the village today, and I am sure this discrepancy is not a new phenomenon. In fact, this region was chosen as the second SCARP site and large capacity tubewells operated by the government were installed in the area, including one on each of Gondalpur's three watercourses in the mid-1960s. These tubewells have lowered the water table somewhat and enabled both the intensification of

[17]Merrey (1983) argues that extraction of much of the surplus production from Small farmers in these early decades of canal irrigation had a fundamental and lasting impact on the system's capacity to respond to development opportunities today. If that argument has any merit, British policies in dealing with waterlogging were a major wntributing factor.

cultivation and the cultivation of crops such as paddy which require more water. However, according to official figures, the area uncultivated due to waterlogging in Gondalpur has increased by a factor of three since the installation of the tubewells. Based on our household survey,[18] and our observations as well as those of farmers, it is clear that waterlogging and salinity continue to have an important impact on the productivity of about 60% of the land in Gondalpur, far beyond what is recognized by the official figures, though further research would be needed to quantify the impact.

The SCARP tubewells are designed to both lower the water table and provide supplementary irrigation. However, they are operated by government employees according to schedules made up in a central office. The schedules are developed by electrical engineers based on expected electric supply (which is short), and are not based on local irrigation or drainage needs. Thus, SCARP water is often not available when most needed (i.e., in the early weeks of the paddy crop before the monsoon starts) or comes when less water is needed, contributing to the over-irrigation blamed on farmers.

This is a clear case of meddling. The SCARP system is a second imposed over-centralized system, and its operation is apparently not coordinated with the operation of the canal system even where the Irrigation Department controls both.[19] By operating in a way that ignores local demands, the SCARP tubewells exacerbate the waterlogging and salinity problems they are designed to solve, inducing further instability in the larger system in the long run. This is shown by the reduction in cropping intensity in Gondalpur from **140%** to **120%** due to waterlogging.

Conclusion

During the British period, a number of large scale irrigation systems were constructed on the various interfluves of Punjab, each managed from a central point by officials responsive primarily to directives from above but having little capacity to respond to demands from below. The British began linking different interfluves into larger systems, a process that reached its culmination in the **1960s** and **1970s** with the completion of the major dams and link canals. These integrated a number of already large, but separate, systems into one huge system. In order to manage this new system and the construction tasks involved, WAPDA was created in **1958.** Since then, WAPDA has expanded its role from construction to include operation of major dams and the national electric grid, construction of the SCARP tubewell schemes and management of some of them, and research into water management and land reclamation at the farm level.

During the **1970s.** when the government became very concerned about alleged mismanagement of water by farmers at the watercourse level, a new organization, the On-Farm Water Management Directorate (OFWM), was set up within the Agriculture Department to take the lead in inducing farmers to rehabilitate watercourses and do precision land leveling. New legislation was adopted in each province, ostensibly enabling the establishment of water users associations but in fact strengthening the power of the state over the watercourse. Farmers are now obliged to carry out maintenance themselves or repay the costs if the government does it for them (OFWM officials also have special roles in these associations).

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[18] Farmers reported that 93 hectares (27% of the cultivated land in the village) were seriously affected by waterlogging and salinity. The survey did not include land at one end of the village. constituting 33% of the total cultivated area. which is owned by outsiders and Cultivated by very poor tenant. This land (about one-third of the village) floods periodically and has lost production recent years as the water table has crept upward.

[19] It is also a case of hyperintegration of the electricity grid. in which local areas suffer as a result of constraints imposed elsewhere. Through its control of the dams (water supply) and the whole electricity production and distribution system. WAPDA presents an interesting case for further research on centralization issues

More recently. under Command Water Management (CWM) there is an attempt underway to integrate - hyperintegrate, if you will - institutions responsible for fertilizer supply, seed supply, extension, watercourse reconstruction, and the Irrigation Department itself. CWM Is presented ostensibly as a decentralization project which attempts to develop a degree of self-management at a localized level (James Wolf, personal communication). There is provision for farmer participation in this program but, similar to the OFWM program, such participation is based on the legislation described above, which defines a long list of duties and sanctions which the government can impose on associations not carrying out required maintenance. Government officials delegated to project areas by the Provincial Government retain control of water and other resources and continue to respond to directives from the provincial capital rather than to the demands of local farmers. All of these activities are directed at trying to impose state wishes at the local level, but they do not address the fundamental organizational issues in Pakistan's irrigation management structure.

With the financial and technical support of the major international donors, Pakistan is proceeding along a path in its irrigation development policies that began with the British colonial government. The processes of segregation (creation of additional institutions) and linearization (coopting lower order control institutions' functions by higher order control institutions) are leading to higher degrees of state control over irrigation water (i.e., centralization). But the system's problems are not solved, and additional new problems are created by the technical solutions implemented by the State, as well as by the performance of the new institutions. These lead to further centralization, and to pathological tendencies such as meddling with lower order affairs and hyper-integration. The state response is further centralize, and the process is exacerbated by a positive feedback loop: the more centralized the system becomes, the less able it is to respond to local level problems until they become crises threatening the viability of the system. And the responses to such local crises often have negative impact on other components of the system since the autonomy of local subsystems has been destroyed.

This paper does not prove a case but rather raises questions about the direction Pakistan is taking in developing its irrigation system. More is known about farmers' management strategies than about how the system works - how state institutions operate, relate to each other, and relate to farmers. This paper has applied an analytical framework to identify key questions and research issues. Much research is already underway in Pakistan with the support of USAID, World Bank. and others. But the focus is primarily on very technical issues and to a lesser extent on local organizational issues. However, the following questions are not being explored systematically:

1. To what extent has the proliferation of agencies (segregation) and concentration of control at high levels of the state (centralization) led to inappropriate intervention at local levels (meddling). inability to respond to local problems until they reach crisis proportions, vulnerability of the larger system to crises that get out of hand and reverberate throughout the system (hyperintegration), and a tendency for institutions created for particular systemic purposes (system-serving institutions) to become self-serving institutions?[20]

2. What management changes are feasible, given the design of the present physical system, and would allow for a greater capacity to respond to local level demands and problems, including an enhanced capacity for local level institutions to take back from higher level institutions some degree of control over local affairs? To what extent and at what level could the system be converted from a supply-driven system to a demand-driven system?

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[20] Flannery (1972:423) suggests that the evolutionary trend of institutions generally is from system-serving to self-serving.

3. What changes could be made in the present physical system to allow greater flexibility in management, greater responsiveness to local demand. and greater autonomy for discrete subsystems, including an enhanced ability for local groups to take responsibility for local level management? For example, the watercourses are far larger than most authorities think can be managed effectively and directly by farmer groups (Uphoff et al. **1985).** Would replacing these watercourses with a larger number of small watercourses be feasible, and would this enable greater local capacity to organize and manage the irrigation system.

4. What changes can be induced in the irrigation agencies themselves which would assist them to decentralize and become more responsive to local needs and problems while still maintaining an overall systemic perspective? For example, could this be induced through a bureaucratic reorientation process which has been successful elsewhere (Korten and Uphoff **1981)?**

5. If some combination of specific action research activities were undertaken to explore the above questions, what difference could be made in the productivity and long term viability of the system and the well-being of the people dependent on the system?

The paper began with a quotation from Bennett **(1976)** which notes the instability and uncertainty, rather than stability and greater control, that results from the growth of large-scale socio-natural systems. A better understanding of Pakistan's irrigation system from a systematic socio-centric perspective would test the validity of Bennett's observation, and could lead to strategies for achieving the potential productivity of the Indus Food Machine.

REORGANIZING IRRIGATION: LOCAL LEVEL MANAGEMENT IN THE PUNJAB (PAKISTAN)

Douglas J. Merrey'

Discussions of the problems facing irrigated agriculture in Pakistan usually begin with an irony: despite the favorable climate, fertile land, hard working farmers, and possession of the largest integrated irrigation system in the world, agricultural production is very low. It is low by any standard in relation to similar situations in other countries, to the potential demonstrated year after year on demonstration plots and - even more so - to the needs of Pakistan's rapidly growing population.

Before World War II, the area which is now Pakistani Punjab was a major exporter of wheat. By Independence in 1947 exports had ended. Output per capita continued to decline until the mid-1960s. By the early 1970s. with the adoption of high yielding varieties of wheat, per capita productivity had returned to the levels of the late 1940s, but during the 1970s it stagnated. In most years up to 1978 Pakistan had to import about one quarter of its wheat requirements. Although the figures have improved significantly since 1978, mainly as the result of the introduction of improved rust resistant varieties, yield per hectare remains low.

Although the irrigation system had originally been built in order to transform drylands into highly productive farmland, the productivity of large areas has been either destroyed or significantly reduced by salinity and a rising water table. A considerable proportion of the population now lives under the threat of this type of desertification. Some surveys show that more than half the approximately 13.5 million hectares of irrigated land in the Indus Basin are affected by varying degrees of waterlogging and salinity (Clyma et al. 1975a; Malik 1978). The situation is regarded so seriously that newspapers carry learned and often passionate articles by experts and frequent editorials urging more action.

There is considerable controversy concerning the seriousness of waterlogging and salinity in Pakistan, and whether the situation is deteriorating or improving. Two factors are responsible for the controversy: first, the relevant information is inadequate, inconsistent, and subject to different interpretations; second, because such large funds are involved in the various programs for controlling the problems, the whole question has become a political issue.

The process of deterioration is generally blamed on the twin menace of salinity and waterlogging. In order to reverse it, several programs have been launched to reclaim waterlogged and saline land by means of drains and high capacity tubewells to lower the water table (referred to as the Salinity Control and Reclamation Program or SCARP), and to flush salts out of the soil. Until recently, all the irrigation projects in Pakistan emphasized large-scale capital-intensive construction: SCARP tubewells, link canals, and dams - culminating in the Tarbela Dam Project on the Upper Indus River. This dam is billed as the largest earth-filled dam in the world. It is financed by huge foreign loans and is designed for both irrigation water control and the generation of electricity. It is important to note that these projects were based on research that was in turn based on certain assumptions about local level water management. The loss of water in watercourses before it reached the crops was assumed to be minimal, and due mostly to evapotranspiration. It was not thought to be adding to the water table. In particular, it was assumed that most of the water delivered to tertiary irrigation ditches (watercourses) reaches the root zones of the crops.

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In the early 1970s research teams from Colorado State University, in cooperation with Pakistani organizations, especially the Mona Reclamation Experimental Research Project (supported by funding from the United States Agency for International Development), began to explore the possibility that a major cause of the twin menace should be sought at the farm level.

They started by measuring watercourse and field application efficiencies. These studies demonstrated a wide variety in the delivery efficiencies of watercourses, but on the whole they were shown to be substantially lower than had previously been assumed. Overall, delivery efficiencies of watercourses seem to be less than 60% - often substantially less; that is, 60% or less of the water entering the watercourses reaches the fields. Unlevelled land, fragmented plots, and lack of knowledge about plant-soil-water relations reduce the efficiency of water use even further. Early studies in a SCARP area demonstrated that wastage of water in these areas is especially high, SCARP tubewells pump the ground water into watercourses where it mixes with canal water, increasing the available irrigation water, while lowering the water table. However, because of poor watercourse construction and maintenance, most of the water returns to the groundwater, minimizing the effectiveness of the SCARP program in reducing waterlogging. Overall, Pakistan's irrigation system is estimated to be operating at less than 30% efficiency; that is, less than 30% of the water diverted from the rivers is stored in root zones for crop use.'

These findings led to the development of pilot projects designed to improve the efficiency of water delivery and usage in order both to increase agricultural productivity and to reduce waterlogging and salinity. A key component of these projects was an attempt to induce local water users to cooperate in reconstructing and maintaining their joint watercourses. This component has also proved to be a major obstacle: it is quite difficult, though not impossible, to organize farmers to co-operate on a short term improvement project, but it is even more difficult to induce them to continue cooperating for maintenance and management of the watercourse on a longer term basis. This paper presents a case study of a reconstruction project on one watercourse and identifies the impediments preventing its successful completion. It also summarizes the results of a larger survey of organizational problems on improved watercourses. The basic argument is that a major source of the severe technical problems of Pakistan's irrigation system is ineffective organization of management especially at the local level; and attempts to improve the system so far have been hindered by the failure to recognize this social dimension of the problem.

The "Indus Food Machine": History and Development Plans

The history of the development of Pakistan's irrigation system is not long, but it is complex. The best recent account is that of Michel (1967), which draws on older histories of irrigation in Punjab plus British and Pakistani administrative and technical documents, and post-Independence research. Only a brief summary is possible here.

Environment. The Indus plain is a vast piedmont alluvial plain; the Indus River system has a mean annual flow of 175,156 million cubic meters in Pakistan, twice the mean annual water production of the Nile River (Johnson et al. 1977). The climate is predominantly arid and semi-arid: in the northern regions annual evaporation averages about 152 centimeters (cm) while in the south it is about 190 cm; annual precipitation ranges from 50 cm in the north to 7.5 cm in the south. The combination of low and unpredictable rainfall and sub-tropical arid to semi-arid climate makes irrigation a necessity for successful agriculture. Because the major portion of the modern system. as well as the research reported here, are centered on what is now the Province of Punjab in Pakistan, the remainder of this paper focuses of this area.

[2] The findings of the Colorado State University research are reported in Corey and Clyrna (1975); Clyma et al. (1975a and b); Reuss and Kemper (1978); Johnson et al. (1977); Eckert et al. (1975); and others.

The Punjab plains are crossed by six rivers, the Indus, Jhelum, Chenab, Ravi, Sutlej, and Beas. Since the implementation of the Indus Waters Treaty of 1960 between India and Pakistan, Pakistani Punjab has been utilizing the waters of the western rivers - the Indus, Jhelum, and Chenab; the bulk of the others rivers' water is utilized by India. The rivers are silt-laden and, because of the deposition of heavy silt particles, the beds are usually higher than the flood plains. The flood plains were (and still are) subject to flooding during the summer monsoon. The land between the rivers includes areas in the central portions that are above the flood plains. These high areas are called bar. Before the modern irrigation system these bar were covered by grassy and woody vegetation. They were exploited by semi-nomadic people with large herds of camels, sheep, goats, and cattle. These people also engaged in some rainfall agriculture, and cultivated small parcels of land irrigated by Persian wheel wells, an endless chain of pots worked by a gear and shaft mechanism and powered by yoked animals. These wells were often 15 - 30 meters deep.

Development of the System. The British began planning canal projects even before the annexation of Punjab in 1849. The first modern canal in Punjab, the Upper Bari Doab Canal, was opened in 1859 and irrigation commenced in 1861. Thereafter the British continued building increasingly sophisticated and large-scale canals, with stock-taking interludes between them, until the end of their rule. Since 1947, Pakistan, with the aid of international donors, has completely remodeled and expanded the system. Aside from several new canal projects, two huge dams (Mangala and Tarbela) have been completed, and link canals constructed to carry water from the western to the eastern rivers and canals to replace water retained by India. According to the official figures, there are some 62,790 kilometers of canals in Pakistan; and there are 88,000 watercourses, irrigation ditches that carry the water to the farmers' own lateral ditches and to their fields. These average over three kilometers in length. Of 14 million hectares of cultivable land with access to river water for irrigation, about 10 million hectares are irrigated and cultivated every year. It is no surprise that the system has been referred to as the "Indus Food Machine" (ibid.; Planning Commission 1978:3).

