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PHYSICAL AND SOCIO-ECONOMIC DYNAMICS OF A WATERCOURSE IN PAKISTAN'S PUNJAB: SYSTEM CONSTRAINTS AND FARMERS' RESPONSES

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Prepared by

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December 1975

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December 1975

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Chief acknowledgements and appreciation are due to the farmers of the watercourse for their time, patience, and cooperation over a two month period. They gave their time freely as we walked the fields, conducted long interviews and interrupted their work with our investigations. Without the help of Mr. Waryam Ali Mohsin and Mr. Pervez, who made major physical measurements, this investigation would have been more difficult. Special appreciation is also in order for the many suggestions offered by Professors Doral Kemper and Gaylord Skogerboe in the writing of this report. Special thanks are due the faithful secretaries in both the Islamabad and Fort Collins offices who typed the manuscript. Finally, we acknowledge the friendships and lessons learned from the farmers and their families.

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PHYSICAL AND SOCIO-ECONOMIC DYNAMICS OF A WATERCOURSE IN PAKISTAN'S PUNJAB: SYSTEM CONSTRAINTS AND FARMERS' RESPONSES

SUMMARY

A detailed study of the physical and socio-economic conditions of a watercourse in Pakistan has been presented. A major constraint on this watercourse was the use of jalars to lift canal water for irrigation on much of the commanded area. Major problems identified are the accumulations of sediment in the watercourse; excessive watercourse losses frequently exceeding 50 percent in only 2,000 to 3,000 feet of channel length; and underirrigation with canal water was observed during the period when canal supplies had been rationed, but measurements for the season for wheat did result in excessive applications of irrigation water. Farmers seem to have little understanding of the magnitude of their water losses, either from the watercourse (seepage, leaking and spillage) or during irrigation (deep percolation).

Jalar operations for lifting water involve excessive costs compared to other available pumping methods. Pumps require cooperation and additional technology (watercourse improvements) for effective use. The costs of jalar operation are further increased by excessive watercourse losses and ineffective irrigation.

Results from cropping experiments with wheat show that yields can be doubled with a 25 to 50 percent reduction in the use of water. Watercourse losses can be reduced substantially by proper renovation and maintenance.

Farmers organize dominately around brotherhood or kinship groups for many cooperative activities, while a major cleavage exists across two castes on the watercourse. To effectively mount a program of cooperative watercourse management improvements, group cooperation must be reinforced. This may be accomplished by providing equal benefits across cleavages and by presenting an effective operational program that ensures village confidence. Such programs should be presented to the village leaders for their approval and support, first in order to gain village input without resulting in farmer resistance around cleavages.

Farmers do effectively cooperate in several activities such as watercourse cleaning, private tubewells, tractors, and some village projects. The benefits must be equitable and substantial to obtain this cooperation.

Farmers perceive water to be the primary limiting agricultural input. Sixty percent of the farmers listed water supply as the first consideration when deciding how many

acres and which crops to plant. The first factor for the remaining farmers was fertilizer price, while water supply was second, but they all had access to private tubewell water. Farmer responses suggest that their perception of water as a limiting factor may negate the incentives of price increases and availability of other inputs to increase cropped acreage and yields.

Farmers operate their irrigation system under a contradictory system of dejure and defacto rules. Trading of water occurs frequently, with complete turns and partial turns being traded between farmers, and also across watercourse boundaries. They use extra legal means to obtain increased water supplies through bribes to Canal Department officials, as well as buying of water allocated for public use.

Farmers receive limited to no assistance for many of their problems. Their knowledge for properly maintaining and operating their irrigation system is understandably inadequate, and in some matters erroneous. Their perceptions of when to irrigate and how much water to apply result in over-irrigations, as well as crop stress. Their knowledge of green revolution technology is inadequate, and their reluctance to adopt new technology reflects their lack of knowledge as to the advantages available to them.

A host of laws and regulations are largely ignored by the farmers as they attempt to remove their constraints to agricultural production. Farmers trade water, install unauthorized nakkas, develop extra legal supplies of water, and evade government revenue collections. These activities flourish under the present administrative procedures of the existing institutional system.

RECOMMENDATIONS

The results of this study reflect the conditions for only one watercourse in Pakistan. However, the results are so startling in some instances, and consistent with other published data in other instances, that a number of recommendations seem necessary and worthwhile. These are:

1. Farmers in Pakistan must be provided with information about watercourse losses with recommendations for improvement and procedures for maintenance of the existing and improved system.

2. Farmers need to be provided with incentives to organize in order to improve water delivery by legal means, through institutional encouragement from the Irrigation and Agriculture Departments, and through assistance to farmers who have organized and made

improvements. The same farmer organization should provide for regular and frequent (sometimes daily) maintenance of existing and improved watercourse systems.

3. An effective extension program must be developed to provide services to the farmer such as seeds, fertilizer, insecticides, and knowledge for improved crop production and proper use of irrigation water. This program must evaluate and improve, through a practical field training program, the existing organizations for extension, as well as broaden the concept of extension to include multi-media communication and innovative approaches for obtaining farmer confidence, cooperation and action.

4. Canal Department operations have remained the same for over 100 years. Legal, administrative, and policy procedures should be reviewed with the objectives of changing water distribution procedures to eliminate extra-legal distribution of water, enhance revenue collections through increased water rates, develop revised collection procedures to reduce bribes and evasion of revenue due the Government, and provide protection to each farmer's water supply while providing flexibility to legalizing trading and purchase of turns between farmers. Irrigation Department extension must provide to farmers frequent multi-media communication of knowledge about weekly and seasonal water supply conditions, along with continuous information about rules and rights of farmers regarding their water supply.*

*Since this initial watercourse study, cooperative studies since May, 1975, have been conducted on 37 watercourses located in all major cropping regions of the Punjab and Sind. These data will appear in forthcoming publications, Water Management Technical Reports Nos. 45 and 47.

PHYSICAL AND SOCIO-ECONOMIC DYNAMICS OF A WATERCOURSE IN PAKISTAN'S PUNJAB: SYSTEM CONSTRAINTS AND FARMERS' RESPONSES[1]

by

Max K. Lowdermilk, Wayne Clyma, Alan C. Early[2]

INTRODUCTION

Very little is known about the physical constraints and the socio-economic problems which orbit farmers of Pakistan who must apply their scarce resource of water and other inputs for increased crop production. The farmers on millions of farms in Pakistan require direction toward improvement of their irrigation practices. The farmer's situation as he relates to and interacts with complex physical and socio-economic problems on one of Pakistan's 78,000 watercourses is the focus of this study. The famous canal irrigation system of Pakistan has been described in several studies from the great rivers to the canal outlets (mogha) (Corey and Clyma, 1973). However, little attention by the farmers or overseers has been given to the subsystem from the outlet to the last farm on the watercourse.

The farmer though can do little until he is provided the technology plus the means, incentives, and knowledge to implement improvements. The major assumption of this study which identifies farmer problems and seeks to understand them is that the primary building block of any irrigation system for agriculture is essentially the farmer. The authors are of the view that effective water management at the farm level, though made possible by modern technology, is in many respects as much a human problem as a water problem.

Therefore, this study is an attempt to define the physical and socio-economic problems of a watercourse and compare these with the farmer's perceptions of his problems. Farmer attempts to solve these problems within complex constraints will be discussed and suggestions will be given for helping the farmer to improve his irrigation subsystem.

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[1]Research for this study was supported by the United States Agency for International Development Contracts AID/csd-2162 and AID/ta-c-1100.

[2]Extension Education and Applied Rural Sociologist and Agricultural Engineers, Colorado State University, Water Management Research Contract, Fort Collins, Colorado, and Islamabad, Pakistan, respectively.

Purpose of Study

The specific objectives of this watercourse study are:

1. To identify the physical problems of the watercourse subsystem and gain an understanding of how the farmer interacts with the irrigation systems' constraints.

2. To examine the influence of the social systems of farmers with respect to leadership roles, status, decision making processes and patterns of cooperation and conflict.

3. To examine farmers' irrigation practices, adoption behaviors, and cropping patterns and develop ways to facilitate the increased adoption of relevant technologies.

4. To understand the linkages, interactions with, and utilization of agencies by farmers for essential inputs and services.

Methodology

The condition of all distribution channels (i.e., siltation, leaks and spills at nakkas[3] and buffalo wallows) were documented by photographs. A topographic survey was completed as well as a soil survey. A crop survey for rabi and kharif was completed and a special map shows all water channels and cuts in ditches for field irrigations. An ownership map was also developed.

Physical measurements of mogha discharge, ditch losses and on-farm irrigation efficiency evaluations were made with 4 inch and 8 inch Cutthroat flumes. Moisture samples were taken with King tubes and soil moisture deficiency was evaluated by the "feel" method.

Key informants were carefully selected for general historical, social, and economic information about the watercourse. This information was compared with intensive personal interview data collected from 35, or 87 percent, of all farmers on the watercourse. The interview instruments had been pretested earlier and revised; the individual farmer interviews were completed in two separate one hour sessions.

Reliability checks[4] were used in relationship to cropping patterns, cropping intensities, irrigation schedules, use of

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[3] Nakkas - the field inlet opening for irrigating basins.

[4] Rabi crops were mapped in the fields as well as kharif season crops which provided checks of farmers' reports.

water lifts, cropping practices used and innovations adopted. The investigators utilized about two man-months in the collection of these data and were able to double check through actual observations. Of the 41 farmers cultivating some land on this watercourse, 35 were interviewed. The 6 farmers for which interviews were not completed owned a total of only 13 acres on this particular watercourse. Thus, almost a total enumeration of farms was made.

THE WATERCOURSE AREA AND PHYSICAL SYSTEM

This watercourse is located outside Lahore City, and is in an area where farmers cultivate wheat, rice and fodder crops primarily. The major cash crops are fodder and some milk is marketed in Lahore.

Due to the extremely irregular topography of the land commanded by the watercourse for most of the area, irrigation water must be lifted by water lifts (jalars or rahats).[5] The jalari system requires much labor and expense in lifting the canal water from the main ditch a height of only .5 to 1.5 feet before fields can be irrigated.

The watercourse receives water from the upper Bari Doab system through the Lahore branch canal. This system was established about 1860-61. Until about 40 years ago there were 3 mogha outlets for the village area with a command area of about 1,426 acres. Today, 4 moghas serve the area, one of which serves the sample watercourse.

Rainfall during the summer of kharif cropping season ranges from approximately 10 to 15 inches and during rabi or winter season only about 3 to 5 inches; however, the range in yearly rainfall over ten years (1961-70) is from 14 to 31 inches due to the erratic monsoon period which begins near the end of June and often lasts through August.

Mean summer maximum temperatures from May to July range between 96°F and 103°F with extremes of 115°F; from December to February mean maximum temperatures range between 64°F to 70°F with minimums near to 34°F. Diurnal ranges in air temperatures often vary as much as 35-45°F during summer and winter. Frost is not unknown in the Lahore area, however, it seldom damages crops. Therefore, intensive multiple cropping is possible as in most areas of the Indus Basin where water is available.