The British engineers who built the system had no previous experience in building irrigation works. When they began, they had little theoretical knowledge of hydraulics, and knew little about groundwater hydrology and the like (Michel 1967:50-51). Furthermore, modern construction technology - machinery and building materials - was not available at first. By trial and error and experiments they developed many of the basic formulas and techniques now used throughout the world.

The system uses barrages to divert water from the rivers into the canals. The canals are designed for continuous operation at or near full capacity, some year-round (perennial canals), some for only the summer season (non-perennial). They are designed to maintain a "stable regime;" that is, silting and scouring ultimately balance in the main canals (Michel 1967:61). But the amount of flow cannot be regulated on demand and it may sometimes be interrupted during floods or repair work. Water flows continuously from canals into distributaries, through concrete modular outlets (mogha) into watercourses (which often have several branches). and finally into farmers' laterals and onto the fields (Fig. 1). The mogha is designed to deliver a fixed quantity of water when the canal is flowing at full capacity. Each watercourse commands from 60 - 250 hectares of land, generally cultivated by from 10 to over 150 farmers. The Irrigation Department is directly responsible for the operation and maintenance of the barrages, canals and distributaries, to the mogha. It also lays out the route and commanded area of the watercourse, but its operation and maintenance are the joint responsibility of the farmers cultivating land in its commanded area. Individual farmers (or small groups) build and maintain small ditches (laterals) to carry water from the watercourse to their own fields.

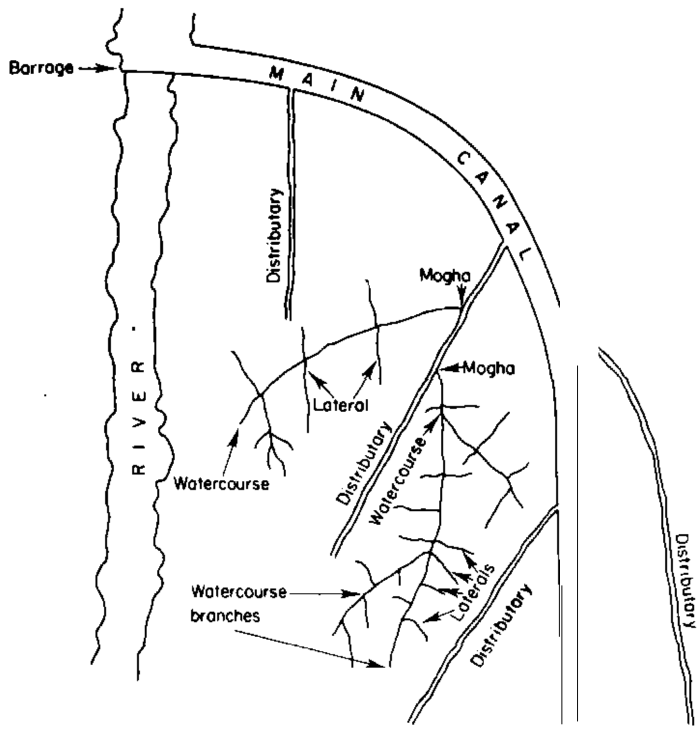

Fig. 1. Schematic diagram of canal system

Each farmer has a right to water proportional to the size of his land holding. Water is distributed on a time basis: each farmer is alloted a period of time to take water, usually on a weekly rotation basis. Originally the watercourse rotations *(warabandi)* were devised by mutual agreement among the shareholders. Shareholders who cannot agree on a rotation system may apply to the Irrigation Department to'establish a fixed legal system; most watercourses have now been converted to this pakka *warabandi.* Because it is a continuous flow system farmers receive the same share every week regardless of needs - which leads to periodic over- and under-irrigation. Trading of water among farmers is illegal because it causes waste, but it is commonly practiced.

The system was originally designed to operate with a minimum of human regulation or interference. For example, water is regulated at the head of the canal, but it is not possible to vary the flow into watercourses. Aside from engineering considerations, undoubtedly the British knew that recruitment of competent and responsible people would be difficult and a flexible system of water distribution would lead to uncontrollable abuses. They were also concerned to keep operational costs at a minimum since they were interested in recovering their investment quickly. These considerations also underlay the policy of minimal local intervention: farmers were expected to build and maintain their watercourses and settle disputes among themselves. The Irrigation Department retains considerable residual power, set out in the Canal and Drainage Act of 1873 (Jahania 1973). This power is used only when the shareholders appeal to the Irrigation Department. Similarly, the extension of irrigation included no instructions to the farmers on irrigation techniques. Farmers were left to their own devices (Johnson et al. 1977:1257). The major method continues to consist of the flooding of small basins. There is no adequate means of communicating information from the users to the higher level managers, or even from the top-down. Finally. no efforts have been made to organize farmers locally on either a formal or informal basis to manage the watercourse. The watercourse is a collective or "public good" which benefits all farmers using it, but there is no mechanism to insure that each contributes his share to its maintenance (Olson 1965; Lowdermilk et al. 1978[II]:119-29).

The British had several motives for building the canal system. In the beginning there was an idealistic and enthusiastic desire to extend irrigation to demonstrate the benefits of European science. A decisive motive for the first canal was to give employment to potentially disruptive Sikh army veterans. Another more important and lasting motive was to improve the agricultural value and thus the revenue-producing capacity of the newly annexed lands. Yet another motive was fear of famine (Michel 1967:65-66).

The earlier canals were mostly designed to improve agriculture in already settled areas. Later projects emphasized settling new waste lands, which involved not only canal building but laying out of new villages, cities, roads, railroads, etc., and distribution of land to settlers. The British hoped to reduce famine in India by making Punjab the "granary of India" and to relieve overpopulation in the eastern districts of Punjab by settling farmers from these areas on new lands.

Characteristics of Modern Indus Basin Development Plans. Michel (ibid.) provides a detailed account of all the programs that have been proposed to solve the problems of the Indus Basin irrigation system, and the results of their implementation up to the mid-1960s. In this section I do not discuss these programs per se but focus on certain common characteristics of the proposals and policies. Since the Independence of Pakistan and especially since the signing of the Indus Waters Treaty in 1960 with India, a series of distinguished panels and study groups have produced long and detailed reports on the problems of the Indus Basin and their solutions. Perhaps the most influential reports have been the so-called "Revelle Report" (White House 1964) and the World Bank report (Lieftinck et al. 1969). A more recent panel, of which Revelle was a member, has reviewed the Revelle Report's recommendations and progress (or lack thereof) *so* far, and offered a series of research guidelines and topics (Planning Commission 1978).

While these panels have suggested a wide variety of solutions to the problems of Pakistan's irrigation system, all of their recommendations share several basic characteristics. The first is that they all have emphasized engineering and technological programs: large-scale tubewell projects, dams and link canals, and the like. The White House (1964) report recommended a massive integrated extension program to get farmers to adopt modern technology, but this program never materialized. The second characteristic is that all of the advice offered has required massive capital outlays, mostly of foreign origin. Michel discusses Pakistani criticism of the SCARP tubewell programs made on this basis in the early 1960s - criticism that was not heeded and that Michel himself dismisses (1967:470-72). The third characteristic is that the implementation of the proposed projects requires continuous input from foreign experts; that is, foreign consultants financed by major donors to Pakistan have advised Pakistan to adopt highly capital - and foreign-expert - intensive solutions, many of which have been and are being implemented. Michel discusses this point and defends the use of foreign consultants, but his arguments are not entirely convincing (ibid.:357-64).

The final major characteristic of the advice given in the Revelle and World Bank reports concerns the administration and organization of the system. Neither panel included any kind of social scientist other than economists. No research data on organization were available, but there is no indication in the reports that this was perceived as a handicap. Both reports were written after the Water and Power Development Authority (WAPDA) had been set up to execute the large scale water, power, and reclamation projects envisioned by Pakistan's planners; in fact, Michel suggests that one motivation for establishing WAPDA may have been to attract foreign aid (ibid.:350). The few pages devoted to advice on organizational matters (White House 1964:179-84; Lieftinck et al. 1969[II]:186-91) suggest further centralization of planning and management at the highest levels, and better co-ordination of the various organizations involved. No serious consideration seems to have been given - either by the foreign advisors or by the Pakistani planners and administrators -

to the problem of the relationship between the users of the irrigation water and the managers of the system; all assumed that the problems and their solutions were ones the planners understood best and could impose from above. One short paragraph in the Revelle Report, entitled "Long Range Goals," does suggest that "a central hope for the future should be the gradual emergence of associations for farmers...." (White House 1964:184), but this obviously was for the future, after the system had developed; it was not recommended as a strategy for developing the system.

More recently, for the first time in Pakistan's history, research has begun to focus on local level water management, This research has identified local level waste and mismanagement of irrigation water as a key constraint on improving agricultural production as well as a cause of waterlogging and salinity. Research on a similar irrigation system in India suggests that certain characteristics of the administration of the system itself result in farmers' uncertainty about their water supply, and this is a major constraint on productivity (Reidinger 1974; Gustafson and Reidinger 1971). All of this research has resulted in a recognition of the importance of local organizational factors, and recommendations for forming local farmer organizations (Water Management Research Project 1976 Planning Commission 1978).

Many of these recommendations, however, retain the "engineering mentality" of earlier advisors; that is, farmer participation and organization are viewed as being of the same order as technological problems: the function of research is to discover the appropriate organization of design - "the solution" - and introduce it. Just as the problems of rising water-tables, salinization, and inadequate supply of irrigation water are "solved" by installation a network of tubewells, so, it seems to be assumed, inadequate organization can be solved by installing a new farmer organization. Furthermore, only the formation of local organizations with vaguely defined but limited responsibilities have been suggested. There has been no consideration of the dynamics, the adequacy, or the consequences of the present organization of the irrigation system.

Most of the high-powered recommendations and the policies pursued to date, then, share the same characteristics: an orientation toward purely technical solutions, designed and implemented from the top down, with the financial and advisory aid of foreign organizations, and an assumption that the experts know best what the problems are and how to solve them. Although the major reports and recommendations are thick and comprehensive, none have seriously addressed the most fundamental problem of all for the future of the Indus irrigation system: how should it be organized? What should be the role of its users in its management? What have been the consequences of the present organizational structure? Policy based on faulty assumptions about the goals, values, ability to co-operate, and behaviors of local users is bound to fail. For example, if local irrigation associations were established in Pakistan and the legal framework for these organizations were to specify Western rules and procedures, such as decision-making by majority vote and some version of Robert's Rules of Procedure, these organizations would probably not work in the way envisioned by the planners. Such procedures are inconsistent with local users' decision-making patterns as well as with the prevailing stratified socio-economic structure of rural society. The remainder of this chapter illustrates the potential of an approach from social science towards the problems of designing and evaluating programs to involve the farmers in local irrigation improvement projects.

Watercourse Reconstruction: A Case Study

Gondalpur (a pseudonym) is a village in central Punjab, on the Chaj Doab, the area between the Jhelum and Chenab Rivers. This area has traditionally been called Gondalbar, because historically the Gondal tribe dominated the area. In the flood plains among the rivers, intensive agriculture based on flooding by the river, inundation canals, and wells, has been practiced for centuries. Being located above the flood plain, Gondalpur had no canal or inundation irrigation before 1904. The vegetation of this semi-arid area consisted of various small and deep-rooted trees which provided fuel, fruit, and fodder, and a variety of grasses on which the ancestors of the present inhabitants raised large herds of cattle. At the time of the first British survey in 1857. there was one Persian wheel well irrigating 7 hectares; irrigation was also practiced during the monsoon by catching runoff in a low place, and planting primarily millets, By the 1880s, 30 years after British rule was established in the area, there were 3 Persian wheel wells. The wells tapped a water table 15 - 25 meters deep, so that even with good oxen or buffaloes, only about one-fifth of a hectare could be irrigated in a 12 hour turn.

Informants claim that animals, not land, were wealth: a man's standing in his community depended mainly on the size and quality of his herd. Agriculture was meant to supplement a diet which was based on dairy products and meat. The British land records show that the short-lived previous regime of Ranjit Singh had imposed a head tax on animals and no tax on land in this village. The British discontinued this policy and imposed a moderate (in their eyes) land revenue. This meant that land had to be registered in individuals' names - an innovation. Informants say that their ancestors regarded this as an unfair burden and some sold or gave their land rights to others for almost nothing. Stories are told of how people in nearby villages punished their enemies and servants by having land registered in their names.

During the 49 years between the first British land settlement and the arrival of the canal water in Gondalpur. however, there was a substantial rise in population and a gradual extension and intensification of agriculture (Table 1). Population grew far more rapidly than did the extent of cultivable land, mostly as a result of immigration. There was also a fairly large-scale transfer of control over land to outsiders - and a concomitant increase in tenancy. The Lower Jhelum Canal was officially opened in 1901, but its water did not reach Gondalpur until the 1904-05 winter *(rabbi)* growing season. Its impact was immediate: scores of hectares of land came under cultivation during both the summer *(kharif)* and winter growing seasons. Former cattle keepers and part-time farmers became full-time farmers, either on their own land or as tenants on others' land. The area available for grazing animals declined while the number of animals increased, so that even a few years before the canal was introduced most farmers had begun devoting a substantial percentage of their land to growing fodder for their animals. Other changes since the introduction of canal

Table 1. **Changes in population and cultivated area in Gondalpur since 1857.**

Year	Population	Areas of crops harvested to hectares			
		Rainfed	Irrigated		Total
			Well	Canal	
1857	67	18.8	7.3	0	26.1
1890-91	310	87.1	17.2	0	104.3
1901-02	568	69.3	18.2	0	87.5
1905-06	na	4.5	0	194.4	198.8
1910-11	565	0	0	233.7	233.7
1921	767	2.0	0	315.1	317.1
1931	758	133.4	0	139.7	273.4
1951	914	40.5	0	242.6	283.1
1961	1117	25.9	0	313.9	339.8
1972a/	1246	36.5	0	384.3	420.8
1977b/	1450	21.4	5.2	356.2	382.8

Sources: **All data are from unpublished village records except the 1961, 1972, and 1977 population figures. The 1961 and 1972 population figures are from the District Census Handbooks for those years; the 1977 population is based on a census carried out by the author and his wife in February-March 1977. "Na" means "not available." a/ The figures for area harvested are 1968-69 figures, the closest ones available to the 1972 population figure. b/ The figures for area harvested are for 1975-76.**

irrigation include: a further rise in population; increasing fragmentation of land holdings; major changes in diet; increasingly intensive agriculture; and a rise in the water table of 12 to 20 meters, so that today nearly everywhere it is less than 6 meters below the surface, and in some it is less than a meter and a half. A large low-lying tract in Gondalpur has become waterlogged and an adjacent previously productive area is now saline and unproductive. The major crops today are wheat and fodder crops in the winter, and rice, sugar cane, fodder crops, and some melons and cotton in the summer. Most of the land is double-cropped every year.[3]

Watercourse Social Organization'. The dominant landowners in Gondalpur, the Gondals. are divided into four named *biradari,* brotherhoods which are local co-resident groups based on a combination of patrilineal descent and marriage (Alvi 1972). The biradari are concentrated on different watercourse branches (Fig. 2).