The soil survey of the watercourse command area shows that the soils are rather uniform (see Soil Survey Map I on page 9); only ten acres are classed as silty clay loam while

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[5]It is estimated that roughly 200,000 jalar lift pumps are still used in Pakistan today. See picture of jalar on page 8.

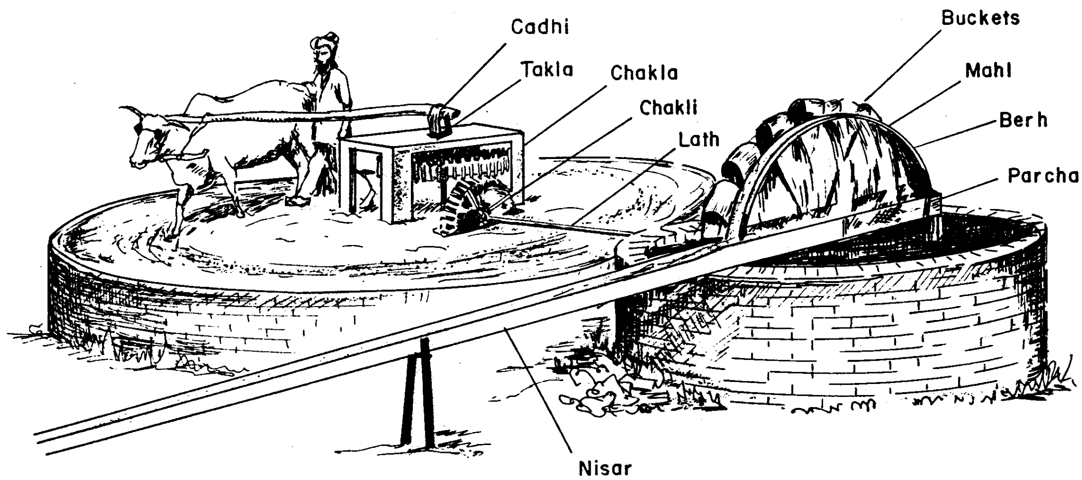
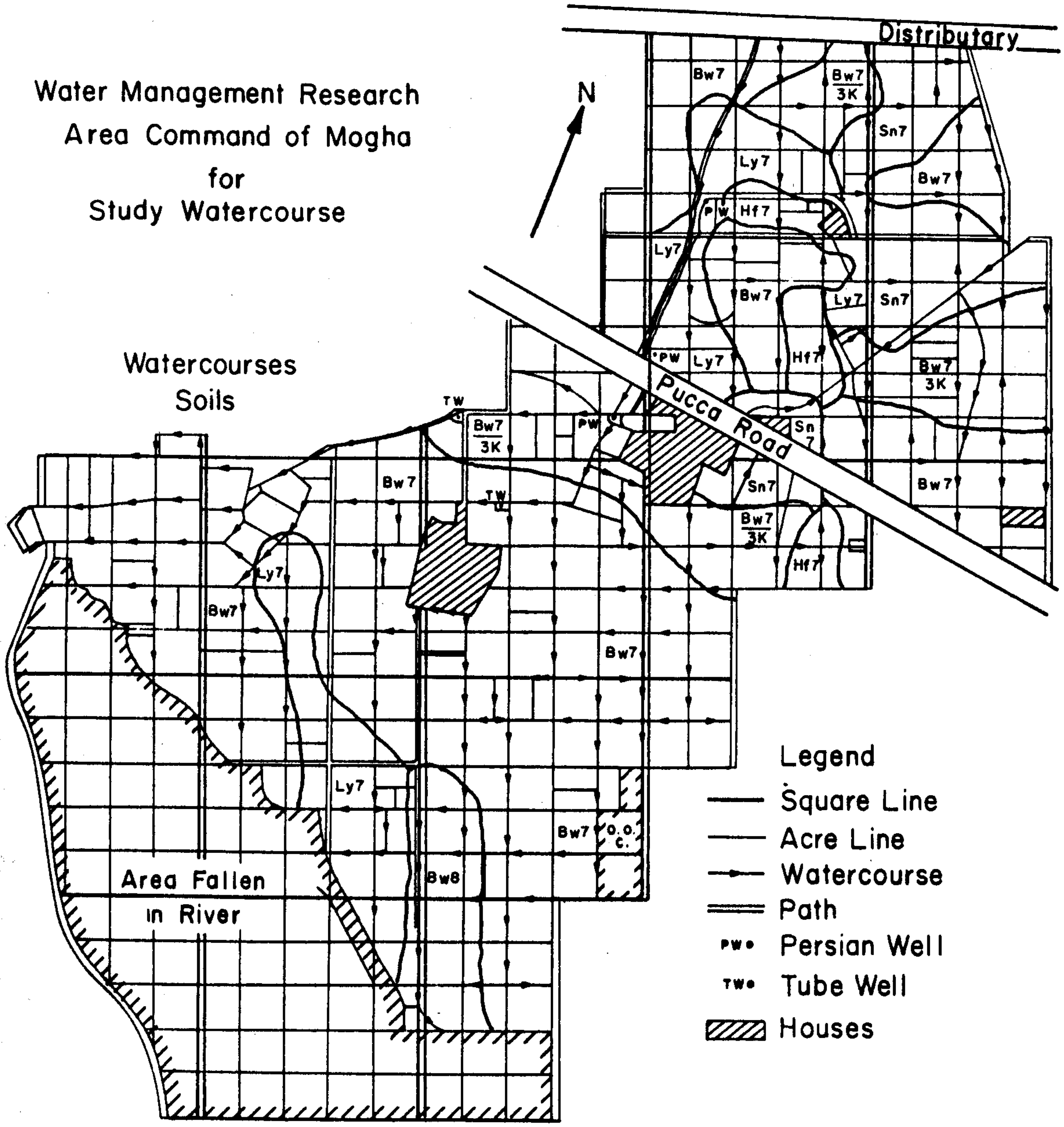


Figure 3. Persian Wheel (Jalar)



Legend for Soils

Bw7	Bhalwal Silt Loam
Bw7 / 3K	Bhalwal Silt Loam with Kanker Zone between 21 to 36 inches
Bw8	Bhalwal Silty Clay Loam
Hf7	Hafizabad Silt Loam
Ly7	Lyallpur Silt Loam
Sn7	Sindhwan Silt Loam

Scale

0 400 800 1200 1600 ft

Map I. Soil types for study watercourse.

the remainder is silt loam. The primary soil type is Bhalwal silt loam and the minor areas of Sindhwan, Lyallpur, and Hafizabad are silt loams.

The crops in terms of acreage on the total watercourse command area for rabi season are wheat (115 acres); oats for fodder (67 acres); and berseem for fodder (43 acres). For kharif season, rice (50 acres); maize fodder (38 acres), millets (35 acres); cotton (50 acres); and sugarcane (4 acres). Cotton and sugarcane are cropped for home use and a few acres of vegetables are cultivated. The total cropping intensity for the 238 acres is about 157 percent. The two tubewells and the extra water allotted for lands eroded into the river give these farmers more water per acre than most watercourses.

The Watercourse and Commanded Area

The actual gross area being served by the watercourse is 319 acres of which 8 acres are in buildings and about 73 acres have been removed by river action leaving a total cultivated area served by the mogha of about 238 acres. The command area is officially recorded as about 268 acres including the 73 acres eroded into the river, but according to Canal Department records, only 201 acres or 75 percent is now permitted irrigation by canal water annually. This restriction, however, is not enforced.[6] The Canal Department gives the water supply rates for this watercourse as 1 cusec discharge per 268 acres.

Given the regulated mogha discharge of 1.2 cusecs plus .6 cusec as bonus for the labor of lifting water, the regulated watercourse supply rate is about 1 cusec per 110 acres on the authorized command area, or 1 cusec per 140 acres including the area served on adjacent watercourses; with two tubewells on the watercourse and manipulation of the mogha size, the actual rate is even higher. As is later documented, however, the inefficiencies of the water lifts and extremely high ditch losses cause the actual rate farmers receive for crop irrigation to be much less.

The watercourse main ditch from the mogha outlet at the distributary to the last jalar water lift is about one mile long. However, the main channel plus all branches and field ditches constitute about 61,402 feet, or 11.63 miles in length and represents one mile of watercourse per 20 acres served.

Table I shows four farm size classes for the 41 farmers on the watercourse, and also includes their total holdings on

[6]Also a total of 23.5 acres of land lying in the command area of two other watercourses are served unofficially by this mogha. At three or more places along the watercourse, fields can also be irrigated at will by other moghas.

Table I. Size of total holdings and degree of fragmentation.[1]

Farm size class	Number and percent of farmers		Separate parcels on watercourse	Separate parcels other watercourses	Total separate parcels cultivated	Average parcels/holding
	No.	Pct.				
<10 acres	17	42	26	13	39	2.2
10≤25 "	16	39	72	77	149	9.3
25≤50 "	7	17	30	19	49	7.0
>50 "	1	02	8	5	13	13.0
Totals	41	100	136	114	250	6.0

[1] See ownership map on page 14. Each number represents individual or joint ownership. As an example, look for farm 8 and find all the separate parcels!

other watercourses along with the degree of fragmented parcels.[7] Though the average holding on the watercourse is 5.67 acres, the median sized total holding of the farmers on all watercourses is about 17 acres. This is inflated in the sense that 28 of the 41 farmers participate with relatives in joint farm operations.[8] The most significant factor in Table I is the degree of fragmented holdings, especially on farms of over 10 acres in size. Farmers on the watercourse are largely small operators. A land consolidation program about 12 years ago accomplished little according to farmers except to create enmity between groups of farmers and widen existing cleavages.

With so many separate parcels of land, farmers face a multitude of problems today such as: wastage of time and labor; extra expense of moving people, animals and equipment from one field to another; transport of seed, fertilizer, manure and harvests; guarding of work and crops to secure them from man and predators; choice of cropping patterns; land wasted in excess bunds, banks, boundaries and field ditches; inability to design large level fields; mechanization difficulties because of size of field and access; location of tubewells; loss of water through dead storage in long ditches; and extra spills and leaks. These and other problems result from inheritance laws which require equal division of an ancestor's land among all male heirs. Since all land is not of equal quality, one acre is often divided equally among three or more brothers and later it will be subdivided even more. On this watercourse such divisions have taken place over time even though many of the 41 farmers are cultivating jointly today which lessens the problem slightly. The one possible positive aspect of such fragmentation is that the farmers are forced to cooperate closely with each other in many activities such as trading water and work.

Nine of the farmers who own land on the watercourse also rent from other farmers. At the time of the survey, 34 acres were on rent. Only two of the owners renting land out were absentee. Most agreements are on a yearly lease basis and the rent ranges from Rs.300.00 to Rs.450.00 per acre depending on the quality of land and its distance from a source of water supply.