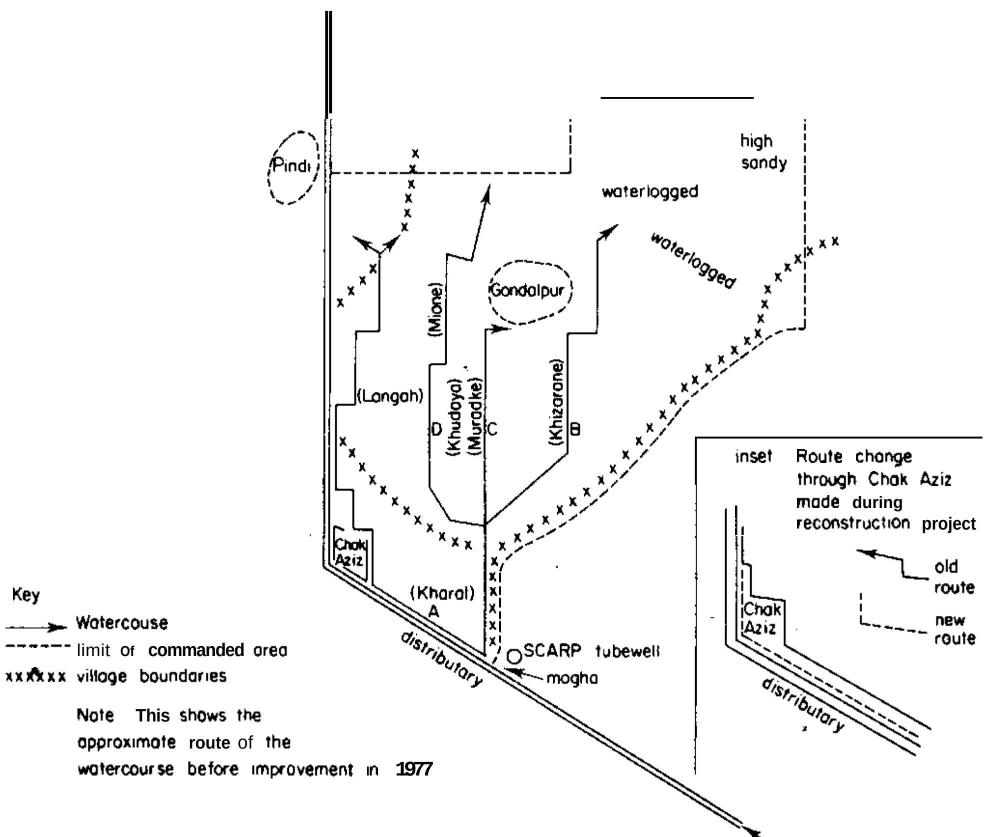

Fig. 2. Sketch map of Gondalpur watercourse branches.

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[3]The changes in Gondalpur between 1857 and 1977. both those that preceded and those that followed the introduction of canal irrigation. are the subjet of D. Merrey (1983).

'Much of the material on the watercourse reconstruction project and implications of the concept of *izzat* appear in Merray (1979)

Table 2 shows the relationship between biradari and watercourse branch. The Gondal biradaris are Khirarane (branch B), Muradke (branch C), and Khudaya and Miane (branch D). The first three so dominate particular branches that they are known by their names. Besides the Gondals, families belonging to other groups or *zat,*[5] also have land on various branches. A few Awan have very small holdings on branches B and C; two Bhattis have some land on branch B, as do three Sayid families; and some Muradke and Khudaya have land on branch B, though most of this land is either waterlogged or saline, or too high for irrigating. On branch D, aside from the Khudaya, a few Pindi farmers also have land, as do the religious leaders of Gondalpur, the Miane. The *numbarda*[6] and his family, who have relatively large holdings (20 - 30 hectares) are Khudaya; the Miane holdings are also relatively large (about 10 hectares for each of three households), while the other two Gondal biradaris are mostly small farmers (2 - 8 hectares). Ehattis outnumber Gondals in the village as a whole as do the Massali laborers, but the former are mostly tenants and the latter landless and poor.

Table 2. Biradaris involved in watercourse reconstruction?'

	Number of Households	Number of People	Watercourse" branch	Position on branch
Gondalpur biradaris:				
Gondal-Khudaya	11	70	D; a little on B	H, M. T
Gondal-Khizarane	212	105	B	H, M, T
Gondal-Muradke	7	43	C; a little on B	H, M, T
Gondal-Miane	5	36	D; a little on A	M, T
Langah	5	36	A	M
Awan	11	47	B and C[c/]	M
Bhatti-Rajeane[d/]	18	78	B (2 households)	M
Sayid	3	25	B	H, M
non-Gondalpur biradaris:				
Kharal (Chak Aziz)	3	?	A; a little on B	H
3 Pindi biradaris[e/]	under 10	?	A & D	Ton both

Notes: Branches: A - Chak Azir, B - Khizarane. C - Muradke. and D - Khudaya H - Head, M - Middle, T - Tail, [a/] This is not a complete list of all biradaris in Gondalpur; only those having land irrigated by the reconstructed watercourse ar listed. Values are based on 1977 complete household census. [b/] See Figure 2. [c/] Very small holdings. 'Only two households of this biradari have land on this watercourse. There are 7 Bhatti biradaris in Gondalpur with a total of 90 households and 416 people as of 1977. [e/] These biradaris did not play an important role in the improvement project - their major holdings are on other watercourses; they generally acted together on this project.

[5] *Zat* is a cognate of the word usually translated as "caste" or "sub-caste" in North India, but caste is not a proper translation of zat here since zats as understood in Gondalpur are not endogamous or systematically ranked vis-a-vis each other. For a complete discussion of ceste in Gondalpur (and Pakistan Punjab) see K. Merrey (1983).

[6] *Numbardar* is a hereditary position created by the British: he collects the land revenue and irrigation fees for the government, keeping a percentage for himself, and acts as an intermediary between the villageis and government officials.

At the head of branch A, where it passes through Chak Aziz, are four related households of Kharal zat. One is a very large landowner (about 122 hectares), having bought much land in a nearby village. His brother has about 20 hectares on branch A and their half-brother's two sons have about 20 hectares between them. Though these two brothers often quarrel with each other, they did not during the watercourse project. I shall refer to them collectively as the "step-nephews." Following the Kharal, on Gondalpur land, branch A irrigates the land of several very small farmers (0.5 - 9 hectares) of Langah zat. The members of this zat, though poor, have marriage relations with the Khuydaya, Muradke. Kharal, and a large Pindi landlord. Some of the land belonging to the Miane is irrigated after the Langahs by branch A, and finally, at the tail, branch A irrigates small portions of the relatively large holdings of several Pindi families.

Watercourse Conditions Before Reconstruction. At the time of the study (1976-77). the level of maintenance of all the branches on the watercourse was extremely poor. A SCARP tubewell had been installed at the head of the watercourse in the mid-1960s. doubling the amount of water flowing through it. As is generally the case in the SCARP areas, the intensity of cultivation increased substantially as a result of the increased water supply. Most land is now double-cropped each year on this watercourse. However, the capacity of the watercourse was not increased. Furthermore, for some years after the installation of the tubewell, there was no perceived shortage of water. According to informants this led to a decrease in maintenance efforts, atrophying the already weak sanctions enforcing participation in watercourse cleaning. Further, fragmentation of plots has led to increased numbers of illegal (that is. not sanctioned by the Irrigation Department) cuts in the main water channels. The watercourse on all branches was choked with grass, bushes, and trees; leaked through rat holes, thin banks, and at junctions; and water remained standing in many low sections after irrigation. On branch A, since the Chak Aziz land is relatively high, the Kharal owners actively sabotaged efforts to clean the head of the watercourse. Silting raised the water level, and thus their ability to irrigate their high land, but it blocked a large percentage of the water from reaching the middle and tail farmers.

The Reconstruction Process. The lack of watercourse maintenance, combined with increasing pressure to raise production (in part limited by the water supply), had created considerable dissatisfaction with the condition of the watercourse by 1976. In response to this dissatisfaction, I was instrumental in arranging for the Mona Reclamation Experimental Project to choose this watercourse for an experimental improvement program.' In this program, the Government supplies technical advice, supervision, and materials such as concrete outlets *(nakka)*. The farmers are responsible for supplying all labor for the earthen improvements, masons for installing outlets, concrete sections, and culverts, and for subsequent maintenance. Some Gondalpur farmers had heard about the success of the improvement program in other villages: according to a survey they were aware that the losses from their watercourse were high and they were eager to improve it.

The improvement program on this watercourse undoubtedly faced more problems than is usual on a single watercourse, but this makes it an important case to study as all of the problems encountered characterize other watercourse reconstruction efforts to various degrees. A description of all that happened during the six months of active improvement work would constitute a book in itself; a brief summary will show the kinds of problems faced by the project.

At a farmer meeting in June 1977. two committees were set up: one, for branch A, included a Kharal representative from Chak Aziz (the youngest of the two step-nephews), a Gondalpur Langah, and Pindi numbardar. For the main branch and branches B, C, and D, one Khudaya, one

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'The arrangement was that I would observe, but not participate in. the process; in fact. people often sought my intervention to influence the engineers and upon occasion I did offer suggestions to the Mona Project personnel - which were rarely followed.

Khizarane. and an Awan were chosen. The branch C Muradke refused to take part in the improvement program on their branch and therefore had no committee member. There were several reasons for their refusal: they did not perceive much of a water shortage; they preferred to continue cutting their watercourse freely; and, because they were angry at their Awan relatives over unrelated issues, they opposed any program the Awan supported.

Work began on branch A - but on the same day as an announcement of land allotments under' the land consolidation program in Gondalpur; therefore, only Chak Aziz shareholders were present at the work site and they successfully pressured the Government engineer to start work on a new route for the watercourse that was parallel to the distributary around their village (see inset on Fig. 2). This route had been discussed previously and opposed by the middle shareholders, but now it became a fait accompli and they could not oppose it. Because the old route had passed through the step-nephews' land and another Kharal's courtyard, while the new one is on Government land and higher than the old one, the Kharal benefited substantially from this change.

Over the next few months work continued fitfully on branch A, and the engineer had branch D and B work begun even though he had not yet done a survey to indicate the route, width, and depth. The farmers on B and D noticed that their water supply was reduced as a result, leading to considerable tension between them and the engineer. At the meeting with the farmers, the engineer accused the farmers of not co-operating with him and gave them an ultimatum - to follow his instructions without argument or he would abandon the project. The farmers were angry but agreed to his demands. These branches were then surveyed and the work redone.'

A number of disputes broke out among the farmers (aside from a series of continuing disputes between the farmers and government officials):

1. On branch D, two Khudaya, the numbardar (supported by the Miane), whose lands were at the head and middle, and his paternal cousin, a watercourse committee member most of whose land is at the tail, disputed over how far towards the tail the improvement work should go. The numbardar and Miane wanted the work to stop about 300 meters short of the cousin's land, so that no improvement work would be done on the section through their land. When the tail cousin refused to cooperate unless his demands were met the numbardar agreed, though the Miane continued to protest and refused to cooperate on the work.

2. The Miane, near the middle and tail of D, continued to dispute with Khudaya over how far the improvement should go and over the route of the watercourse. The engineer, based on his survey, wished to straighten it. Because it skirted the edge of Mianes' land and over the years had shifted, increasing their land, moving it would have reduced their land slightly. It was straightened, finally, but over their continuing protest.

3. On branch B, the Khizarane leader frequently argued with Muradke, Khudaya, and Sayid shareholders over the division of the work.

'There were significant differences among the branches in the organization and efficiency of the work. Except for a few portions of branch D done collectively. the work on each portion of all the branches were divided among the shareholders proportionally to the amount of land they irrigated. The large farmers at the head and tail of branch A had their tenants and servants do the work, while the small farmers in the middle did their own share - and did it more quickly. Most of branch D was doen by tenants, servants, and hired laborers, and more time was spent smoking and gossiping than working, significantly slowing the work. All but a few of the branch B shareholders did their own work, and theirs was completed very quickly.

4. On branch A, the Pindi shareholders and Miane were lax about doing their share of the work, leading to conflict with the others and long delays in completing the section.

5. The Langah committee member and the Kharal member disputed over the route changes in branch A demanded by the Kharal, as well as the division of work shares. Because of his weak position, the Langah pursued these issues more with the engineer than with the Kharal directly. In every case, the Kharal won because both the government officials and other farmers feared the consequences of the Kharal not cooperating given their strategic position on the watercourse,

6. The Kharal step-nephews, who had traditionally taken unauthorized water from the main branch, successfully sabotaged the work on that branch, including preventing the removal of trees and straightening the route. There seemed to be three reasons for their obstructionism: they realized that taking illegal water from the main branch would be more difficult; they would lose a little of the land they had occupied if the watercourse were straightened; and they were jealous. They opposed any program that would benefit the weaker Gondalpur people, perhaps fearing they would become independent.

7. The Kharal demanded and, by threatening to sabotage the project, obtained extra nakkas and double-sized culverts for their land but even after getting them the two step-nephews in particular continued to sabotage the work.

A project that was expected to be completed in less than two months was not finished in December 1977. the sixth month, when I left. When I returned in May 1978, I discovered that some sections still had not been reconstructed, especially in the middle and tail sections of A and B; some of the sanctioned nakkas had not been installed and several of the installed ones had been damaged; and no cleaning or maintenance had been done. All the branches were choked with weeds and silt and leaked from new unauthorized cuts in rebuilt banks. Even in October 1978, the normal watercourse cleaning in preparation for the winter season had only been haphazardly done.

The sections completed up to December 1977, immediately after reconstruction, did not leak, and farmers enthusiastically reported up to five times as much water reaching their fields as before. However, by October 1978. the water delivery had drastically declined to only slightly above pre-improvement rates. The watercourse sides, because of both poor construction and very poor maintenance, had deteriorated considerably and were leaking badly; much water remained standing in the ditch after irrigation and many farmers felt discouraged about the prospects of maintaining even the present level of efficiency.

Punjabi **Culture: The Game of Izzat**

There is no doubt that one source of the problems faced by this project is the relationship that developed between the farmers and the government officials supervising the program. Although some of these engineers and extension workers have rural backgrounds, their education has seemingly made them unfit for rural work. Possessing a formal degree and a respectable position in the government bureaucracy, they are "officers." They create barriers between themselves and their clients by wearing western clothes, speaking an urban dialect, and doing all they can to create the impression that they possess a superior knowledge and position which ought to be respected. When the clients assert themselves and refuse the officer the respect (read obeisance) he claims, conflict arises and the officer's low opinion of his clients is confirmed in his mind. This kind of relationship between government officials and farmers is not confined to Pakistan.

Another factor was that the potential benefits of the program were not perceived as equally distributed (Doherty and Jodha 1977). Indeed, equal distribution of benefits in a watercourse reconstruction program is impossible to achieve because of differences in size of landholdings, differences between owners and tenants, and most crucial, the relatively greater benefits accruing to farmers with land at the tail than to those with land at the head of the watercourse. Even if the benefits of reconstruction were distributed equally. one could argue that any rational individual will minimize his contribution toward such a collective good because he cannot be denied its benefits even if he does not invest in the project (Olson 1965). However, the active attempts by the step-nephews to sabotage the program, even on other branches in order to prevent others from benefiting, and the disputes that developed among persons whose benefits were about equal, suggests these factors are insufficient as explanations of the problems encountered,

A major source is to be sought within the social organization and culture of rural society. Punjabi rural society is characterized by a set of values and structural mechanisms which - in relation to their irrigation system - encourage conflict, make it endemic and unavoidable, and thus tend to discourage co-operation on a long term basis. These values may have been adaptive before the irrigation system but have continued to operate even though they appear maladaptive under present conditions.

The ancestors of the Gondalpur farmers who were cattle herders and part-time farmers were probably not permanent residents of Gondalpur before the British settlement. This settlement awarded permanent rights that had not existed before. One characteristic of pre-British Gondal society was relative mobility of individuals and families: larger local groups were unstable as people were free to move and often did move with their animals. The type of situation now known as the "tragedy of the commons" (after Hardin 1968). in which individual herdsmen continue to increase the size of their individual herds even after the carrying capacity of commonly owned grazing lands had been exceeded, did not arise because people were able to leave for less crowded, if not greener, pastures. It seems likely that under these conditions it was not necessarily recognition of overgrazing per se that triggered dispersion but rather a high incidence of social conflict maintained dispersion.

The most fundamental concept or theme in rural Punjabi culture, in terms of which much of Punjabi behavior can be understood. is ***izzat***.[9] Izzat may be glossed as "honor," "esteem," "reputation," "status," or "face." It is a "limited good" (Foster 1965) and one acquires it only at others' expense. As in a zero-sum game, the success of one person is a threat to all the other players, a characteristic that generates competition and jealousy. For example, when government officials agreed to a very reasonable request for a double-width culvert for truck access to one of the Kharal's brick kilns, his step-nephew demanded a double-width culvert for himself. Informants said his izzat was at stake: if he got less than his step-uncle he would lose izzat. Government personnel, not accepting the rules of the local izzat game, rejected his demand, which led to further problems with the man.

All men wish to avoid losing izzat. but many men also attempt to increase their own izzat or reduce others'. One acquires and increases one's izzat by several different strategies. First, one must have the ability and, more importantly, the willingness to use force. There is a famous Punjabi saying, "Whoever holds the stick owns the buffalo." This does not necessarily mean force is resorted to frequently; it is enough to create the impression that one is willing and able to use force and, in times of tension, much calculation and speculation revolves around this issue. The Kharal step-nephews were feared because they had demonstrated their willingness to use force in previous fights. The Bhattis of Gondalpur. mostly tenants and poor, in the past also had a high

[9] *Izzat* is the most common and broadest term; there are others but they tend to have more restricted meanings. The term has obvious affinities, conceptual and historical with the Middle Eastern and Mediterranean concept of "honor" (see Peristany *1966* and Campbell *1964* for examples).

izzat for the same reason. On the other hand, the Khudaya numbardar, despite land holdings, his official position, and several adult brothers, had less izzat then he might have had because it was known he feared violence. This was not an unreasonable fear since his father had been murdered in 1962.

A second means of acquiring izzat is possession of inftuence with government officials, and willingness to use it for one's supporters and against one's enemies. The Kharal step-nephews, some Pindi landlords, and a recently deceased poor and landless Bhatti leader before his death, all had a substantial amount of izzat from this source (as did the author). A third source is willingness to entertain guests lavishly, whether they are government officials or relatives at a wedding - even to the point of bankruptcy. The deceased Bhatti leader mentioned above kept himself bankrupt but high in izzat by this strategy.

Success in competition, whether in organized games such as kabadi or in a stick fight, is another source of izzat. Winning, not a valiant loss, is the key. Another source is generosity. not to the general public, but towards individuals (who are obliged then to render support)." Finally, successful one-upmanship, including revenge for a previous defeat or insult is important. For example, disputes are often taken to the police; the person or group that can avoid jail or being beaten by the police, while getting the opponent punished and spending the least money doing it, "wins." Such cases often become very long, involved, and expensive but they continue even when people are aware that after so much trouble and expense they will have nothing tangible to show.

In order to improve izzat, ***taqat*** (strength or power) is needed, but taqat alone is insufficient; it is also necessary to use this power to help clients or defeat enemies. The richest of the Kharals has less izzat than one would predict from his wealth and government contacts because he is unwilling to use his position in this way. A person whose taqat and izzat are increasing attracts followers and allies who hope to benefit, but he also attracts the jealousy and fear of others who are likely to band together behind the scenes to plot strategies to limit or reduce him. If a group (such as a biradari) or several brothers become too powerful, efforts are made to sow dissension and thus weaken their unity. Because individuals' primary loyalties are to themselves - and each one assumes this to be true of others - efforts to divide groups, or evén two brothers, often succeed.

People informally recognized as leaders are supposed to work for the benefit of their followers as a group. But more often than not-such persons keep their own interests in mind first and attract clients by aiding individuals (against their enemies or with the police, for example) who are then obliged to them. Only infrequently do leaders work for the benefit of a group or community as a whole - and even when they do, others may accuse them of seeking only their own benefit.

Opposition is often expressed verbally in terms of issues, but in fact the issue is nearly always a pretext: men oppose or support decisions and programs based on their perceptions of their competitors' position. For example, even though all farmers suffered the exactions of a corrupt tubewell operator, they did nothing because, informants explained, if one man or group proposed petitioning for his removal, others would oppose. This would be done not out of love for the tubewell operator but to prevent the others from gaining some advantage from the issue or to pursue some long-standing grudge. This can he carried further: the non-cooperative behavior of the Kharal on branch A during the watercourse reconstruction was interpreted by informants as based on a desire to prevent others from benefiting - even if it means foregoing their own potential benefits. There is a Punjabi saying, "If my neighbor's wall falls, it is good - even if it falls on me." Opposition is never legitimate in the western parliamentary sense: it is always personal (or interpreted as personal) and aimed at weakening others or strengthening one's own position.

"Religious generosity such as building a mosque earns one "respect" *(abad)* for piety. but is not itself a source of izzat; pious acts score points in a different game.

There is a strong ethic of loyalty to one's kinsmen; one ought to be prepared to make sacrifices for their benefit. Marriage within the biradari - siblings and cousins exchange children - is intended to cement their affections and relationships. Divisions within the community, in Gondalpur and other villages, are usually between biradaris. This was the case for most disputes over the watercourse reconstruction program. There is a feeling that a biradari's izzat must be protected from others' attacks, and if a man's izzat suffers at the hands of a member of a different biradari, all of his close kinsmen may unite in opposition to the "enemy."

Nevertheless, despite the emphasis on loyalty to one's kinsmen, tensions among biradari members are always present. Patrilateral cousins and brothers often have tense and competitive relationships and do not completely trust each other. One's brother's or cousin's personal izzat is not necessarily one's own: hence, a man is apt to be jealous of and feel threatened by a brother's success. Tension is also generated among biradari members by joint potential rights in land. One of the worst cases of conflict in Gondalpur history, resulting in two murders and three executions, occurred within the Khudaya biradari over land: one branch attempted to deprive another branch of rights to some land. Tensions built up and the latter finally took action by murdering the numbardar and his brother. The amount of land involved was in fact not great; the real issue was izzat. If the second group had allowed itself to be deprived of the land, its members' izzat would have been severely damaged.[11]

During the improvement process there was much petty conflict among biradari members over work shares and the like; the Kharal are seriously divided, and the Khudaya only slightly less so. The Awan and Muradke, though separate biradaris in one sense, are closely intermarried, yet. at the time of this project, they were involved in conflict over several issues which prevented them from cooperating on the project.

The sense of community within the village is real but also intertwined with izzat. In opposition to outsiders, villagers will act together in a stick fight or a competitive game to preserve the izzat of the village. However, cooperation within a community to achieve a mutually beneficial goal is very difficult as people fear others may benefit more than they or the leaders will gain undue influence. In some villages there are leaders who are sufficiently trusted (or feared) to insure that farmers cooperate to maintain their watercourse, but this is not true of most communities and is not a permanent characteristic of any community.[12]

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[11] The numbardar and the cousing with whom he argued over the extent of work on the watercourse are the sons of the two murdered men; their relations are tense in part because of jealousy and idssatisfaction over the subsequent partitioning of their fathers' land; and in part because each fears the other will gain an advantage. An exchange of sisters would seem to be called for here but each branch is marrying matrilaterally (outside the village), thus accentuating the division.

[12] One Pakistani commentator on an earlier draft of this chapter, as well as one of my Gondalpur informants with whom I discussed my conceptualization of izzat, suggested that I have confused what my informant calls "false izzat" with "true izzat." "True" izzat refers to the more positive characteristics included in the concept. while "false: izzat includes more negative behaviors such as undercutting others, and creating fear in others. It is important to note that my informant hers is one of the Langah. who are not active participants in the main game of izzat. Other Gondalpur informants. while understanding the distinction. insist nevertheless that obstructionists like the step-nephews do have izzat in most peoples' eyes; men who are feared to as *badmash* (bad character, trouble-maker, bully) are also respected (even admired) and regarded as having izzat; and the badmash themselves believe they are increasing their izzat by their behavior,

Social Organization on Other Watercourses[13]

During 1978, I collaborated in a study of the social organization of ten reconstructed watercourses in Punjab. We deliberately chose our sample so as to include several problem and several model watercourses. We also chose watercourses for which a maximum period of time had elapsed since improvement (the range was four months to two years), and which represented several different agronomic areas of the province. The purpose of the study was to identify those sociological characteristics of rural society that both promote and inhibit effective cooperation on watercourse rehabilitation and maintenance. The results complement the intensive research reported above. Mirza and Merrey (1979) provide a detailed discussion of the methods and results of the research. Here only a brief summary of the conclusion is possible.

We discovered that both the ease and completeness of the actual reconstruction process, and the quality of the maintenance after improvement, vary considerably. Furthermore, there are systematic relationships between the relative success of improvement and maintenance quality, and also between these and certain sociological characteristics. Watercourses whose improvement was completed without significant delay or disruptive conflict are generally better maintained than those where the improvement process has been difficult. The better maintained watercourses tend to have all or most of the following characteristics:

1. ***A large percentage of farmers with the landholdings in the 2.5 to 10 hectare range.*** We defined holdings in this range as "small but economically viable" in irrigated Punjab. Watercourses dominated by farmers below this range seem to be very difficult to organize for cooperative programs, perhaps because they are less committed to farming as a full-time occupation. Larger farmers usually have laborers do their share of the watercourse work, with the result that it is often done carelessly. Large farmers are also more able to violate sanctions, and are more involved in conflict.

2. ***Relatively equal distribution of power and influence among farmers on a watercourse.*** "Power and influence" was measured by asking sample farmers to rate all the other farmers on the watercourse and adding the scores. Where influence is more equally distributed, and one or a few farmers do not dominate, farmers seem to cooperate better on collective projects.

3. ***A large percentage of farmers being perceived by fellow shareholders as having some influence and power.*** On some watercourses, power and influence scores were uniformly low - no one commanded any respect. Cooperation on such watercourses was much less than on those where the scores were higher across the board; that is, where most shareholders have at least some standing and respect.

4. ***Concentration of power and influence at the tail or at the tail and middle of the watercourse.*** Farmers at the tail of a watercourse usually receive the greatest benefits from improvements and are thus more highly motivated. If these farmers have comparatively greater influence, they often insure maximum cooperation by others.

5. ***Progressiveness of the community.*** This is measured as the percentage of farmers with a better than primary education, number of institutional services available in the community, and percentage of farmers who listen to the radio regularly. These three components together were used as a measure of community attitudes toward modernization and change.

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[13] **Some of the material in this section was first presented in D Merrey (1980), but the implications are developed further here**

6. Previous history of co-operation on community projects, and lack of serious recent conflict. Communities that had successfully cooperated on previous projects - such as building a school - and which had not been divided by serious conflict in recent years, cooperate more effectively on watercourse rehabilitation and maintenance.

7. A small number of shareholders on the watercourse. On the watercourses with the largest number of shareholders - even if they all belonged to one biradari - getting the farmers to work together to rebuild and maintain their watercourse proved very difficult.

8. Membership of most of the shareholders in a single *biradari*.

In reality the ideal characteristics listed above are not found very often in rural Punjab. None of the watercourses in our sample were well-maintained, but those which were comparatively better maintained share more of these characteristics than those which were in poor condition. None of the watercourses had an effective organizational mechanism to insure that all shareholders did their share of the cleaning. On five of the ten watercourses studied, the reconstruction work had not even been completed because of conflict among the shareholders or between the farmers and government engineers. Our study shows that quality of improvement and maintenance is closely related to sociological characteristics of the watercourses, but it also shows that present forms of organization are not adequate to insure good maintenance of the system, even on relatively conflict-free watercourses.

Punjab villages exhibit a considerable variety of structural forms: single, double, and multi-biradari villages; villages with strong leaders and those with weak leaders; villages with no recent history of serious conflict and others where murders occur yearly; and villages of small, medium, and large farmers, as well as owners and tenants; and, a few villages where landholding distribution is fairly equal and many where the pattern is highly skewed in favor of a few farmers. Gondalpur's social organization included all of the characteristics shown in the later study to be least conducive to successful cooperation on a watercourse reconstruction project.

However, in contrast with the variation in social organization, there is relatively little variation in cultural values: the concept of izzat is shared to a large extent by all rural Punjabis but it leads to the pursuit of different strategies depending on the social context. Both of the studies together show that the organizational and cultural impediments to a cooperative program - such as watercourse reconqtruction - are serious indeed, and even if the watercourse is successfully rebuilt, the inability of the users to maintain it means the investment in reconstruction may be wasted. However, one can go further than this: these organizational and cultural impediments, together with the ineffectiveness of the overly centralized bureaucratic management structure of the system, are at the root of the low productivity of the system; the minimal payoffs from the huge amount of capital invested in dams, canals, and SCARP tubewells; and, to an undetermined but probabiy very large extent, the waterlogging and salinization - the processes of desertification.

Conclusion

For decades, research and development projects on Pakistan's irrigation system have focused solely on the perceived technical problems and on their solution by means of large scale capital. intensive purely technological approaches. The users of the water - the farmers - have been ignored. In the 1970s, as a result of the research efforts of a number of American and Pakistani scientists, local-level problems and inefficiencies began to be recognized. However, initially this research too focused solely on technical problems such as watercourse leakage and rehabilitation. Experience with pilot watercourse reconstruction projects soon demonstrated that farmer cooperation was the key to the success of the projects. The focus on farmer cooperation, on which little research had been done, led to an increasing level of collaboration of sociologists and anthropologists with the engineers, agronomists, and irrigation specialists in an attempt to develop and effective watercourse program. It was expected that about a dozen experimental Water User Associations would be'organized under existing laws and their activities monitored. The end-product was to be recommendations for forms of organization to be used for establishing associations of irrigators for improving local level water management (see Mirza and Merrey 1979). However, the cut-off of American aid to Pakistan in 1980, as well as various political developments in that country, made it seem extremely unlikely that this program would be carried out in the foreseeable future.[14]

This work was based on the assumption that such tinkering with the system could be effective in improving its productivity as a whole, and reversing the process of decline and desertification in the form of declining levels of maintenance at all levels, and waterlogging and salinity. This assumption now seems highly questionable. The technical problems of the system cannot be solved as if they were isolated from the larger social, cultural, and economic context. This point may appear obvious to a social scientist but it does not generally characterize development policies and programs, especially of relatively conservative countries such as Pakistan.

The "engineering mentality" has been carried over from the older style development projects such as dam construction to the more people-oriented programs. For example, the planners of the pilot watercourse reconstruction project in Pakistan believed their own rhetoric that farmers' perceptions of their self-interest in watercourse reconstruction would overcome long-standing social and cultural impediments. The social scientists were called in somewhat later and expected to carry out rapid surveys (complete with statistics) to identify the problems and propose solutions to insure the success of the project. Social scientists, can, it is true, often identify social and cultural impediments to seemingly useful projects, and social and cultural factors involved in processes of environmental deterioration, and, having identified the problems, they can suggest strategies to overcome them. There are undoubtedly many situations where this narrowly conceived role is quite adequate, but Pakistan's irrigation system is not one of them.