Physical Watercourse System

A problem common to many watercourses in Pakistan exists on this watercourse. A portion of the area served by the watercourse is higher in elevation than the full supply level of the distributary. This means that the area cannot be

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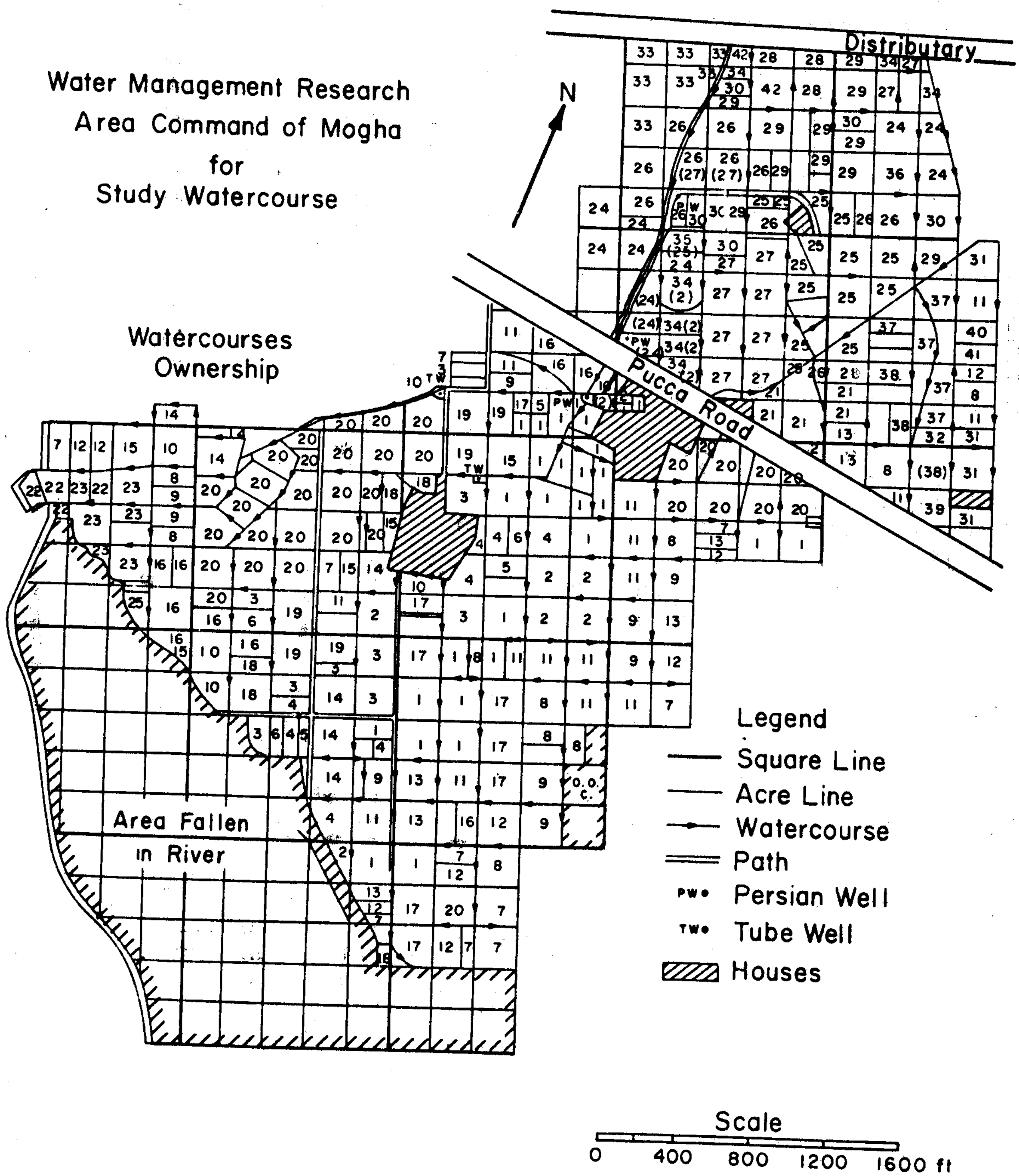
[7]A parcel is defined as a separate plot owned by a farmer which does not directly join an adjacent plot of the farmer.

[8]A joint farm operation is defined as a father with married sons, brothers, etc., who participate in farm operations and share expenses and income jointly on some agreed basis.

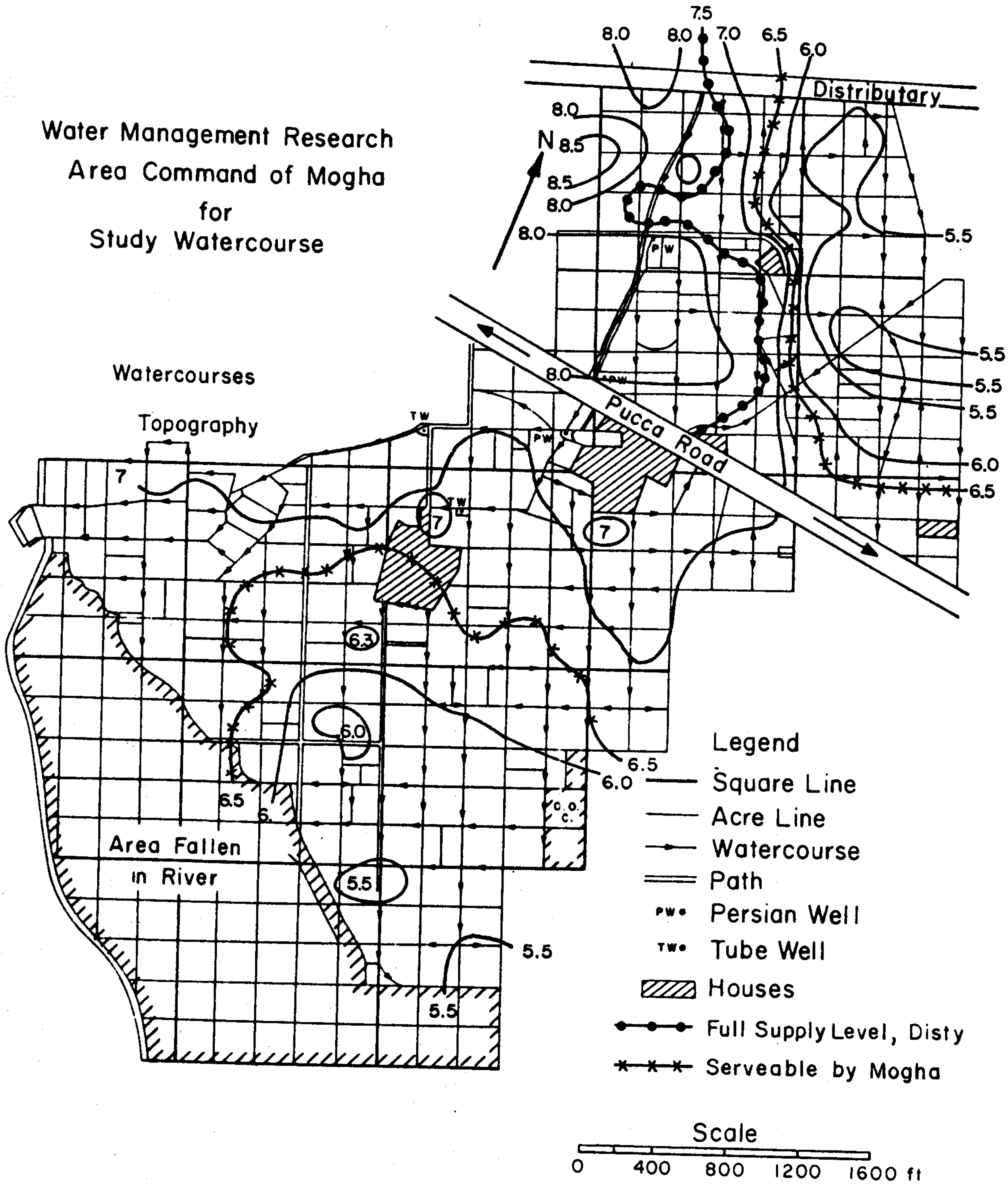
served by a gravity flow system. Another factor that complicates the farmer's ability to obtain water by gravity flow is that the structure (mogha) that functions to supply water to the farmer at the authorized rate also incurs a head loss of 0.3 feet. This means that the full supply level in the watercourse will serve the area up to the 7.1 contour shown on Map II, page 15, and any area in the watercourse above this elevation cannot be served by the watercourse without a reduction in the flow. Practically, a grade is required to carry water in a watercourse plus a minimum water surface above the field. Map III, the topographic map, shows the area that cannot be served by the watercourse because it is above the full supply level in the distributary. This corresponds approximately to the 7.5 foot contour, and the area above that contour cannot be served by the watercourse without a reduction in flow. Allowing for this minimum head difference between the full supply level in the watercourse and the field elevation is that area above the 6.5 foot contour.

This watercourse is further complicated by the fact that farmers have lowered the bottom elevation of the main watercourse several feet below the ground surface elevation through which it passes. This means that the farmers have difficulty seeing which land can be served by gravity; thus, a considerable depth of water in the watercourse is ponded. Because of this lack of elevation control, the Persian wheels or jalars frequently lift water three or four feet out of the watercourse into a channel at a new elevation that then goes into a channel where water flows by gravity to the field. The result is that frequently the jalar effectively lifts the water only six inches above the existing water surface elevation in the main channel. Water pumping costs discussed in subsequent sections are incurred to raise the water surface only approximately six inches above existing gravity flow levels. The effective lift may be even less than this.

The flow at the mogha appears to be quite variable. This is related to the circumstance explained previously (i.e., when the full supply level in the watercourse rises above the design level, the mogha becomes partially submerged and a reduction in flow occurs). As water flows into the watercourse from the distributary, should several Persian wheels and/or gravity flow sections or branches be operating, then a relatively large flow in excess of three cusecs is available from the mogha. When only the jalars are working, then the flow through the mogha will eventually equal the pumping rate of the jalars because the submergence will reduce the inflow at the mogha to equal the outflow at the jalars. The water supply rate of the watercourse is the maximum flow rate at the mogha for the full supply level in the distributary. The only thing that is required for the farmers to receive water at this rate is to operate the jalars and gravity flow channels when the maximum flow rate at the mogha is occurring. When the farmers use water at a lower rate than the maximum



Map II. Ownership map for study watercourse (each number represents a different owner).



Map III. Topographic map of study watercourse.

rate, then the mogha becomes submerged, and the inflow at the mogha is reduced appropriately.

The problem that occurs frequently is that farmers attempt to irrigate land above the full supply level in the watercourse, thereby reducing the flow and allow sediment to accumulate in the watercourse. When sediment that accumulates in the watercourse is not removed, it raises the elevation in the bottom of the watercourse. When farmers are irrigating land below the full supply level in the watercourse, the sediment accumulations have permanently submerged the mogha and the reduced flow occurs on a continuous basis. One watercourse in Multan was measured where the permanent flow was reduced by one-third by lack of frequent or adequate cleanings of the sediment from the watercourse at the mogha. It is this condition that probably explains the large mounds of sediment along watercourse banks resulting from cleaning operations that occur frequently at moghas on watercourses in Pakistan. It is not unusual to find long reaches of the main watercourse near the mogha with silt mounds from 5 to 10 feet and even higher. Some have become so high that farmers can no longer clean them and therefore they are abandoned.

Watercourse Losses

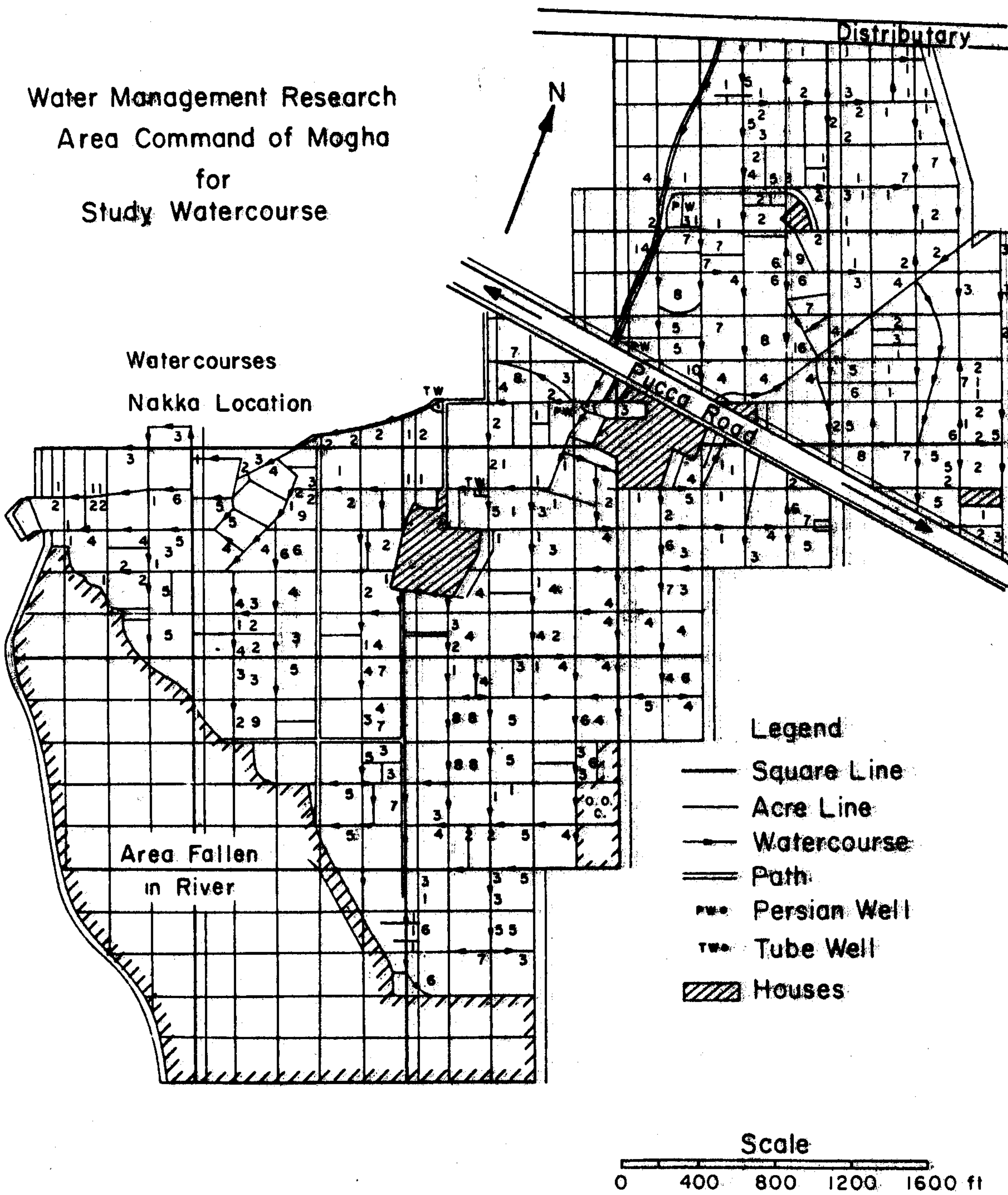
Limited data, based upon measurements of watercourse losses, are presented in Table II. Compared to losses on watercourses near Mian Channu, Lyallpur and at the Mona Reclamation Experimental Project, losses measured on this watercourse in the channels serving the jalars are from 50 percent to several hundred percent higher (Clyma, Ali and Ashraf, 197 The two measurements for gravity flow were much different. T measurement on November 8 was for a branch near the mogha and serving land near the distributary. The watercourse is below ground much of the distance with well maintained sides. No maj loss was detected by inflow-outflow measurements, although some seepage occurred. The other gravity flow measurement was in the main channel where the bottom is nearly three feet below the ground surface. A seepage loss consisting of 10 per cent of the initial flow, and near the average loss rate for the two cusec watercourse, was measured.

The high losses measured in the channels serving the jala consisted of both seepage and spills. Seepage is defined as water which goes directly to groundwater. Spills are losses caused from leaky nakkas[9] and overtopping, whereby water moves from the channel to the ground surface where it goes to

[9]Map IV shows about 1250 nakka cuts where farmers let water o to their fields. Map II shows an average of about 5 per acr The ditches for 238 acres measure 61,402 feet or 11.63 miles.

Table II. Watercourse losses for the study watercourse.

Date	Jalar No.	Initial flow (cusecs)	Final flow (cusecs)	Distance (ft.)	Efficiency (Pct.)	Loss (cusecs/1000 ft.)
4/11/74	3	0.75	0.42	3680	55	.090
5/11/74	4	1.0	0.6	2000	60	0.200
6/11/74	2	0.6	0.3	2500	50	0.120
7/11/74	4	0.77	0.4	2000	50	0.185
8/11/74	Gravity	0.70	0.7	900	100	0
9/11/74	1	0.70	0.35	1100	50	0.318
12/11/74	4	0.90	0.4	3600	45	0.139
15/11/74	Gravity	2.2	2.0	1500	90	0.133
19/11/74	Electric TW	0.4	0.3	500	75	0.200
24/11/74	Electric TW	0.33	0.3	400	90	0.075
11/2/75	Gravity	0.57	0.2	1700	35	0.218
11/2/75	Gravity	0.50	0.2	1800	4.0	0.167
11/2/75	Gravity	0.65	0.47	2000	72	0.090



Map IV. Locations for nakkas and channels in study watercourse.

groundwater, evaporates or is transpired. Seepage, caused from extremely thin walls resulting from farmers extending their fields by removing soil from the sides of the watercourse, is a major cause of loss. When water is flowing in the channel, water commonly covers the surface of fields for 10 to 20 feet on either side of the watercourse. Since much of the area is above or just at the full supply level in the distributary, much of the watercourse is below the ground and at the end of an irrigation the water remains in the bottom of the watercourse. This loss is not included in the measurements in Table II.

That farmers will allow 50 percent of the water to be lost that they have lifted at a very great cost would seem inconceivable. A primary factor in this loss is their attempt to extend their fields only a few feet. This same procedure causes reduced yields of crops in fields from ten to fifty feet on either side of the watercourse.

An analysis of flow losses during a period when the branches were using water by gravity flow suggested only 30 percent of the inflow at the mogha reached the farmers' fields. This study also suggested that the effectiveness of the jalar is not just the amount delivered to the field, but is the difference between what is delivered at the field by gravity and that delivered by the jalar. This difference is near 0.1 cusec and makes the cost of lifting water by jalar very expensive.

Irrigation Practices

Limited quantitative studies have been made of irrigation practices in Pakistan. Clyma, Ali, and Ashraf (1975) have reviewed irrigation practices in a Salinity Control and Reclamation Project (SCARP) which has water supplemented from government tubewells at a water supply rate of approximately one cusec per 150 acres. van der Boom and Gerards[10] monitored irrigation practices on precision leveled fields near Mian Channu, where the water supply was supplemented by private tubewells. Both studies measured excessive applications of water to fields and generally low efficiencies. The greatest wastage of water was in the SCARP area.

Preliminary data for this watercourse summarized in Table III and other unpublished data suggest that under unsupplemented (canal water only) watercourses, farmers use a

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[10]Results from "Effects of Precision Land Leveling on Farm Management and Irrigation Practices in Pakistan," by P.G.M. van der Boom and T.L.M.H. Gerards. Unpublished report of Agricultural University of Wageningen, the Netherlands, Agricultural Extension and Farmers Training Center, and Colorado State University.

Table III. Distribution of the amounts of water applied during an irrigation for both canal and tubewell water, as well as a comparison of the amounts applied for canal water only and tubewell water only for the study watercourse.

All Observations

Application depth (inches)	No. evaluations	% of total evaluation
0 $\leq$ 1.0	0	0
1 $\leq$ 2.0	11	28.0
2 $\leq$ 3.0	12	30.0
3 $\leq$ 4.0	10	25.0
4 $\leq$ 5.0	7	17.0
Totals	40	100.0

Canal water only

Application depth (inches)	No. evaluations	% of total evaluation
0 $\leq$ 1.0	0	0
1 $\leq$ 2.0	10	37.0
2 $\leq$ 3.0	11	40.0
3 $\leq$ 4.0	4	15.0
4 $\leq$ 5.0	2	8.5
Totals	27	100.0

Tubewell water only

Application depth (inches)	No. evaluations	% of total evaluation
0 $\leq$ 1.0	0	0
1 $\leq$ 2.0	1	8.0
2 $\leq$ 3.0	1	8.0
3 $\leq$ 4.0	6	46.0
4 $\leq$ 5.0	5	38.0
Totals	13	100.0

combination of small fields that are relatively level and small applications of irrigation water to achieve higher cropping intensities than the water supply normally warrants. In Table IV, about 70 percent of the irrigation applications were on fields of less than 0.24 acre and about one-third were on fields of less than 0.15 acre. All except two of the irrigations with canal water were underirrigations and many of these were irrigations of land that had been fallow for several months. Those observations were made during a period of scarcity of canal water when supplies were available only about two-thirds of the time. As a result, the soil moisture profile was relatively depleted and 77 percent of the irrigations were less than three inches. This water is expensive to the farmer in terms of labor utilized in jalar operation. Therefore, he probably attempts to apply minimum applications of irrigation water. Although he may waste much water in the watercourse, the water that reaches his field is carefully applied. Under this system of irrigation, his crops are most likely stressed significantly during periods of peak water use with a consequent reduction in yield. If practiced on a continuing basis, these fields are expected to show salinity accumulations. However, more data on seasonal irrigation practices are needed in order to understand the water management problems on these farmers' fields over time.

Table III summarizes the amount of water applied for all irrigation applications. The median amount for all applications was 2 to 3 inches. The applications were separated into canal water and tubewell water applications. Seventy-seven percent of the canal water applications were less than three inches, while 84 percent of the tubewell applications were greater than three inches. The only explanation for this difference at present is that a laborer of the farmer managed the tubewell irrigations and was not particularly interested in using the water effectively. As shown in Table IV, most of the application efficiencies for tubewell water were between 20 to 30 percent.

Preliminary results from seasonal irrigation practices for wheat suggest that farmers apply almost twice as much water as the consumptive use requirement. In field demonstrations on this watercourse, the yield on properly irrigated plots was double the farmers' yield.[11] Thus, about 60 percent as much water for irrigation gave double the yield. Seasonal application efficiency did not exceed 50 percent.