In my discussion of the various recommendations and development projects in the Indus Basin, I have drawn attention to the fact that none have dealt with the most fundamental issue: the organization of the system. The study of organization comprehends the nesting of local systems in larger systems, and the complex relationships among social structure, values, technology, and environment. A beginning has been made in this direction with the various proposals to decentralize the management of the system and to organize water users into viable associations,[15] but these are very preliminary and are based on as thin a data base as are many of the technological solutions now being implemented. A great deal more research is needed on the organization of the system at all levels, and especially on social constraints and cultural perceptions and motivation. Such research can be used to develop a more comprehensive and realistic model of how the Indus system actually operates. Based on this model, alternative forms of organization can be suggested.

Pakistan's irrigation system - indeed that nation as a whole - is in crisis. Poor management and maintenance of the system at all levels, waterlogging and salinization, low productivity despite capital-intensive inputs (e.g., dams, wells, fertilizer, tractors), and the socio-economic inequalities which have increased in recent years as a result of "green revolution" technological changes (Nulty 1972) are all facets of the same fundamental problem: inadequate and inappropriate organization. Capital-intensive technological projects are unlikely to lead to any substantial development of the Indus Food Machine unless accompanied by substantial and effective social and economic reorganization.

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[14] Although the experimental work proposed under that project was not continued, the provinces of Pakistan have adopted laws to facilitate forming water users associations on watercourses, and are attempting with donor assistance to organize associations.

[15] See Radosevich (1975); Water Management Research Project (1976); Reuss, Skogerboe. and D. Merrey (1979); and D. Merrey (1983).

THE SOCIOLOGY OF *WARABANDI:* A CASE STUDY FROM PAKISTAN

Douglas J. Merrey[1]

The Problem

This paper uses a case study to address a fundamental issue in irrigation management: the relationship between technology and the organization required to use that technology productively. When an irrigation system is developed over time by a local community, the technology and the organization evolve together. However, when engineers design and construct large scale irrigation systems, there is a tendency to concentrate on the civil works, and to assume that, at least on the local level, whatever organization is required will evolve by itself. This was the assumption of the designers of the large irrigation systems built by the British and post colonial governments in present day Pakistan and the northwestern states of India.

Warabandi refers specifically to the roster of turns for taking water along the watercourses of these Indian and Pakistani irrigation systems. Basically, the irrigation system delivers a constant but limited quantity of water at the head of a watercourse. Farmers then take the full supply of water for a period of time proportional to the size of their landholding, at a specific time once a week. Since the amount of water supplied is far less than required to irrigate the whole area during the week, each farmer has to adjust his cropping pattern to the expected quantity of water.

In India the warabandi system has been seen by some irrigation specialists as a panacea to severe problems on irrigation systems outside the northwestern states (Singh 1980). However, whatever the merits of the system in northern India and Pakistan, it has proven extremely difficult to implement outside of this region. Even within the region, there are few detailed studies of the actual operation of warabandi (Malhotra 1982).

The present paper contributes to filling this gap in our knowledge of warabandi. Based on detailed field work in a village in Punjab Province, Pakistan, it takes an historical perspective on how the route of a particular watercourse, and the rotations on that watercourse, have evolved over time. It demonstrates the lack of "fit" or congruence between the imposed irrigation technology and the pre-existing social organization of the village. The attempts by some water users to adapt both the route and the rotation to solve social conflicts have proven unsatisfactory.

An Overview of Pakistan's Irrigation System

The Irrigation System. The Punjab (Pakistan) irrigation system uses barrages to divert water from the rivers into the canals. The canals are designed for continuous operation at or near full capacity. They can be closed for repairs, during floods, or to conserve water in times of shortage, but the amount of flow cannot be regulated on demand. Water flows continuously from the main canals into distributaries and through ungated concrete outlets *(mogha)* into watercourses and finally into farmers' ditches and onto the fields. As an indication of the size of the main canals, the Lower Jhelum Canal has a discharge at the head of 151 cumecs and commands 628.000 hectares. Distributaries are designed with capacities up to 5,660 liters per second (l/s). They are the lowest level channels directly controlled by the Irrigation Department. Since distributaries have gates, rotations can be instituted in times of water shortage. The moghas are ungated modular outlets designed to deliver fixed amounts of water up to 113 l/s (4 cusecs) into watercourses,

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usually at a rate of about .21 liters per second/hectare (one cusec for 350 - 400 acres).

On average, each watercourse irrigates about 225 hectares of land, usually cultivated by about 50 farmers. The route and command area of each watercourse is laid out by the Irrigation Department, and legally can be changed only with its sanction; but the building, maintenance, and management of the watercourse are the responsibility of the farmers in its command area. Each farmer has a right to water proportional to the size of his land holding.

The irrigation system was originally designed to operate with a minimum of human regulation or interference. Aside from engineering considerations the British believed that a flexible system of water distribution would lead to uncontrollable abuses. They also wished to keep construction and operational costs at a minimum since they were interested in a quick return on their investment. These considerations also underlay the minimal local intervention: farmers were expected to build and maintain their watercourses and settle disputes themselves. Under the Canal and Drainage Act of 1873, still the basic irrigation law, the Irrigation Department retains considerable residual power, but this is only rarely used upon farmers' appeal (Jahania 1973). The major irrigation method remains flooding of small basins, as originally recommended by the Irrigation Department (Trevaskis 1931:293).

Efficient continuous operation of the system requires, at the local level, that a minimum of three tasks be accomplished: regular system maintenance; water allocation; and conflict management (Coward 1980:19). Regular cleaning and maintenance of watercourses, including de-silting, removal of weeds, and repair of banks, is essential because the earthen channels deteriorate rapidly, leading to high water losses. Water flow must be rotated because the rate and volume of flow is inadequate to allow irrigation from all the outlets simultaneously. Finally, conflict over shares in maintenance work and rotation of water, and accusations of water theft are inevitable, and dictate some means to resolve disputes and insure equitable sharing of water and costs of operation. The government did not make any provision for local institutions to fulfill these tasks. Given the principles of non-interference in local affairs and minimum bureaucracy, cultivators must depend on their own cultural traditions to fulfill these tasks.

Land Demarcation. As part of the colonization of new land through irrigated agriculture, the Punjab government established a policy to survey all the land and lay down squares on a common base line for the whole commanded area of each canal project. At the time the Lower Jhelum Canal was being built (1897 to 1917) it was decided to compel farmers in the old villages to conform to this requirement too, as a pre-condition to receiving canal irrigation. Accordingly, during the 1905-06 settlement in Gondalpur (a pseudonym), the village where I worked, all of the land was resurveyed and field boundaries were moved to conform to a grid pattern (Hailey 1907:1-2). This involved imposing a grid of squares *(murabah)* which, within each *mauza* (revenue village), are numbered consecutively beginning in the northwest portion. Each square is further subdivided into 25 numbered killa, as shown in the key to Map I. This process was called *killabandi,* or "rectification."[1] The corners of the squares are marked by permanent concrete posts. Although the squares are not all exactly equal in size (Hailey 1907:2), they are supposed to be approximately 11.2 hectares, so each killa is about 0.45 hectares.

Today, most people know the location of their fields by the square and killa number; and the fields do form a grid even though the actual lines have shifted somewhat with time. The grid pattern does makes resolution of disputes over land boundaries easier. The watercourses also usually follow the grid lines with official turnouts usually located on the corners of squares.

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[1]See Douie (1960 Appendix XIV) for a complete description of the process

Construction and Operation of Watercourses. Map 1 shows the square numbers and the location of the residential area, paths, the railroad line, and the three watercourses found in Gondalpur. The watercourse routes shown are the official ones, as of 1976. They are approximately, but not exactly. accurate. Farmers' ditches to carry water from the watercourse to their fields are not shown; they form an intricate pattern since nearly every killa is irrigated. The low-lying land to the east of the Miani path, and north of the Pirpur path, was more valuable than higher land before canal irrigation was introduced, since rain water could be impounded; but today it is inferior to the rest of the village land because much of it is wateriogged and/or saline.

The system was not designed to irrigate all of the land during any one season. The Lower Jhelum Canal was designed for a total cropping intensity of 75% per year. The actual sown area, however, tended to average over 95% per year (Rudkin 1911:9). Watercourses on the Lower Jhelum Canal were designed to carry an average of 28.3 l/s (1 cusec) for every 142 hectares. According to Trevaskis (1931:293) the Irrigation Department assumed 1 cusec would irrigate 0.4 hectares (1 acre) in 1 *pehr;* that is, 3 hours. "Irrigate" here is defined as covering 0.4 hectares with 7.6 centimeters of water. By this standard, a maximum of 3.2 hectares can be irrigated in one 24 hour day. and 22.7 hectares in a 7 day rotation. This would mean only 16% of the command area could be irrigated in a week, and it would take 3 weeks to irrigate 50% of the commanded area.

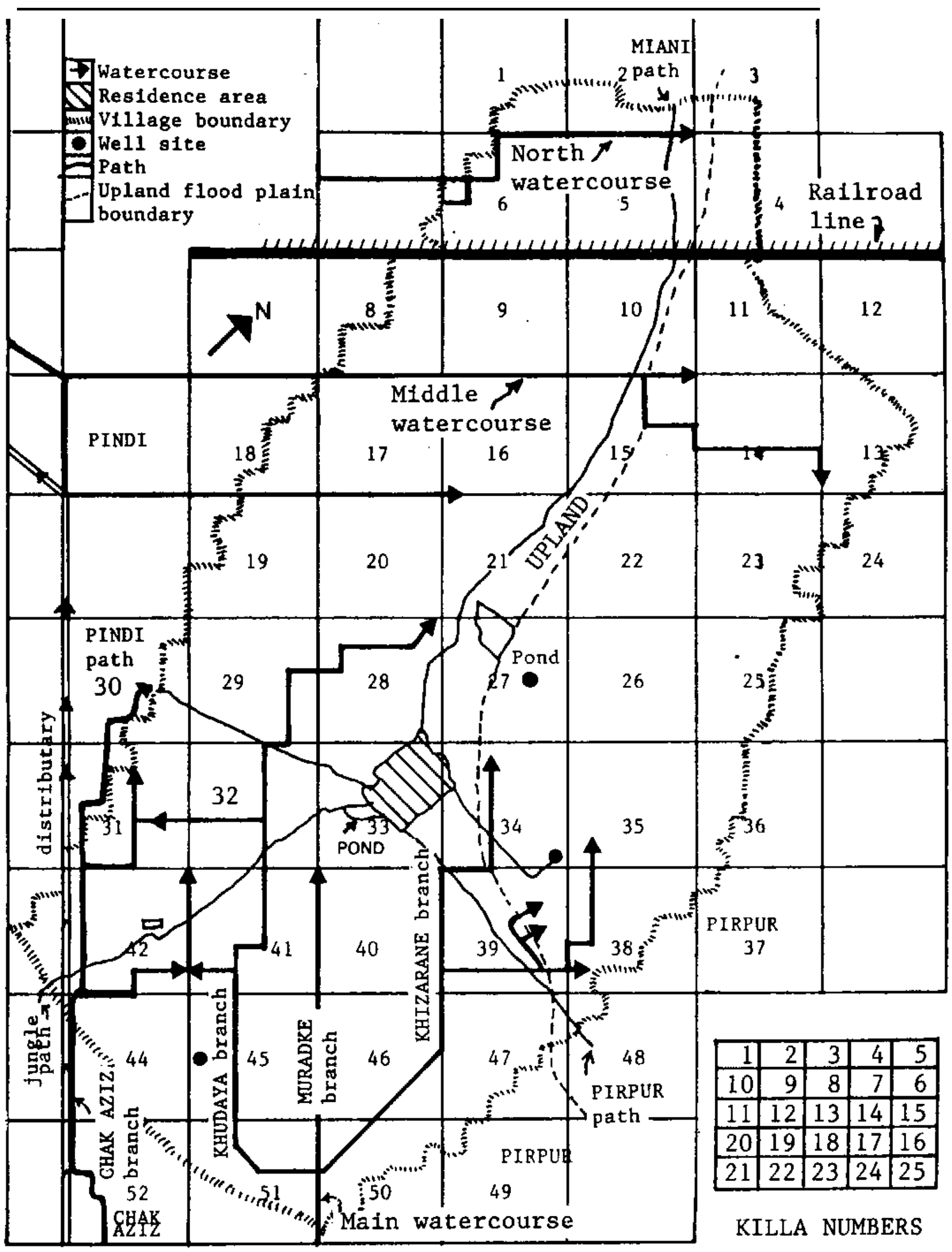
Given the high moisture deficit in the region, the shortage of water relative to area and crop water requirements necessitates a rationing system in order to distribute water widely and equitably. As every farmer on a watercourse has a right to water proportional to the size of his holding, water is rationed according to a rotation, usually of seven days. Within this period, each farmer is supposed to have sole access to the water flow during a fixed period of time. The rotation always begins with the farmers located at the head and proceeds to the tail of the watercourse.

In most cases, the farmers themselves established the first rotation. Farmer-established rotations are called *kachcha,* meaning impermanent, having no legal basis, or informal, while those established by the Irrigation Department under its own rules are calledpakka, meaning solid, legal, regulated, or formal. Through the 1950s. the rotations in Gondalpur remained informal, and the rotation on the middle one is still informal in practice.

Informants say that unlike the formal rotation, the informal rotation takes into consideration local conditions such as the sandiness of soils and the height of the field relative to the ditch. Thus, a sandy or high field is awarded extra time to ensure it can be irrigated. More time is also allowed for filling long sections of the watercourse. However, an informal rotation seems to work only when there are relatively few irrigators, as in the past in Gondalpur, or where one or two irrigators have sufficient authority to enforce it. This is the case on the middle watercourse in Gondalpur, dominated by several large Pindi Village landlords who find the system advantageous.

In some cases, the one man in whose name the time is recorded has been succeeded by a number of sons and nephews; these individuals must then agree upon an informal rotation among themselves. There are several examples of this in Gondalpur. If some or all of the farmers become dissatisfied with a rotation, they can petition the Irrigation Department to set up a new one, as has happened on two of the Gondalpur watercourses.

This formal rotation is set up by the lowest Irrigation Department official on the revenue side, the canal clerk *(patwari)* and confirmed by a higher official when all the irrigators agree. It is established according to formal procedures laid down by the Irrigation Department (Jahania 1973: Appendix VIII). Basically, after allowing lead time for filling sections of the watercourse, the clerk divides the number of minutes in a seven day rotation by the total area irrigated to arrive at the number of minutes per hectare to be allowed. He then awards the amount of time to individual land owners according to the total amount of land they irrigate. The rotation on the main watercourse in Gondalpur, for example, allows 14.43 minutes per 0.4 hectares.



Map 1. Routes of Watercourses, Gondalpur, 1976. Based on 1910-11 revised settlement map and 1977 observations.

Every April 1, under Irrigation Department rules, the irrigation times shift forward and backward in alternate years, so that those who irrigate during the night one year will irrigate during the day the following year. However, the formal rotation does not allow for differences in soil or height of the field, or for losses of water due to seepage or leaking from the watercourse. This means the farmers near the tail of the branches do not get as much water per hectare as those at the head, and this difference in water supply is reflected in differences in cropping patterns and intensity and in land value.

In the Pakistani system there are no "ditch tenders," government or community officials diverting the water or overseeing the rotation; each man closes and opens outlets himself. Therefore, not surprisingly. taking water out of turn and trading water rights, though against Irrigation Department rules, are common practices.[3] I observed a number'of cases, and heard of others, in which farmers near the head opened outlets onto their land during others' turns. This often leads to disputes and arguments, but I never observed any serious fights caused by this. This is because the watercourses are long, so the irrigator may not know of the theft; and people are careful about whose water, and how much, they take.

Trading, even by people on different branches, is-also common. A man often needs more water than he is allotted one week, and less than he is allocated the next. Trading is therefore a way of making a formal rotation more flexible in practice. The Irrigation Department never takes action against trading or theft unless it receives formal complaints from the farmers. Another reason for trading water is that a farmer often has several pieces of land located on different parts of the watercourse. but all of his time is allocated at once. Time is allotted to people, not parcels of land.[4] (This is discussed further below.)

When asked how much time it takes to irrigate 0.4 hectare of land, the responses of farmers varied considerably. Generally, those near the division box of the three branches within Gondalpur (Map 1) said it takes 1.5 - 2 hours if the watercourse is clean and the tubewell running; on the middle and tail reaches the estimates ranged from 2 - 4 hours, with the same conditions. Since the rotation allows less than 15 minutes for 0.4 hectares, no one can irrigate all or even half his land in one turn, and farmers at the tail are able to irrigate only a small portion of their land.

One other notable characteristic of Gondalpur's watercourses is that all three originate in other villages controlled by relatively large and powerful landowners. The main watercourse originates on and runs along the line between Pirpur Village and Chak Aziz Village. Although there is no official outlet on the main branch leading to the division box among the three branches within Gondalpur. Pirpur and Chak Aziz landlords owning the adjacent land cut the banks and take water with impunity. The Chak Aziz branch runs through the land of three relatively powerful (and in one case ruthless) families of Chak Aziz; they too often take water out of turn, and refuse to do their share of maintenance.

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[3] Lowdermilk et al. 11978[II]:36) and Lowdermilk et al. (1975:54-56) show that trading of turns on watercourses is common.

[4] The Canal and Draingage Act provides for two procedures: outlet by outlet (nakka by *nakka*) process. and turns by holding (*rozwari*). In the former. if a man's holdings are fragmented he gets separate turns for each fragment along a watercourse (see Reidinger 1974). In the latter. time is largest fragment. The Act says that the shareholders may choose the procedure they wish to follow. See Jahania (1973:96). See also Lowdermilk et al. (1978 [II]:34-35) for a slightly different diefinition of rozawari.

The other two watercourses begin in Pindi Village, and irrigate the land of several powerful landlords who own land in both Pirpur and Gondalpur; many Gondalpur people are their tenants and clients, and depend on them for access to land as well as help with the bureaucracy. Even landowners on these watercourses are in a dependent (client) relationship with the Pindi landlords. The analysis in this paper concentrates on the main watercourse.

The Main Watercourse in Gondalpur

Gondalpur village. Gondalpur is the pseudonym I use for a village in central Punjab where my wife and I resided and carried out research for 18 months in 1976-77. It is located on the Chaj Doab, the area between the Jhelum and Chenab Rivers. Its existence predates the first British colonial records on the village, in 1857. It grew rapidly. primarily due to immigration, during the decades before the turn of the century. Gondalpur began receiving water from the Lower Jhelum Canal in 1904, and within a few years all of the land in the village was under cultivation.

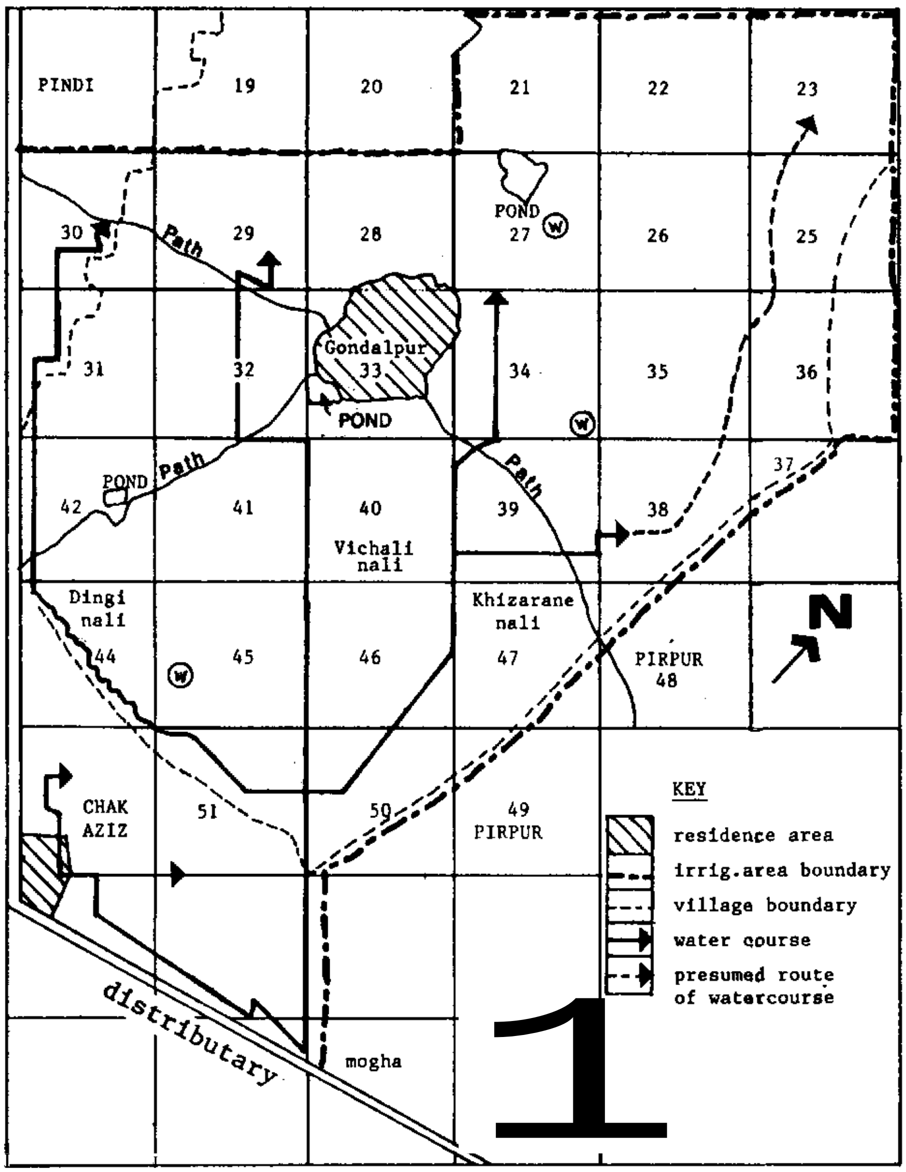
The dominant landowners, the Gondals, are divided into four named biradari, or brotherhoods, which are local co-resident groups based on a combination of patrilineal descent and marriage (Alavi 1972). The biradari members' lands tend to be concentrated on different branches of the watercourse, with some mixture. Table 1 summarizes the size and location of the lands of each biradari. Although in this paper I speak of land belonging to this or that biradari, land is registered in individuals' names, and patrilateral relatives hold residual rights. (For detailed discussions of village history and social organization, see Merrey 1982, 1983, 1986).

Table 1. Biradaris **on** the main watercourse.[a/]

	Number of Households	Number of People	Watercourse[b/] branch	Position **on** branch
Gondalpur biradaris:				
Gondal-Khudaya	**11**	***70***	D; a little **on** B	H, M, T
Gondal-Khizarane	212	105	B	H, M, T
Gondal-Muradke	7	43	C, a linle **on** B	H, M, T
Gondal-Miane	5	**36**	D; a little **on** A	M, T
Langah	5	36	A	M
Awan	**11**	47	**B** and C[c/]	M .
Bhatti-Rajeaned[d/]	**18**	**78**	**B (2** households)	**M**
Sayid	3	25	B	H, M
non-Gondalpur biradaris:				
Kharal (Chak Aziz)	**3**	?	A; a little **on** B	H
3 Pindi biradaris[e/]	under 10	?	A & D	T on both

Notes: Branches: A - Chak Aziz, B - Khizarane. C - Muradke. D - Khudaya, H - Head, M - Middle, T - Tail. [a/] This is not a complete list of all biradaris in Gondalpur; only those having land irrigated by the reconstructed watercour are listed. Values are based on **1977** complete household census. [b/] See Map **1.** [c/] Very small holdings. [d/] Only two households of this biradari have land on this watercourse. There are 7 Bhani biradaris in Gondalpur with a total of 90 households and 416 people as of **1977.** [e/] These biradaris did not play an important role in the improvement project - their major holdings are **on** other watercourses; they generally acted together on this project.

The main watercourse, like others in Pakistan, was constructed by the farmers themselves, on a route laid out by the Irrigation Department at the time the Lower Jhelum Canal was built. The main channel, officially sanctioned by the Irrigation Department, is called the *sarkari khal,* or official watercourse. Its route cannot legally be altered without prior official approval. Map 2 shows the route of the official watercourse as it appeared until the early 1960s: there is no evidence of any changes taking place, and the official map of the SCARP tubewell[5] constructed in 1965 indicates the organization that built it, the Water and Power Development Authority (WAPDA), had not been informed of changes made at that time



Map 2. Original Route of Main Watercourse Gondalpur

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[5]The Salinity Control and Reclamation Program (SCARP), implemented in stages since the early 1960s. involves the installation of large publicly managed tubewells in areas of high water table. Water is pumped into watercourses (unless it is too saline) to provide extra irrigation. Gondalpur is in the SCARP II area. See Johnson (1982) for an economic analysis of this program.

As Map 2 shows, the main watercourse has several major branches. The main branch follows the boundary between Chak Aziz and Pirpur villages to a three-way division box. The right hand (eastern side) branch was and still is called the *Khizarane nali* (Khizarane's channel), since it primarily irrigates land owned by members of the Khizarane biradari. The middle branch used to be called the *vichali nali* (center channel), and was used primarily to irrigate land owned by members of Muradke. Khudaya, and Miane biradaris. This branch still exists, but is shorter, and is now called the Muradke branch. The third branch used to be called the *utali* (high) or *dingi* (crooked) *nali*. It used to irrigate the high land owned today by a Chak Aziz village landlord, as well as land owned by the Langah biradari, and some Pindi village landlords. The other branch near the outlet irrigated the remainder of the land owned by the landlords of Chak Aziz. The routes of these two branches have been significantly altered in recent years.

Although there were apparently no changes made in the route of the official watercourse, the cultivators did add many unofficial ditches and turnouts over the years. For example, about 40 years ago, in squares 42 and **41** (Map **2).** a Langah man built a long unofficial ditch from the *dingi nali* to irrigate land officially commanded by the center branch. This ditch now links both branches. Similarly, in squares **32** and **31,** the Miane biradari people have built extra ditches so that they can bring water from either branch (*dingi nali* or center) to their fields located between the two, though their irrigation time is officially on the center branch. Further, although only one turnout per square is permitted on official channels, there has been a tremendous proliferation of locations where the channels are cut: this is true on most watercourses in Pakistan.'

The total cultivable commanded area (CCA). or potentially irrigated area, of the main watercourse is 275 hectares. This is called its *chakbandi*. Of this, **35.6** hectares are **in** Chak Aziz, near the head, while **9.9** hectares are at the tail end in Pindi. The remaining **229.5** hectares are in Gondalpur itself. However, because of waterlogging and other problems discussed below, not all of the commanded area within Gondalpur is irrigated by this watercourse. I estimate that only **150** hectares, about **55%** of the commanded area within Gondalpur is actually irrigated in most **years**.[7] In other words, of the total **275** commanded hectares **on** this watercourse, only about 200 hectares, or 70 - 75% of the total is irrigated.

Until **1961,** the rotation **on** this watercourse was an unofficial kachcha *warabandi*. There is no record available today of how this rotation worked. Informants say that if the canal water stopped for some time. the person in line for the next turn would be the first to get the water. Thus, rotations were not necessarily on fixed days. Similarly, specific data are unavailable on the level of conflict over water or on the level or effectiveness of maintenance. Informants made general statements that there used to be many quarrels, usually over rotation times (attributed to the lack of preciseness of the pehr system), and sometimes over water theft, but they insisted these did not lead to major problems and did not affect the ability of the farmers to cooperate in channel maintenance. They claim the channel was better maintained before the installation of the SCARP tubewell, as before that water was short and frequent cleaning was essential to get water.

Developments Since 1960. Conflicts within and among biradaris in Gondalpur became intense in the late **1950s.** culminating in a double murder in **1962** (Merrey **1983).** Conflicts and tensions have continued since then, and two members of the Kharal family in Chak Aziz have also been involved. All of the land owning parties in these conflicts have their major holdings on this

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[6] Lowdermilk et al. (1979 [III]:26-33) found an average of 2.6 *nakka* (field turnout) cuts hectare in a survey of 40 water courses in Pakistan.

[7] Some of the non-irrigated land is waterlogged, but is cultivated with paddy once a year.

watercourse. It is not surprising that watercourse politics have become intertwined with the larger political conflicts in Gondalpur. Several other factors have had an impact on the operation of the watercourse and biradari politics.

One factor is the increase in population, leading to subdivision of land holdings, necessitating more minute subdivision of water rights. This subdivision makes it difficult to maintain an informal rotation, and has led throughout Punjab to appeals to the Irrigation Department to create official rotations. Related to this subdivision is a second factor, the purchase of land by people of other biradaris, leading to an increase in the mixture of biradaris on the watercourse. For example the Kharal of Chak Aziz village have acquired small plots of land here and there in Gondalpur; Pindi village people have bought land from some of the Khudaya involved in the 1962 murder; and in recent years two Rajeane Bhatti have bought land in several locations on the Khizarane branch. These purchases have complicated the rotation and made cooperation for maintenance more difficult to enforce.

A third factor is the intensification of cultivation, partly a result of increased population pressure and facilitated by the introduction of higher yielding varieties of crops: these are far more water-sensitive, placing a greater premium on amount and timing of irrigation water. Related to this is the fourth factor, the installation of the SCARP tubewell in 1965 which in effect doubled the water supply. Increased water supply has led to an increase in double cropping and in the area of crops requiring large amounts of water, especially rice and sugar cane (Merrey 1983). It also led to an increase in the wastage of water: as on other watercourses supplemented by public tubewells, this one was not enlarged to accommodate the enhanced flow, leading to erosion, overtopping, leaking, and washouts. Further, since there was far more water than farmers were accustomed to using, the frequency and effectiveness of watercourse cleaning declined. As the watercourse deteriorated from both these factors (lack of maintenance and water flow greater than channel capacity) the distribution of water became increasingly inequitable: farmers at the tail were probably getting half to a third of the amount available at the head by 1977 (farmers' statements; Lowdermilk et al. 1978[III]:97-99).

As on other watercourses in Gondalpur, there is a five rupee fine for non-participation in periodic cleaning; but while many do not cooperate, I could not find one example of a fine actually collected. On the branch passing through Chak Aziz village and Gondalpur to Pindi village, biradaris have assigned shares to clean based on the amount of land irrigated. This cleaning is done about twice, a year; but the head cultivators, the Kharal of Chak Aziz village, not only avoid their share but often sabotage the cleaning of others. On the other branches farmers work together beginning at the head, and stop when the section up to their individual plots are clean. With this system those near the tail do more'work; and there were many complaints that the ditches are not cleaned often or well enough.