Determinants of Cropping Patterns

Canal water supplies, rainfall, home consumptive needs, market prices and perhaps differential rates in water charges

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[11]Refer to page 73 for a discussion of field trials with farmers on this watercourse.

Table IV. Irrigation application efficiencies with tubewells.

Date	Location jalar No.	Crop & height (ft) Oats, .5 Maize, 1'	Date of last irrigation	Soil moisture deficiency	Amount applied (in)	Irrigation application efficiency (pct.)
4/11/74	3	"	13/10/74	5.7	1.1	100[1]
"	3	"	"	5.7	4.5	100
"	3	"	"	5.7	1.8	100
"	3	"	"	5.7	2.3	100
"	3	"	"	5.7	2.3	100
"	3	"	"	5.7	2.5	100
5/11/74	4	Rauni	15/3/74	6.0	1.7	100
"	4	"	"	6.0	1.7	100
"	4	"	"	6.0	2.1	100
"	4	"	"	6.0	1.9	100
"	4	"	"	6.0	1.9	100
"	4	"	"	6.0	3.6	100
"	4	"	"	6.0	2.0	100
6/11/74	2	"	6/5/74	2.9	3.9	100
"	2	"	"	3.9	1.4	100
"	2	"	"	3.9	1.2	100
"	2	"	"	3.9	2.6	100
"	2	"	"	3.9	1.3	100
7/11/74	4	Oats	24/10/74	3.4	2.2	100
"	4	"	"	3.4	1.8	100
"	4	"	"	3.4	2.0	100
8/11/74	Gravity	Rauni	8/5/74	3.7	4.3	86
"	Gravity	"	"	3.7	3.8	97
9/11/74	1	Oats	25/10/74	2.8	1.2	100
"	1	Oats .5	"	2.8	1.0	100
12/11/74	4	Rauni,Wheat	12/5/74	3.9	3.2	100
"	4	"	"	4.0	2.5	100
"	4	"	"	3.9	2.1	100
"	4	Rauni	"	3.9	2.7	100
"	4	"	"	4.0	2.5	100
"	4	"	:	2.9	2.1	100
19/11/74	Elec.TW	Oats .75	9/11/74	2.8	1.5	100
"	Elec.TW	"	"	2.8	1.2	100
24/12/74	Elec.TW	Wheat .33	20/11/74	0.8	3.5	23
"	Elec.TW	"	"	0.8	3.4	24
"	Elec.TW	"	"	0.8	4.1	20
"	Elec.TW	"	"	0.8	3.8	21
"	Elec.TW	"	"	0.8	3.6	22
"	Elec.TW	"	"	0.8	3.4	23
"	Elec.TW	"	"	0.8	4.5	18
"	Elec.TW	"	"	0.8	3.0	27
"	Elec.TW	"	"	0.8	3.6	22
"	Elec.TW	"	"	0.8	3.1	26
"	Elec.TW	"	"	0.8	4.1	20
25/12/74	Elec.TW	"	"	0.8	2.5	32

[1]An irrigation that is less than the soil moisture deficiency is recorded as 100 percent.

for various crops, along with custom, exert some influence on cropping patterns. When farmers were asked to give the major factors which helped them make decisions about what crops and how many acres to cultivate, 24 of the 35 (69 percent) farmers interviewed gave, "water supply" as most important. "Price level" of either rice, fodder crops, or milk[12] was given by 5 farmers and the remaining 6 farmers reported both "water supply" and "price level." The 11 farmers who reported "price" either own shares in the two tubewells on the watercourse, or have easy access to extra water supplies. This suggests that "price" became most important only when the water constraint was removed.

The constraint of water is also seen in the fact that during Kharif season 1974, there were about 100 acres left fallow, while the previous year with early, unprecedented rains only a few acres were not cultivated according to farmers' reports.

In order to analyze most accurately the water constraint on cropping patterns, all crops for Kharif and Rabi seasons were mapped in the fields as shown on the following Map V. Two areas below the last waterlift were demarcated in relationship to distance from source of supply of water. Table V shows Area I which lies from a few feet to about 1,300 feet from sources of water supply, which are two jalar lifts and two small discharge tubewells all located close to each other at the head of Area I. Area II is located at the tail of the watercourse and extends from about 1,300 feet up to more than 3,400 feet from the same source of water supply as Area I.

Table V shows how distance from the source of water significantly affects the cropping pattern. Crops with high water demands such as rice and sugarcane are cultivated on 39 percent of the land in Area I and on about 6 percent of the land in Area II.

Table V also shows clearly the differences in cropping patterns and cropping intensities between Areas I and II.[13] The greater the distance from the source of water supply, the more seepage, dead storage, leaks and spills and kutcha nakkas along a maze of field ditches which average one mile in length per 20 acres of cultivated land. Area I has a cropping intensity of 178 percent in contrast to Area II which has an average of 130 percent. Crops such as rice and berseem with high water demands are almost entirely located in Area I. In Area II, about 70 percent of the land is left fallow during Kharif while in Area I, only 22 percent is fallow. A tubewell farmer in Area I had a cropping intensity of 185 percent for Rabi-Kharif seasons, 1974-75.

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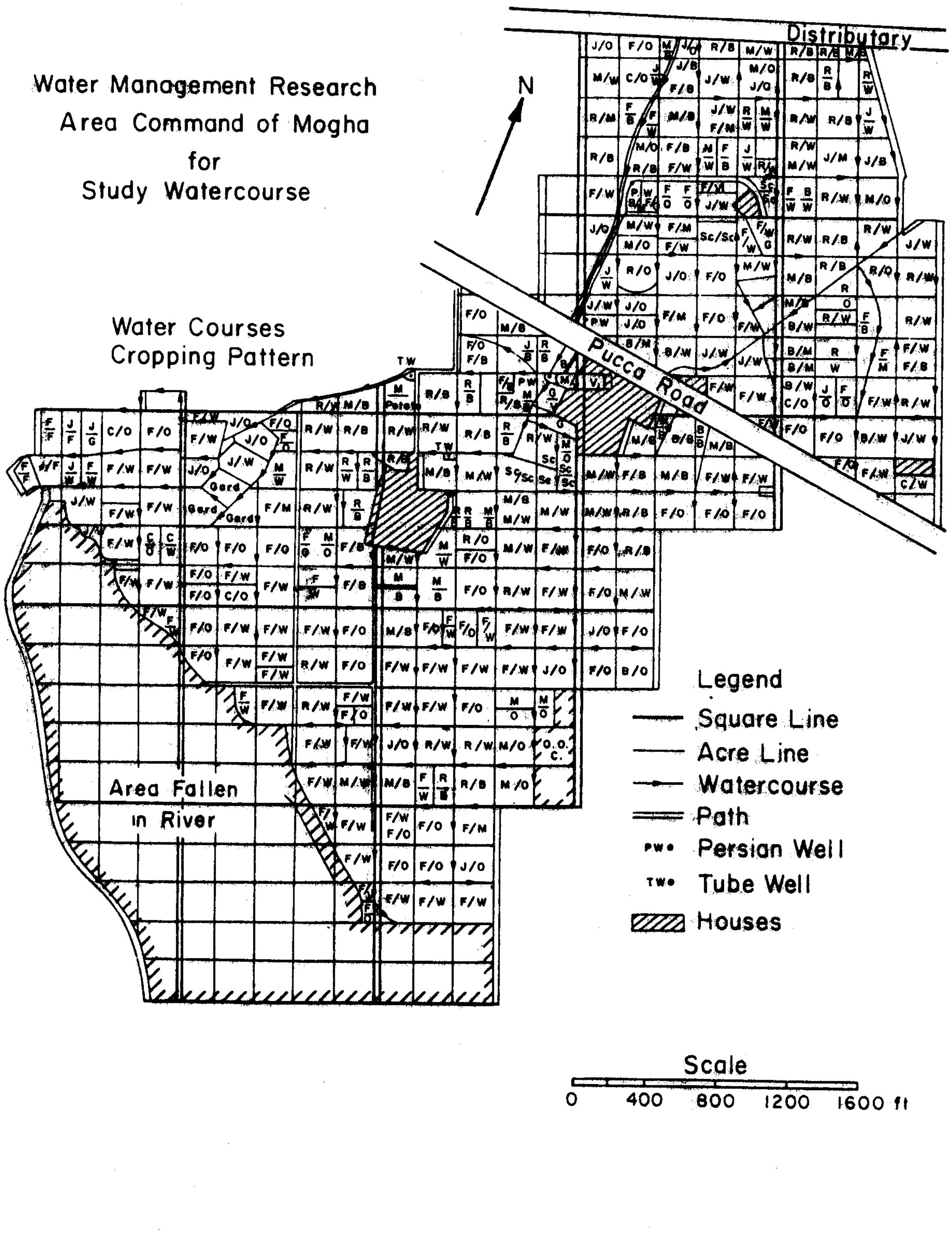
[12]Thirteen households market milk in Lahore.
[13]Areas I and II are shown on Map VI on page 26.



Map V. Crop survey for Kharif 74 and Rabi 74-75.

Table V. Difference in cropping patterns and intensity of cultivation for two areas of watercourse.

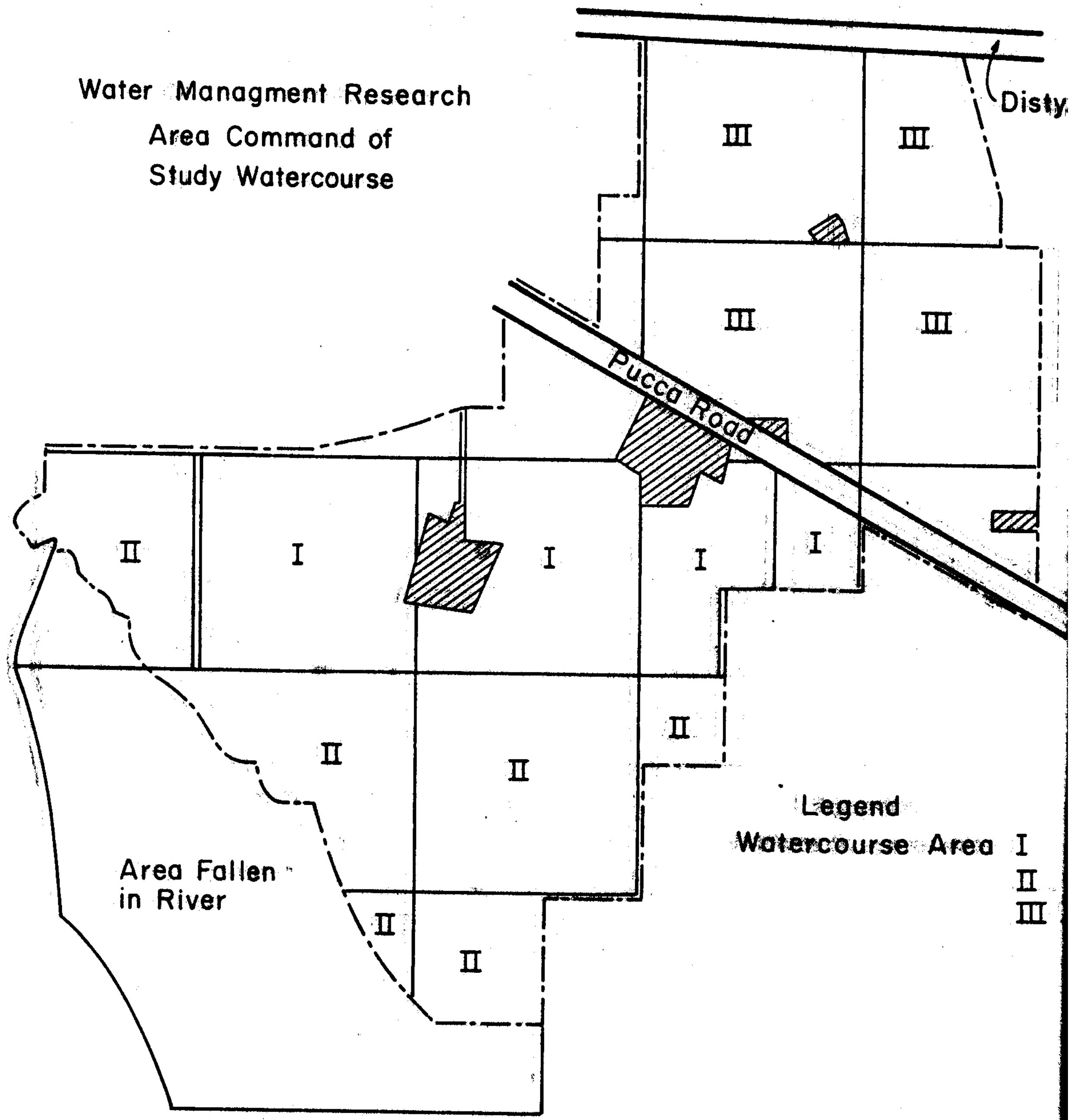
Crop	AREA I* Acres	AREA I* Total for each season (pct)	AREA II* Acres	AREA II* Total for each season (pct)
		Kharif		
Rice	20.8	35	6.1	6
Millet	2.3	4	8.7	9
Maize fodder	19.5	33	8.4	9
Sugarcane	2.2	4	--	-
**Others	1.4	2	2.8	3
Cotton	0.4	1	3.3	3
Fallow	13.0	22	66.9	70
***Total in Kharif	59.6	101	96.2	100
***Cropping Intensity	78%		31%	
		Rabi		
Wheat	20.7	34	49.1	51
Oats Fodder	8.6	14	38.1	40
Maize Fodder	--	--	--	--
Berseem	26.6	45	3.5	4
Sugarcane	2.2	4	--	--
Others	1.6	3	4.1	4
Fallow	--	--	1.4	1
Total in Rabi	59.7	100	96.2	100
***Cropping Intensity	100%		99%	
Total --------------------Kharif and Rabi------------------------------				
Cropping Intensity	178%		130%	

*Total Acres in Area I is 59.3 and in Area II 96.3

**Other refers to citrus gardens and small vegetable plots for home use

***Slight differences result from actual acreage and crops mapped due to errors.

***Cropping percentage or intensity is calculated as: $\frac{\text{cropping acres}}{\text{cultivated acres}} \times 100$



Map VI. Areas from mogha given in Table 7 of text.

Table V also suggests that farmers with fields closer to the supply of water leave few fields fallow as compared to those near the tail. As described earlier, there are substantial losses of water relative to distance from the source of supply. As a result, along a given watercourse, there is considerable variability in the availability of water for crops. Given the present system with losses resulting from seepage, dead storage, countless leaks and spills along watercourses at improper elevation along unlevel fields, there is actually a built-in mechanism creating mini-type economic dualism between watercourse users located at the head and tail positions. The farmers who own land at the tail are always at a disadvantage for canal water.

The data presented showing significant differences in cropping patterns and cropping intensities in relationship to distance from jalars and tubewells clearly shows that farmers behaviors are rational. They realize that crops with higher water demands must be cultivated where the water supply is more dependable and where losses of water enroute to fields are less.

The 35 farmers interviewed were asked what changes they would most likely make in their cropping patterns if their water supply was doubled. Table VI is a summary of the reported increases in crops, which shows the actual present acreage of crops on the watercourse and expected changes. Present price levels for crops and input costs would enter strongly in farmers decisions and currently price levels are changing for several crops.

Farmers report that they would substantially increase rice and wheat acreage. Most likely, at least two crops of maize for fodder would be cultivated according to farmers' reports in Kharif season. The estimated cropping intensity would increase to more than 193 percent and only a few acres would remain fallow.

When more water becomes available through an improved delivery system or from tubewells, and more efficient irrigation practices are employed, one can assume that the price factor becomes increasingly important. Table VI shows that farmers would move stronger into rice and wheat food crops for which there is high demand. Evidence from farmers on this watercourse suggests that farmers strain to increase cropped acreage. <u>Given programs with incentives and services to help farmers utilize available water more efficiently, there is little doubt that they would respond positively by increasing cash crop production</u>.

Crop rotations are determined primarily by expected availability of water. Farmers also plan rotations so that there will be a more equal distribution of income and labor throughout the year. Though present rotations can be improved to

Table VI. Farmers' present acreage of kharif and rabi crops and ecpected acreage if water supply doubled.

Crops	Presently Cultivated Acres	Expected Acres	Percent Change
Wheat	114	179	+57
Rice	51	102	+100
Fodder Crops*	186	102	-45
Sugarcane	8	14	+75
Others	15	10	-33
Fallow	102	17	-83
Total Acreage Rabi and Kharif	374	459	+23
Cropping Intensity	157	193	+36

*Fodder crops are millets, maize, oats and berseem. If two crops of maize were cultivated instead of the current single crop per season, the cropping intensity for Rabi and Kharif would increase to about 210%.

ensure improved weed control, soil fertility, physical soil conditions and natural control of insects and some crop diseases, the major constraint currently is water available at the farmer's fields.

Table VII shows the crop rotations for two seasons (Rabi and Kharif) during 1974-75. The crops were mapped in 227 separate fields for Areas I and II, and also III, which is another Area of the watercourse. The totals in Table VII do not represent acres, but number of fields. On the total command area, fallow follows wheat or oats in 49 percent of the fields observed. Rice is followed by wheat and berseem respectively on 13 and 12 percent of the fields.

In Area II[14] which extends from 1,300 feet to over 4,000 feet from a jalar or tubewell source of water supply, wheat or oats follow fallow on about 82 percent of the fields. This is compared to about 40 percent in Areas I and II. Table VII shows that rice hardly figures in the rotations in Area II due to shortage of water. The crop survey Map V also shows that the high water demand crops such as berseem and rice are all located in fields close to jalars and tubewells. Where water is available, farmers practice very intensive polyculture of intercropping.[15] Sugarcane is often intercropped with tobacco and onions. Farmers also mix maize, jowar and bajra in the same field. Berseem is sometimes intercropped in sugarcane fields and often it is mixed with oats and sold as green fodder. "Sarson" (Brassica Compestris) is often sown in wheat and oat fields as well as other pot herbs used as vegetables. They are removed by January or early February and provide good Rabi (winter) vegetables.

Forty-three percent of the 35 sample farmers reported that as a result of small holdings, fragmentation, and irregular supplies[16] of canal water, they usually follow wheat or oats with maize or millets. Twenty-six percent of the farmers reported that they use a rice-berseem-rice-berseem rotation. These farmers have holdings close to jalars or tubewells. Seventeen percent of the farmers reported a fallow-wheat or oats-fallow-wheat rotation. Nine percent of the farmers

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[14]See Map VI, page 26, for Areas I, II, and III.

[15]Attention should be given to the widespread use of polyculture by small farmers. Little is known about fertility or water requirements for polyculture. Where water is available, such intensive cultivation should provide more organic matter to the soil and should conserve considerable water and perhaps nutrients.

[16]Due to shortage of canal water in Rabi 1974-75 rationing of canal water was a problem though when there are no canal closures the discharge of the mogha also varies considerably.

Table VII. Crop rotations for Kharif and Rabi seasons (1973-1974) in relationship to three areas on the watercourse.

Area	Crop Rotations for Kharif/Rabi									
	F/W*	F/O	R/W	R/B	M/W	B or J/W	M/O	B or J/O	M/B	Total Fields
I										
No. of Fields	19	21	13	13	9	3	2	1	13	94
% of Fields	20	22	14	14	10	3	2	1	14	100
II										
No. of Fields	35	13	2	2	--	2	--	4	--	58
% of Fields	61	23	3	3	--	3	--	7	--	100
III*										
No. of Fields	13	9	13	9	--	13	--	5	--	62
% of Fields	21	14	21	15	--	21	--	8	--	100
All Fields	67	43	28	24	9	18	2	10	13	214
% All Fields	31	20	13	11	4	9	1	5	6	100

*The symbols used are:
F/W - Fallow-wheat; F/O - Fallow-oats; R/W - Rice-wheat; R/B - Rice-berseem; M/W - Maize-wheat; B-J/W - Bajra or Jowar-wheat; M/O - Mai[ze-] oats; B-J/O - Bajra or Jowar-oats; M/B - Maize-berseem.

**Area III is shown on Map V on page 24. It is located near the mogha and is demarcated from other fields by a main road. This area was not shown in Table V because about 25 acres are irrigated from another mogha from time to time.

reported rice-wheat-fallow-wheat rotation. Only six percent reported rice-wheat-rice-wheat rotations and these farmers are also near the jalars or tubewells.