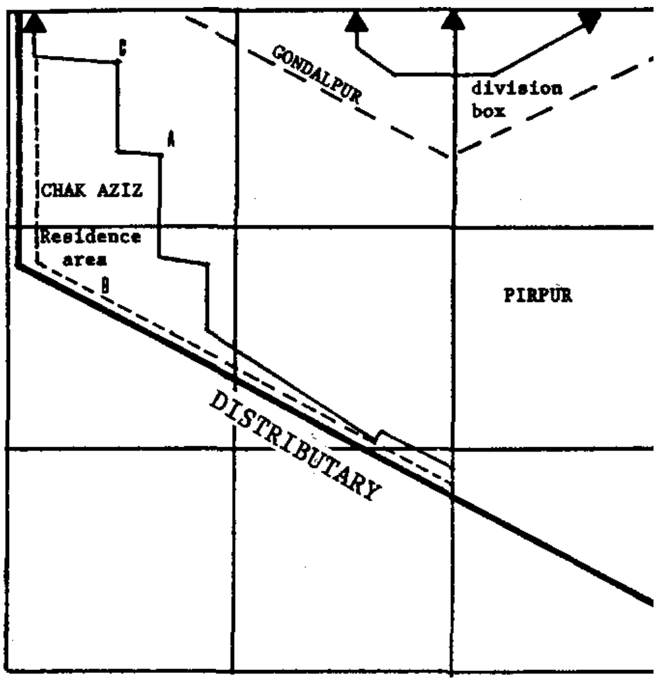
All of these factors have led to three inter-related responses on this watercourse: attempts to change the route of the official watercourse to better fit perceptions of the needs and realities of social relationships; changes in the rotation of water; and more recently, demands for government-aided watercourse rehabilitation. The route changes are also related to the attempts of some to use a favorable location on the watercourse as a political weapon.

Route Changes

1. Chak Aziz *and dingi* branches. The unauthorized ditch built about 40 years ago by a Langah man to irrigate his land in squares 41 and 42 has been mentioned above. Informants say this route was shorter, and therefore more efficient. However, both this and the legal route pass

through land owned by the ***numbardar***[8] family, a relatively powerful group within the Khudaya biradari. Several years before the 1962 murder of the previous numbardar, a Langah biradari man was suspected of having been involved in the attempt to burn him and his cousin to death (Merrey 1983). Therefore, the numbardar destroyed the sections of the Langah ditch passing through his land; for two years the Langah man got no crops as he had no water. Later the numbardar allowed it to be rebuilt when he discovered the Langah had not been involved in the plot.

Until the early 1960s. the *dingi nali* route remained as shown in Map 2. It ran though land owned by the numbardar and Fazal Kharal, of Chak Aziz village; it cut across squares and ***killas***, rather than running along the ridges between the fields. Then Fazal arranged a land trade with the numbardar to consolidate his land. To facilitate cultivation of his newly consolidated land with a tractor, Fazal then convinced the other people on the branch to agree to a major change in the route. This was an extension of the previous Chak Aziz branch to replace the ***dingi nali***, and runs along the ridges between squares, and then along the distributary, as shown in Map **3**.



Map **3.** Changes in Route of Chak Aziz Watercourse Branch.

Key

A. Route of Watercourse branch until rehabilitation project. 1977.

B. Route of watercourse as built during rehabilitation project, 1977. which probably reflects the route actually sanction by the irrigation deparment in the mid-1960s.

C. Before mid-1960s this watercourse stopped here, irrigating only Chak Aziz land; it was extended from here to Gondalpur when the route was changed and the ***dingi nali*** abandoned.

[8] ***Numbardar*** (from the English word "number") refers to the village resident selected by the Government as its contact point in the village. He collects land revenue and irrigation fees from individuals, based **on** the revenue and cnal clerks' assessments. The position is normally hereditary (father to **son),** subject to Government confirmation.

The Langah biradari's land is located just downstream of Fazal's land. Langah informants say now that they made a mistake in agreeing to the change in the route, and accuse Fazal of fraud, Since Fazal's land is high, and the new route is also higher, he gets more water than before. However, he and his relatives refuse to de-silt the channel regularly because the silt helps raise the water level, facilitating irrigation to their fields. The Langah are forced to de-silt the Kharal's share as well as their own to get water--but they claim the Kharal then often refill the channel with silt again. The Langah can do little as the Kharal are far wealthier and politically more powerful.

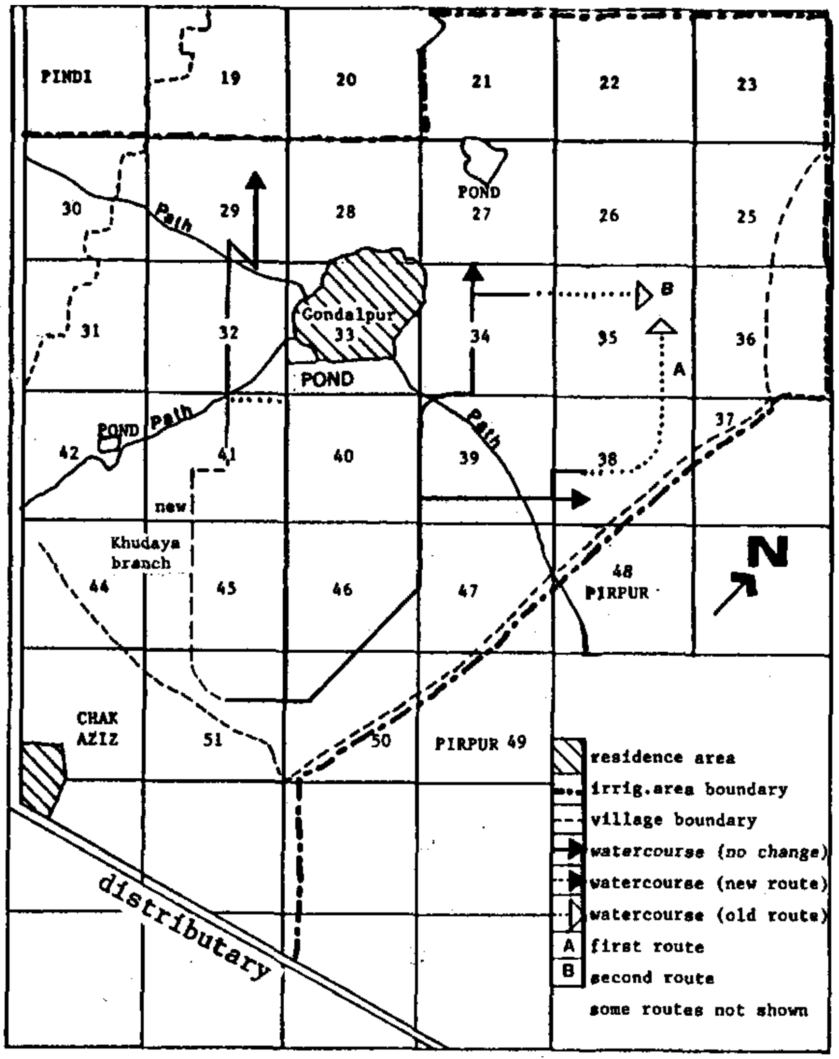
The Langah claim that Fazal got the Irrigation Department's sanction after a new ditch had been built. but instead of getting sanction for the route just constructed, he got yet another route sanctioned along the distributary, behind the residential area of Chak Aziz, and continuing downstream along the distributary. The Langah say they did not realize this change had been made when they agreed to its sanctioning; after it was authorized; they had no choice but to go along with its reconstruction again, along the distributary downstream of the Chak Aziz residential area (the section through this residential area was sanctioned but not built until the watercourse reconstruction program in 1977; Merrey 1982). The Langah probably agreed to these changes out of both powerlessness to oppose the Kharal, and faith in their kinship tie with Fazal, whose mother is a Langah. The Langah today have acute water problems, and in 1976-77 were among the most enthusiastic supporters of a proposed watercourse reconstruction program.

2. ***The Muradke and Khudaya branches.*** As is shown on Map 2, the Khudaya and Miane biradaris' land in squares 45, 41, 32, 33, 28, 29, 19-21, etc. used to be irrigated from the center (vichali) branch. Today it is shorter, and primarily irrigates Muradke land and some Awan land. The Muradke and Awan were initially accused along with the Langah in the first attempt to kill the numbardar and his cousin, though they were later exonerated. Nevertheless, several informants date the tension between the Khudaya and Muradke from that incident. The tension continued after the murder of the numbardar and his cousin (both Khudaya biradari). The new numbardar and his brothers were young and weak then, and other Khudaya feared they would get into trouble while irrigating since the water passed through Muradke land while irrigating. They also feared the Muradke would attempt to deny them water. Other informants attribute the heightened tension to the effect of the first "Union Council" election under the "Basic Democracy" system. in 1960, when a Muradke opposed a Khudaya for Gondalpur's seat (the Khudaya won).

About a year after the murder, about the time the new Chak Aziz branch was under construction. the Khudaya built a new watercourse branch, now called the Khudaya branch (see Map 4). This new branch utilizes part of the former dingi branch in square 51, and runs northwest through the land owned by the Khudaya and Miane (squares 45, 41), to link up with the old section through squares 32, 29, 28, and beyond. No survey was done, and the ditch was made the same depth throughout regardless of land height. A few years later, about 1966, the numbardar got the new route sanctioned by the Irrigation Department.

Not everyone is happy with the new route: the Miane biradari, whose land is relatively high, complain they get less water than before, while the numbardar's poor relatives at the tail say they also get less water. Nevertheless, the new route accomplished its purpose: the Khudaya now have their own channel, which they control right from the division box; they are no longer dependent on the Muradkes' good will, and no longer have to pass through their land. Perhaps as a result, the Khudaya-Muradke tension has not led to any overt conflict since the early 1960s.

3. ***The tail of the Khizarane branch.*** At its tail, the Khizarane branch is supposed to irrigate land in parts of squares 23, 25, 26, 35, and 36. The land furthest from the head of the watercourse is relatively high and sandy land, while the intervening land, parts of squares 38-39, 34-35, 26-27, and 21, are low and waterlogged. Thus the watercourse must pass through this waterlogged low land in order to reach the higher sandy land. Much of this higher land is owned by Muradke, Rajeane Bhattis, and an urban landlord. The lower land is owned by various people, including

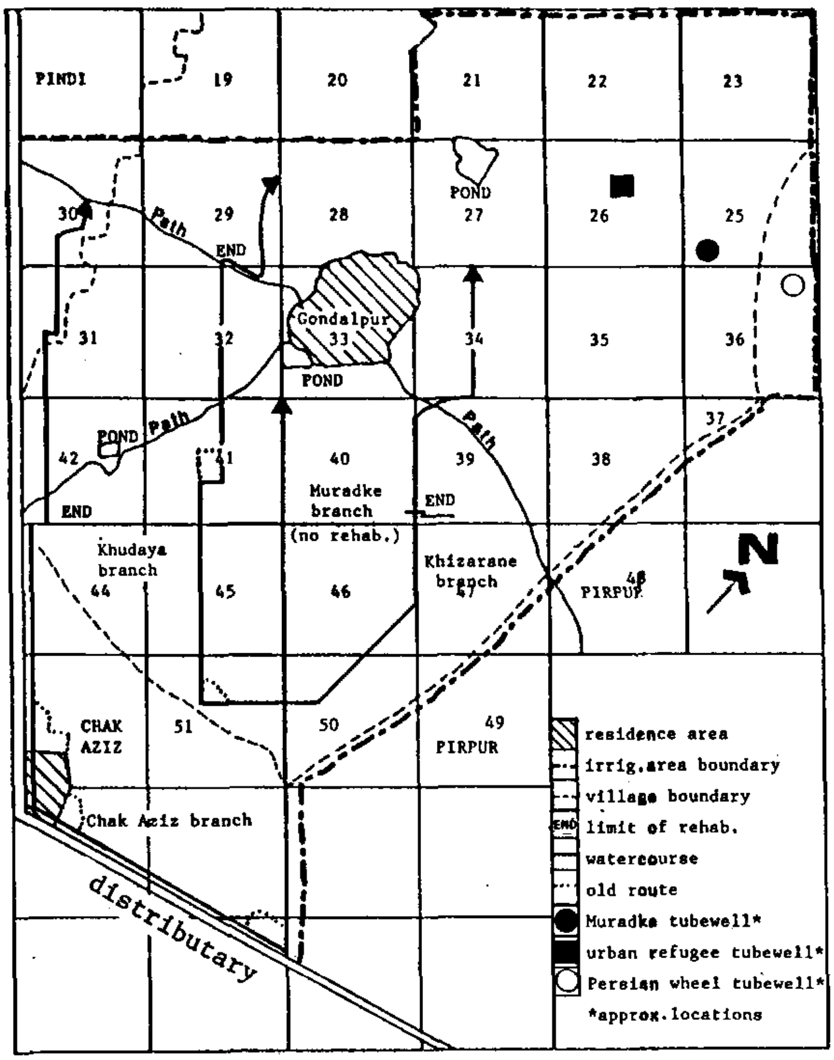


Map 4. Modification in Route, Khudaya/Muradke and Khizarane Branches, Gondalpur.

Khudaya, Muradke, and Khizarane, as well as the urban landlord. According to informants, originally there was a watercourse (A on Map 4) carrying water to this high land. At one time parts of this high land were very productive. However, some decades ago, perhaps in the 1920s when waterlogging in this portion of Gondalpur became severe, this channel was ruined. Two factors were responsible: on the one hand it was difficult to maintain a functioning channel through a waterlogged, sometimes flooded area (which had become uncultivable); and the sandy area itself became saline.

However, after the construction of a drain by the government north of this area in the late 1920s, the water table declined and it became possible to build a channel through the still rather waterlogged area. Through leaching of salts, some of the high sandy soil was also reclaimed. I do not know when this channel was rebuilt, but estimate it was sometime in the late 1950s. Its route was different from the previous one (B on Map 4). This land is included in the official rotations established since 1961 (see below).

During the interim, a Persian wheel well was constructed in the 1930s just beyond the village *(mauza)* boundary on Pirpur land. This irrigated some of the sandy land and is still functioning (Map 5). In addition, the urban landlord installed a diesel-powered tubewell on his sandy land about 10 - 12 years ago, and the Muradke built another one about 1974 (Map 5). In 1977, the landlord had stopped running his tubewell because his tenants refused to pay for its use, while the Muradke ran theirs occasionally, but at great expense.



Map 5. Main Watercourse Routes after Rehabilitation, and Modern Wells, Gondalpur, 1977

About 1974, the new watercourse channel running through the waterlogged land to this higher land (B on Map 4) was knocked down again and was still not operating in 1977. Informants gave several explanations: first, it was difficult to keep the channel in repair, as the waterlogging and periodic flooding of the land tended to obliterate it. Second, informants say it was deliberately knocked down by the Muradke so that the Rajeane Bhatti and the landlord's tenants would be forced to buy water from their tubewell (this has not happened, however). The third and major reason is the Muradke knocked it down after a dispute over a marriage with a Rajeane Bhatti man.

Summary. This section has shown how the routes of the watercourse branches have been manipulated by more powerful people to gain control over, or to punish, others on the watercourse. In only one case, the modifications in Chak Aziz village, was an economic benefit also important: the changed route enabled Fazal Kharal to better cultivate his land with a tractor, and possibly to improve his water supply. However, in the process the Langah supply was reduced, and Fazal and his relatives' power over the Langah enhanced. In the case of the Khudaya. they were able to separate themselves from having to cooperate with the Muradke, with whom relations were tense; but this was at the expense of a reduced water supply for at least some people. On the Khizarane branch, the watercourse was used by the Muradke as a weapon to hurt a person of another biradari who had slighted them, i.e., struck a blow at their honor *(izzat)*, even though their action was at their own expense as well. All of these changes in the route of the watercourse are inseparable from changes in the rotation, the subject of the next section.