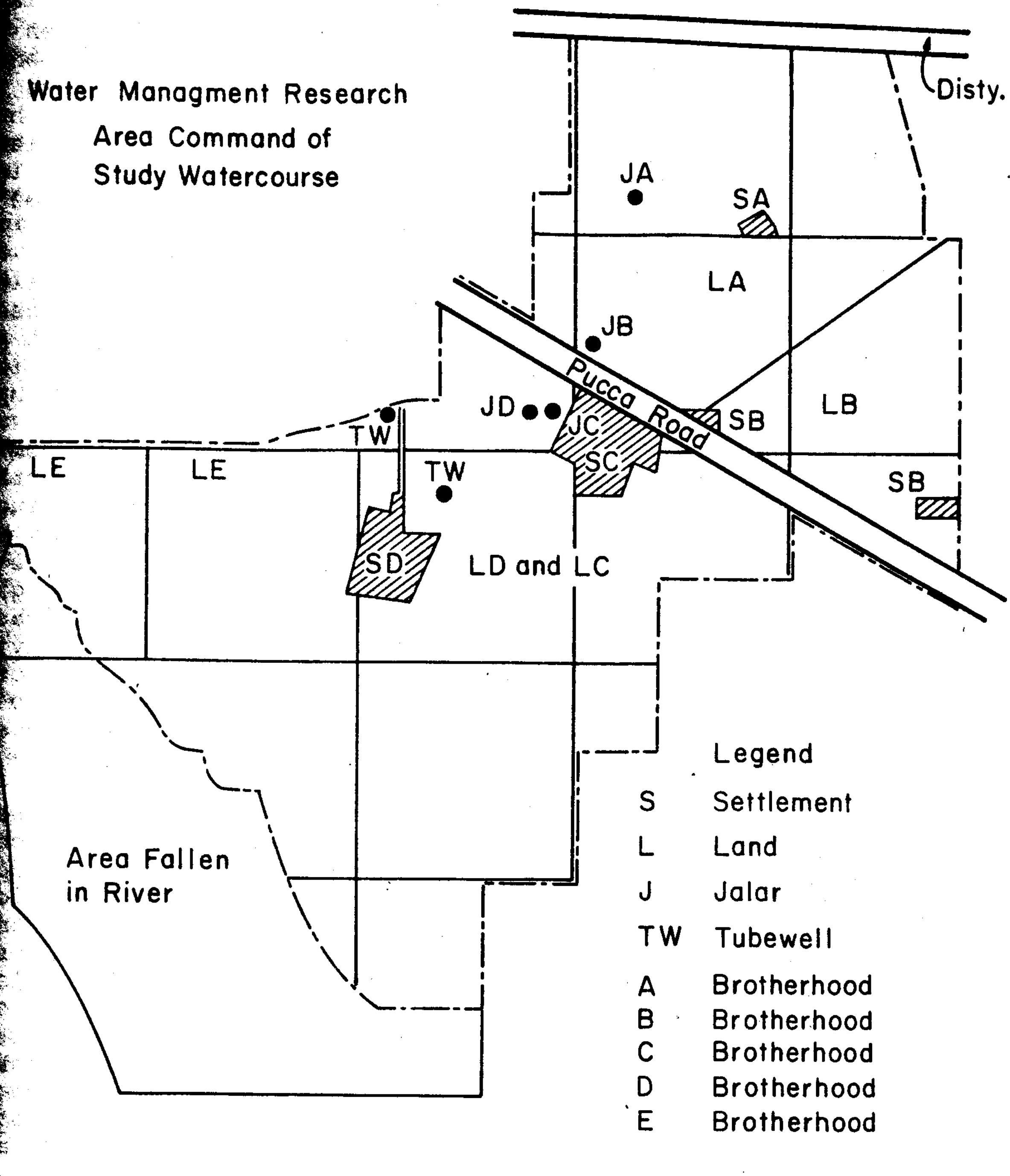
As water supplies increase from tubewells or other sources, farmers do increase their cropping intensities; however, they need to be assisted in improved crop rotations, scheduling of irrigations and use of more optimum cultural practices for more efficient utilization of water and other inputs for various crops. Also, new crops such as vegetables, which require more intensive management practices, could be introduced. The market demand for quality vegetables is especially good in this area. Farmers know this and report that given more water and increased control they would shift more to vegetables for the Lahore market.

SOCIAL FACTORS AND FARMERS' IRRIGATION BEHAVIOR

The most important unit of an irrigation system for agriculture is the farmer who must manage the water on his farm. On-farm irrigation improvements center on the key word, "management". The farmer who manages must be assisted in improved ways of management of the scarce water resources in Pakistan. Farmers are members of various village social groups, which influence their behaviors. It is therefore imperative to understand patterns of social stratification which influence how farmers interact with each other to distribute and manage a collective good, such as irrigation water. The watercourse must be viewed as a dynamic social, economic and physical subsystem of the basic village social unit. In this subsystem, farmers, due to present constraints, use many ways and means to achieve goals in the use of water for crops. A knowledge of patterns of cohesion and cleavage between and within groups is essential for designing and implementing programs to improve on-farm water management. Future development programs might include such collective tasks as watercourse improvements, maintenance systems, land leveling, improved irrigation practices, scheduling of irrigations and new water distribution rules. Data of how the system works at the watercourse micro level is essential for organizing water users associations, and especially, for evolving relevant water laws and codes suited to the demands of today.

Farmers of Pakistan are socially organized or stratified into various caste and subcaste groups, which are further subdivided into kinship or brotherhood groups. As a result of Partition in 1947 and the mass immigration to Pakistan, farmers also still think of themselves as either "locals" or "refugees".

The watercourse investigated is made up of two caste groups known as Bhatti and Arian, all of whom are "locals" and members of the Sunni religious sect. The results of this stratification are easily observed on the watercourse. For example, all members of the Bhatti caste own land laying near the mogha in one contigious area and all but one Bhatti farmer live in a village completely separated from the Arian village. This is shown on Map VII, page 33. The Arian farmers live either near their fields in separate settlements based on brotherhood groups or in the main Arian village nearby. The two caste groups also own and operate separate jalars or waterlifts. During two months of observation, it was evident that, along with physical separation, a definite social boundary maintenance also exists between these two caste groups. Physical evidence such as separate places of residence and demarcated fields, plus observations and reports about farmer interactions, support this conclusion.



p VII. Caste/brotherhood locations on the study watercourse. "A" refers to Bhatti Caste; "B", "C", "D" and "E" refer to brotherhood groups of the Arian Caste.

No marriage, for example, was ever reported between the Bhattis and the Arians. The investigators over a two month period also observed no social or cooperative activities taking place between these two groups, such as smoking the hukkh gossip, trading of water, animals or equipment. The Arians report that the Bhattis are inferior in farming and are ignorant of the benefits of schooling for their children (see Table VIII).

The Arian caste group of farmers is further stratified into four distinct "baradri" or brotherhood groups. These separate paterlineal kinship groups reside for the most part in four separate areas (see places of residence on Idealized Map VII on the previous page). Two of these kinship groups own and operate separate jalars while two other groups jointly operate a jalar with one kinship group always dominant. Three of the four kinship groups were observed working together on farm activities such as trading water, sharing animals on the jalar and exchanging of work implements. They also were observed spending time chatting and smoking the hukkha. Marriages were reported between three of these group and several members of these brotherhoods own a joint tubewel and operate a jointly owned tractor. While in some activiti they tend to cooperate, this does not imply the absence of social cleavages between these groups because factions do develop that make cooperation difficult in some activities as is evidenced by two separate jalars at one place.

Farmers reported that earlier a single jalar was owned and operated by two brotherhood groups, but due to factionalism caused over a land dispute some years ago, one group built its own jalar waterlift. These cleavages must be identified and understood before any program of development and implementation is undertaken. (Recently a watercourse improve ment project in another area of Pakistan has become problemat due to cleavages and factionalism between caste groups; no attempt was made before the project was initiated to identify the cleavages between various groups and to access the potential for cooperation across social groups in collective activ ities.) It is as important to understand these social factor as it is to know the physical problems if the aim is to gain cooperation for collective action.

The power structure and the leadership patterns on this watercourse, or in a village community, can be identified. Other studies[17] and experience in the Punjab confirm the fin ings that larger landlords (by virtue of their holdings) usually have more power, prestige, and influence than farmers with smaller holdings. Other sources of prestige and authori in rural Pakistan are good linkages with officials and

[17]Raza, Muhammad Rafique, Two Pakistani Villages: A Study in Social Stratification, Punjab University Sociologists Alumn Association, University of Punjab, Lahore, 1969, pp. 30-31.

politicians, ability to give advice and settle disputes, caste positions, and spiritual attainment such as that of a Pir, Maulvi, Haji and Hafiz.[18] Usually the strongest social indicator is that of land ownership.

Each of 35 of the 41 farmers on the watercourse was asked to cast a vote for the natural leader of each of the brotherhood groups. It is significant that of the five distinct social groups the five members with the highest number of votes all owned 20 acres or more. Of the 15 names presented as natural leaders, only one owned less than ten acres.

Four key informants were asked to rank all the farmers on the watercourse in terms of "Amir" (high class), "Darmiana" (middle class), "gharib" (low class) and "Bahat Gharib" (very low class). All the individuals nominated as leaders of the respective kinship groups were ranked as "Amirs", or upper class.

The leader of one kinship group (who received 27 of a possible 35 votes) was not only a larger landlord, but also was once elected as a member of the Union Council under the Basic Democracies Program. During the investigation, his influence in decision-making was observed in a typical incident. He was called to settle a water dispute between two factions. Another leader of a kinship group had previously been elected to a position in a cooperative society; he is also known as a good arbitrator of village disputes and has added prestige through being known as a very religious person. It was observed on several occasions that when these two leaders approached, others seated on a charpoi would always surrender their seats and give them the prominent place. These two men were always listened to by others when talking with the investigators. They raised the question and presented the views of their kinship groups. To bypass such leaders in any program of planned change, such as watercourse improvements, could only create serious problems; they could easily completely stop a project. It is not unusual for change agents to experience problems which result from lack of consultations with all kinship group leaders. To favor one leader over others not only increases existing cleavages, but can spell total disaster in program implementation.

As the leadership of a brotherhood or caste group is usually associated with size of land holdings, likewise the power and influence of one social group versus other groups

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[18] "Pir" in Urdu denotes one with spiritual statutes, "Maulvi" is one who leads Friday prayers and who is in charge of Mosque and Islamic Religious Rites; "Haji" is one who has successfully performed the pilgrimage to Holy Mecca; and "Hafiz" is one who has memorized the Holy Koran.

is usually related to the size of combined holdings of land by caste or brotherhood group members. It is important to take this into account in order to discover the power and influence created in decision-making processes about matters on a given watercourse.

Table VIII shows kinship groups A to E and their total land holdings on the watercourse investigated, as well as their total land holdings including all watercourses. The jalars owned and operated by each brotherhood group are also shown. In terms of land on the watercourse, group D owns fewer acres and ranks lowest in decision-making influence. Groups A, B, C, D, and E have similar size holdings on the watercourse. In terms of land holdings, Group B owns the most land and therefore is powerful in terms of collective decision-making.

Increasingly, educational level of a family or brotherhood is being adopted as a status symbol. Table VIII shows that kinship Groups A, B, and C have larger numbers of educated members. In terms of family members, the smaller kinship Groups A and C have placed more emphasis on education proportionately. It was obvious to the investigators that kinship Group A, though owning less land than B, usually has more connections with development officers and entertain more officials who come to the area, thereby enhancing their leadership position. Such kinship groups build up and maintain extensive networks of personal contacts and obligations, which provide a storehouse of useful social capital over time. This social capital is usually utilized at very opportune times for important tasks. Such connection or obligation networks actually serve as an effective lubricant to get a sluggish bureaucracy moving[19] and there is no doubt that personalism in Asian societies works.

Members of Brotherhood A have less land than B or E Groups, but they place a strong emphasis on education which adds to their status, power and influence in community affairs. They work with some design to keep their networks of personalism in good repair. A member of Brotherhood A remarked on three occasions to one investigator that the "Members of Group D and E are backward and ignorant; they send so few of their children to school." It is evident from Table VIII that they are in fact educationally behind.

Within the joint families of a kinship group, the position of the elder is usually respected. He usually plays a major role in family disputes, marriage arrangements, circumcisions of male children, educational matters, and usually with the oldest son makes decisions about farming matters. It

[19] There is a proverb in Urdu which is translated in English as "That Officer will not Listen to Me because I have No Strong Relative, Influential Friend or a Bribe."

Table VIII. Brotherhood kinship groups on watercourse with size of holdings, jalar ownership, joint families and education.