Changes in the irrigation Rotation: **1961** to **1977**

No record is available today on the informal rotation in operation on the main watercourse until late **1961.** Informants say it was broken when people who had acquired land found they did not get water,' and applied to the Irrigation Department to institute a formal rotation (*pakka warabandi*). The first formal rotation, established in late **1961,** apparently preceded most of the route changes discussed above. There is no indication in the canal clerk's register that this rotation included extra lead time for filling the watercourse, suggesting it may have been technically deficient. This rotation lasted less than five years. It had to be replaced for two reasons: its gross inequity, and the changes in watercourse routes, especially the separation of the Khudaya and Muradke branches.

One informant told me that people began complaining almost immediately after the establishment of this first formal rotation, because of its inequity. He alleged the canal clerk had been "influenced" by certain farmers. His major example was from his own biradari: several holdings which were still together in the record books as one holding were given a total of **9** hours of water, which was reduced to a more reasonable total of 2.5 hours in the next rotation. I had thought this an exaggeration, but examination of the rotations of **1961** and **1966** in the canal clerk's register confirmed this. There were other similar anomalies, but this was the most obvious one; in each case the inflation occurred by including in the rotation schedule land not actually irrigated by this watercourse.

The other factor necessitating the revision of the rotation was the construction of two new branches discussed above: the Chak Aziz branch, which was lengthened and replaced the *dingi* branch; and the creation of a new Khudaya branch separate from the Muradke channel. This new rotation was sanctioned in August **1966** and was the basis for the rotation in operation in **1977.** It includes lead time for filling the channel and extra time for citrus orchards; and it was on this rotation that the annual twelve hour shift of time was introduced: every April **1** the rotation shifts **12** hours alternately backward and forward, so that people who irrigate at night one year, irrigate during the day the following year.

This rotation has been slightly revised twice since **1966.** In March **1971,** it was changed to reflect the division of land between the numbardar family and his cousin. In August **1975.** another revision occurred when an absent Khudaya family sold a small piece of its land. Table **2** presents the revised rotation. Notes are based on observations of, and informants' statements concerning, actual practices where they differ from the official rotation.[9]

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[9] Unfortunately, through an oversight. I failed to get detailed data on tenancy on this watercourse. Most owners are self-cultivators. Some of the landowned by the Kharal is cultivated by tenants, both Gondalpur and Chak Aziz residents. Some of the land owned by the Miane and Several Khudaya is also cultivated by Sayid and Rhani tenants in Gondalpur. In **these cases, the internal distribution of the water is decided by the owners in consultation with his tenants.**

Table 2. Current Irrigation Rotation on the "Main" Watercourse. Gondalpur.

Branch[1] Owner[2]	Square[3] numbers	Area (ha)	Starting time
Khizarane Branch			
			Monday
1. Mumtaz, Mirza, Khizarane[4]	25, 34. 39, 46, 47. 50, 51	7.0	6:00
2. Abdul, Khirarane	23, 25, 26, 34, 38. 46	2.1	10:39
3. Mirza, Ghulam. Khizarane	25, 26, 32. 45, 46, 50, 51	3.1	11:35
4. Lal Shah (Pirpur)	50	0.9	13:44
5. Nawab Shah, Sayid[5]	24, 33, 34, 46, 49, 50	4.3	14:17
6. Khushi, Khirarane[6]	34. 39, 46, 50	6.7.	16:59
7. Raja etc., Khizarane & Sardar Machchi[7]	23, 25, 33. 34, 39.46, 47	2.7	20:58
8. Salabat. Hayat, Sahll, Khizarane[8]	23, 24, 25, 38, 46	4.3	22:46
			Tuesday
9. Nadar & Sardar Shah, Sayid	46	3.1	1:18
10. Murad etc. Dhudhi (Pindi)	47.48.49, 50. 51	1.5	3:07
11. Din & Dost, Khizarane	33, 38, 46, 47, 50	4.2	402
12. Sher. Khizarane[9]	25. 26, 34, 47	2.9	6:32
13. Khan, Khizarane	34.39.40.47	1.8	8:14
14. Jahana & Rahman. Khizarane	34.38. 39	2.3	926
15. Shabu (urban refugee)	34, 38, 39	5.7	1046
16. Fateh (urban refugee)	25, 26 ,33, 36, 39, 40	9.5	1409
17. Rahman. etal. Musalli	39	1.0	19:48
18. Saghir Shah, Sayid	40, 46, 50	2.7	2023
19. Raja, Muradke[10]	29, 33, 40	1.7	22:00
20. Wali, Rajeane[11]	23, 26, 34	6.1	23:00
Khudaya Branch			
			Wednesday
21 Ali, Khudaya[12]	21, 22, 27, 34	7.3	3:02
22 Sher. Khudaya	21, 27, 38, 34, 41	10.6	7:21
23. Baksh & Malik, Khudaya	28, 42, 44, 45	1.7	1332
24 Baksh, Khudaya[13]	30, 40, 42, 45	1.8	14:48
25 Akbar (nambardar). et al., Khudaya[14]	39-42, 44, 45, 51.52	27.3	15:52
			Thursday
26. Ghulam. et al., Miane[15]	21.29.33.40.41.42	13.8	8:39
27. Qaim, et al., Khydaya	28.29	3.9	1705
28. Nuri, Khudaya[16]	21.27.30.31.32.45	15.1	19:25
			Friday
29. Dost. Khudaya	28.29	3.9	422
Muradke Branch			
			Friday
30. Sardar. Khudaya[17]	42, 44, 45	4.1	6:22
31. Sada. Muradke[18]	22. 26, 40, 41, 45	7.8	8:55
32. Ahmad, et al.,[19]	22. 23.26. 32-34, 40, 41, 45	22.7	13:48

Branch[1] Owner[2]		Square[3] numbers	Area (ha)	Starting time
Muradke				
33.	Sher, et al., Kasise	32. 33, 40. 41	0.9	Safurdey 3:17
Khizarane Branch				
34.	Sardar. et al., Awan20	25, 26, 27, 33. 34.40	4.5	4:05
Chak *Aziz* Branch				
35.	Rahim. Fazal, Hafeez, Kharal (Chak Aziz)[21]	all the land in Chak Aziz	35.6	6:26
				Sunday
	"water tank"[22]	?	?	424
	Rahim. et al. again[23]	21. 22. 26-28. 33, 38, 39, 41, 42, 46, 47, 50-52	11.4	5:45
36.	Zaman, Langah[24]	42.44	1.2	12:39
37.	Ghulam. Langah[25]	42	0.5	13:32
38.	Lala, Khudaya	29.44	1.9	14:01
39.	Hayat & Sardar, Langah[26]	41, 42, 44	4.4	15:08
40.	Moulu & Hariana (Pindi)	in Pindi	5.3	17:46
41.	Sahli. Randhavah[27]	31.32	4.7	21:11
				Monday
42.	Rehman. et al., (Pindi)[28]	in Pindi	11.1	12:00
		totalirrigafed: 275.1 water returns *fo* Khizarane branch at *6:00*		

Notes Sources; Official rotation given in canal clerk's register, with notes on present practices from informants.

[1] See Map 1 for location of watercourse branches. [2] Owners' names, biradari. and village in () if not Gondalpur. [3] See Map 1 for locations of square numbers where land is located. [4] Informants include their fraternal nephew; 30 min. lead time. [5] His son now cultivates; 9 min. lead lime. [6] Mumtaz Khizarane cultivates this land on lease. [7] Raja is in Sind: his brothers cultivate; 12 min. lead time. [8] Informants say Hayat takes water at 22:35; then Sahli at 23:25; the Salabat at 00:15 Tuesday. [9] Sher, Kahn. Jahana. Raman (No. 12-14) are deceased; informants say Phule and Gula s/o Khan take water at 6:32; then Dost s/o Jahana at 8:14. Sher's sons are not mentioned but presumably taka water. 6 min. lead time in Khan's time. [10] Deceased; son Ahmad cultivates. Square 29 is not on this branch; previous rotation lists squares 26, 33, 34, 40. [11] Mostly sandy area not irrigated. Informants list this land as owned by Wali's son Anar, who cultivates. [12] Official time is on Khizarane branch, but actually used on Khudaya branch. [13] Deceased; son cultivates. [14] Includes 1.1 ha orchard, which gets extra time. 35 min. lead. Akbar deceased. [15] Deceased; sons manage land now; 15 min. lead time. [16] Nuri's land includes 1.0 ha orchard. [17] Lead time is 6 min. [18] Deceased: 2 sons now cultivate; 15 min. lead time. [19] Ahmad is deceased and succeeded by a son. Four households each take 3 hrs, and rotate who goes first. second. etc. weekly. [20] This land is in fact minutely subdivided. [21] Rahim, deceased, is succeeded by 2 half brothers of the other two. 48 min. lead time. [22] I know of no such tank, and informants never mentioned one. It may be a ruse for the Kharal to increase their supply. [23] Rahim's sons' (the troublemakers) araa, "enemies" with the other two, but they have an informal internal rotation. Dost Rajeane bought 2.8 ha of this land, and rented another .4 ha from 2 Kharal men. but has not yet obtained separate water for his land. Times listed are on Chak Aziz branch - but the land is on Khizarane branch. Each week Dost informally arranges for water. [24] Lead time is 11 min. [25] Lead time is 10 min. [26] Hayat is deceased, and succeeded by brother's son. All these Langah and Lala Khudaya work together and share water. [27] Sahli deceased and replaced by son. [28] Informal internal rotation.

One striking characteristic of the official rotation is that many of the holdings are still listed in the names of persons who were deceased even in **1966** when it was established. This reflects the legal position according to the records, since the rotation is based on the official record of rights. but shows people are evading the legal prescription to subdivide land when the owner dies. As a result of these demographic changes, the record does not reflect actual practice, and informal arrangements have been made among the successors for internal sharing of the water. This gap between the official rotation and social reality is a major force behind recent pressures to apply for another revision of the rotation.

Another striking feature, as noted above, is that water is allocated to people, not specific pieces of land. A comparison of the square numbers in which people hold land with the watercourse map shows that the plots belonging to one holding are widely scattered; in some cases they must even be irrigated by separate branches of the watercourse. If during one turn a man must move water from one branch to another, a great deal of Water is likely to be wasted. In fact this is often done; but in addition there is also a lot of informal trading of water to adjust to the problem. Another result of this single allocation of irrigation time for scattered plots of land is that those owning land in the sandy or waterlogged areas have extra water that can be applied to their cultivable plots, This too has a consequence pointed out by several informants: it reduces the incentive for those farmers to participate in cleaning and maintenance, since they have more water than most.

The allocation of water to people instead of land also creates a problem when land is purchased. After purchasing land, it is necessary to apply to the Irrigation Department for separate time for one's land, a lengthy and somewhat expensive, process. For example, Dost Mohammad, a Rajeane Bhatti, purchased about 2.8 hectares of land from Fazal Kharal of Chak Aziz. The land is actually located in the middle of the Khizarane branch, far from Fazal's main holding. Thus. every week Mohammad must make an arrangement with Fazal to get water, including bringing it from the Chak Aziz branch to the Khizarane branch, a long distance. He has a similar problem with land he rents from another Kharal on the same branch. During the field work he was attempting to get separate rotation time, but despite paying a number of informal "fees," had not succeeded before I left.

Another important characteristic of the rotation schedule given in Table 2 is the exactness of the times allotted to begin or finish irrigating. Times are given to the minute, such as **10:39** or **1:44**. This leads to frequent disagreements, since watches often do not agree, and a man's field may not be completely irrigated at the exact time when his neighbor is scheduled to take the water.

Finally, the designers of the irrigation system (and the rotations) assumed holdings in multiples of at **least 5.1** hectares, the smallest original colony allotment, which entitled the holder to nearly three hours of water per week on this watercourse. Effective irrigation under the constraints imposed by the low water supply per hectare requires planning irrigation for a holding of at least this size. However, many holdings are now far smaller than reflected in the official rotation because of de facto divisions. The smallest holding listed in the official schedule is 0.5 hectare belonging to a Langah. His watercourse has a poor water supply, so that it takes about two hours to irrigate **.4** hectare of land. With **19** minutes plus **10** minutes lead time to fill his irrigation ditch, a total of **29** minutes. this man could not manage within this schedule. Fortunately for him, his is a relatively cooperative biradari, so that with judicious exchanges and trading he is usually able to irrigate his crops adequately. However, it is questionable how long such a formal rotation can work, if it becomes even more detailed and subdivided, in the absence of informal cooperation, trading, and sharing.

The present rotation schedule is already losing its legitimacy, as the processes of land subdivision, land transfers, and increasing conflicts among people who had previously cooperated, continue. During the field work period, a land consolidation program and a watercourse reconstruction program simultaneously raised hopes and led to an increase in tension, and many people expressed the opinion that it was time to break this rotation schedule and create a new one (Merrey **1982, 1983).**

Conclusion

In 1977 a Government research organization offered to assist in implementing a reconstruction program on the main watercourse. In this program, the Government provides engineering assistance and materials, including concrete outlet gates (pakka nakka); the farmers provide the labor. Most people reacted enthusiastically to this program, but it soon bogged down in disagreements over shares of work, and disputes with some who were attempting to sabotage the program. As reported in detail in Merrey **(1982),** the villagers apparently had seen this as yet another opportup ity to solve the underlying social problems, but it was not successful.

Other writings have explored various sociological problems and their historical roots in irrigation management in Pakistan (Merrey **1982, 1983, 1986).** Here I wish to note a feature of rural Pakistani social structure that has not been emphasized previously. Even after about **80** years of adapting to an imposed irrigation system, no specialized irrigation management roles have evolved separate from the larger social structure at the local level. It would not be correct to say that there is no irrigation management organization; rather, the roles and norms through which irrigation tasks are carried out are imbedded in the larger local social structure, especially the kinship-based biradari system.

However, the social structure has no legitimate cultural mechanisms to insure that irrigation functions are fulfilled, i.e., that irrigation tasks requiring cooperation with others are done. Rather, as I have shown in this paper, the irrigation system has become yet another weapon, as it were, in the conflicts endemic in rural Pakistani society.

What lessons can be drawn from this case? It is not possible to offer a simple panacea, to solve all the complex organizational problems faced in designing and managing irrigation systems. But it is clear that when an irrigation system is still at the planning and later at the design stage, it is essential to make serious use of local social data, as well as the usual technical considerations., These data must be gathered systematically by social scientists trained to understand what types of data are appropriate and necessary, to avoid overloading the designers with extraneous data.

Irrigation planners and designers cannot assume that people will adjust themselves to the technology, or by themselves evolve satisfactory solutions to what are often deeply imbedded sociological, political, and economic problems. An integral component of the design, construction, and operation processes must therefore be the development of appropriate organizational capacities so that the users can make the best use of the system. This would apply to rehabilitation and modernization projects on existing systems, as well as to new systems.

Regarding Pakistan specifically, the case reported here is not unique. For example, Mirza and Merrey **(1979;** Merrey **1982)** show that similar problems characterized all of the recently rehabilitated watercourses studied to varying degrees. The minute subdivision of land and therefore irrigation times; the absence of an indigenous local capacity to ensure cooperation on collective tasks; and the "embeddedness" of irrigation management tasks in a highly fragmented and competitive social structure are serious and deep-rooted problems not amenable to standard types of social tinkering usually recommended by social scientists.

The implication is that the continuing implementation of watercourse rehabilitation programs, even including recent efforts to organize water users associations will be problematical from a long term perspective in the absence of more fundamental changes in system design and the organization of irrigation-related tasks.

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