Kinship Groups	Number of Farms	Type of Farms		Number of Waterlifts Owned and Operated	Total Acres on Survey Watercourse	Total Acres on all Watercourses	Education number completed or in classes			College Level	Total Number of Educated
		Joint	indiv.				1 - 6	7 - 8	9 - 10	10+	
A	6	4	2	1	42.0	142.0	24	14	7	6	51
B	11	8	3	1	67.0	191.0	24	11	5	2	42
C	6	4	2	C shares with D	56.0	100.0	21	13	10	4	49
D	9	5	4	D shares with C	17.0	120.0	4	2	2	1	9
E*	9	7	2	1	56.0	145.0	6	2	2	0	10
TOTAL	41	28	13	4	238.0	698.0					

*E is actually a caste group, but they refer to themselves as a brotherhood group also.

must not be assumed though that the elder woman[20] of the house has no influence on family and farming matters; most often, she is the keeper of the keys to the family's box which contains cash, important papers and jewelry.

Brotherhood Influence on Irrigation Schedules

As shown in Table IX, the jalar waterlifts are for the most part owned and operated by brotherhood groups. For example, all members of Jalars I and IV are brothers, uncles and nephews. Jalars II and III strongly reflect kinship group patterns, with one brotherhood group dominant. Gravity System V once had a jalar, but due to lack of cooperation between Groups B and C, it was abandoned. These farmers probably thought it was not worth the effort to increase their water supply by only about .1 of a cusec.[21] These members of kinship Group B are on System V, but irrigate a total of only 12.6 acres.

Due to the irrigation turn system, warabundi,[22] is allotted in relationship to land and the farmer who leases or rents land also becomes a member of the Jalar waterlift system

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[20] An example of the woman's role in farming is seen in the fact that in a 1970 survey in Khanewal Tehsil of 350 wheat farmers, a correlation was found between baking quality of a dwarf wheat variety and the degree of adoption by farmers. Farmers consistently reported complaints from their wives about a red-colored soft-grain wheat variety.

[21] See earlier discussion in section, "Watercourse Losses."

[22] There are two methods of allocation of water from the mogha outlet to farmers' fields known as the "pucca" and "kutcha" warabundi system. Warabundi means an agreement about the turn schedule for receiving water on a rotation system. "Pucca" means a fixed schedule established by the Department of Irrigation and under this system trading of water is illegal. The kutcha warabundi is more flexible and there are several variations but the system of turns or rotations are arranged by the farmers themselves. Trading of water is possible and turns which run dry can be given to the farmer when the canal has water. Sometimes a "wandara" or clockman is appointed by the farmers to keep time on the irrigation schedules but with the advent of the cheap wristwatch in rural Pakistan it becomes less important. Sometimes there is a village clock in a shop, school, or mosque which is the official time if disputes arise, however the radio has widel[y] diffused in the villages and now this is used as official time by some. (Fifteen of the watercourse farmers have radio and 22 listen fairly regularly so official time for the water course is radio time and there is no "wandara.") As change comes to villages, farmers adapt to it and have moved far from the old days when a drum system was used to notify farmers when an irrigation period on the schedule ended.

le IX. Jalars and the gravity system and brotherhood group members.

lar or Gravity System	Number of Members	Members of Brotherhood Groups				
		A	B	C	D	E
I	10	-	-	-	-	10
II	11	-	3	-	7	1
III	12	3	-	-	9	-
IV	6	6	-	-	-	-
V (Gravity system)	7	-	3	4	-	-

Though it would appear that a regulated pucca warabundi (as exists on this watercourse) would allot turns in relationship to location of holdings, as is the usual pattern in th Punjab, it does not hold true on this watercourse. The fragmentation process has reached such a stage that the tur schedule has been amended to follow family lines as a means of minimizing disputes. Though each jalar system receives its supplies at the regulated periods, farmers report that about 40 years ago, the waribundi system was changed. Sinc jalars are kinship group property, through the years as family lands have been subdivided, so have the water rights and turn schedules. Such a system results in greatly scatt fields for a given farmer. This process of land fragmenta and transfers of land has created a strange (and costly) ma of 11.63 miles of ditch for a command area of only 238 acr

Though the pucca warabundi irrigation schedule is in theory fixed and regulated by the Canal Department, and tr ing turns or trading canal water for tubewell water is ill 60 percent of the farmers interviewed reported trading ful turns and 86 percent reported trading part of their schedu turns. So much trading took place during the period of th study that it was often difficult to know the next farmer' turn, which was necessary to conduct meaningful evaluation of irrigation practices. Though the patterns of trading t to follow the kinship groups because the jalars are owned operated by groups, farmer members of a jalar system repor that they will trade water with others when required unles there is some grave conflict with them. Widely scattered fields and the kinship system make trading rational and ea among friends and relations.

In actual practice, there is a kutcha warabundi opera within a pucca warabundi (i.e., the water allotted to the jalar systems and the gravity system is on a fixed regulat schedule, whereas within each system, farmers trade freely Day turns are traded for night turns on an agreed upon bas by jalar members. Whole turns are often traded and repaid subsequent turns. Farmers report a number of reasons for trading, such as demand of crops at certain critical peri demand to complete pre-irrigations, fragmentation of hold and unlevel fields which can be serviced best by tubewells Ten farmers report trading canal water for tubewell water a regular basis. They trade water on the basis of watere area due to the variation in jalar discharge. In summary only five farmers report no trading and the number of tim water is traded during a year by farmers ranges from 5 to times. Twelve farmers report changing full turns about e two weeks. Though they exchange turns frequently, 30 of farmers report that they prefer the pucca warabundi for t jalars because between groups this "reduces conflicts," "i more just," "farmers know the schedule in advance," and " or two large farmers can't steal from smaller farmers." Within each jalar system, however, they prefer to continu operating their own warabundi system.

Some authors, using conventional wisdom and economic rationale, attempt to show that it is uneconomic for farmers to trade water; therefore they don't! An explanation usually provided is that given short supplies of water and similar cropping patterns, farmers can't afford to trade. What is often overlooked, however, is that all farmers do not have the same demand at the same time due to variations in soils, locations of fields, seeding dates, use of fertilizers, types of crops, stages of growth, etc. Also, human factors, such as sickness of men and animals and social as well as business obligations, make trading of water a rational and necessary operation. Those in doubt should practice farming under the constraints of the present system, or follow the water on any given watercourse and compare the scheduled turns on the warabundi list with actual practices. The defacto situation leads one to conclude that <u>many farmers in Pakistan are already approaching a quasi-demand irrigation distribution</u> system.

<u>Areas of Cooperation and Conflict</u>

As suggested in the description of caste, brotherhood, and family social groups, these types of social stratification provide a certain basis for cooperative efforts. However, they can also operate to create cleavages and conflicts. Due to increased industrialization, rapid growth in urbanization, desire for more education, mass media, and planned programs of change by the Government in many fields, village life is undergoing much change. There is naturally some shift toward more individualism. However, caste, brotherhood, and family ties are still strong. There is tension between individual aspirations and group loyalties and responsibilities as general economic development takes place. The modernizing influences of the urban area through cinema, radio, education, increased availability of consumer goods, etc., are gradually influencing village life. As in any nation, the village elders speak about the new "wild individualism" of the young and lament the old days when there was more cohesion in villages. Today, though, there is still substantial cohesion but within kinship groups.

Specific formal cooperative activities identified on the watercourse are the provision of land and construction of a primary school, construction of a mosque and its maintenance, establishment of a cooperative society, a yearly vaccination campaign for smallpox, and the partial support of a village chowkidar[23] who assists the village numbardar.

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[23]Chowkidar means watchman--however in villages he assists the numbardar in collection of seasonal canal and land taxes, carries messages, helps entertain officials, and records births, deaths and marriages for the numbardar's records.

Since 1958, there has been no formal panchayat[24] system or local village government made up of leading "choudreys" (elders) and village numbardars. This was replaced in 1958 by the Basic Democracy form of local government, for which there was roughly one Basic Democrat elected per 1000 population. The Union Council was composed of members representing eight to ten villages. The Union Council was responsible for selected village level development activities and in certain matters it served as a local judicial system. The Basic Democracies system has been dissolved and at present there is no existing formal local or village governmental institution through which villagers can participate and make their needs felt. The absence of some local government unit creates a serious vacuum. Until some formal local government system is evolved, there are many agricultural development activities, especially those of a collective nature, which will be difficult to establish or sustain. This applies especially to watercourse improvement schemes and water users associations. One gains the impression that the absence of local government is partially responsible for the lack of success of some development activities at the village level.[25] However, there are many types of informal cooperation in rural Pakistan.

"Wangar"[26] and "Seri"[27] Activities

Wangar, or Mangi, is a form wherein farmers trade work and bullocks for land preparation, leveling fields with the

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[24] Panchayat is the council of village elders and numbardars who decided many village issues prior to 1958.

[25] See Kizilbash, N. H. "Local Government: Democracy at the Capital and Autocracy in the Villages," Pakistan Economic and Social Review, Vol. XI, No. 1, Spring, 1973, pp. 111-121. This is perhaps one of the most urgent needs of rural Pakistan today as officials interested in rural development realize. Perhaps one of the richest areas of developmental research is that of rural governmental institutions. What, for example, is the role of these institutions in the production and management systems needed for progressive agriculture (i.e., credit, inputs, water management improvements)? What measures of rural development can be identified which provide incentive systems or inhibitors which can be attributed to local government systems? One could address a host of researchable questions to this complex problem area. The hypothesis of some authorities is that Pakistan will not make substantial progress in sustained agricultural development until she evolves viable local institutions.

[26] Wangar in Punjabi means "to request" as does Mangi in Urdu and is from the verb mangna "to ask".

[27] Seri in Punjabi is a custom of sharing work, or cooperation a in a partnership. This is similar to "Lana" which in Urdu means "to bring", "to include", and to agree as in mutual work exchange situations.

arah,[28] planting rice seedlings, threshing of grain and other asks which require collective labor. Usually, relatives and riends are requested to give work; in return they are fed by e host who is obligated to return labor at a later date. e social significance of this practice is that it also is a st of the village status of an individual. The number of rsons with whom a person can do Mangi is some measure of a rson's prestige.[29]

Another form of traditional cooperation observed is known Lana in Urdu and as Seri in Punjabi; though there are many , one type of Seri is similar to a partnership in which wo or more farmers agree to take another farmer's land for a tipulated period with an agreement for the sharing of income nd expenses. Two watercourse members of one brotherhood perate such a Seri by taking the land of a farmer of another rotherhood group. Members of Jalars I and II also operate a form of Seri in which they have an informal agreement to exchange turns when needed on the warabundi schedule. The exchanges are usually night turns for day turns. This is very rational given the long, cold nights during the winter irrigations for Rabi crops. On Jalar II, there was so much trading among two Seri groups that it was difficult to establish a definite schedule for members of Seri groups.

Watercourse Cleaning and Maintenance

Farmers also have various ways in which they organize to clean the silt from the main watercourse.[30] They do very

[28]Karah is an implement worked by two pairs of bullocks for leveling fields somewhat like a large board with two handles. A karahi is smaller for use with one team of bullocks.

[29]Lowdermilk, Max, Cooperative Education of Farmers (Punjab) M.Sc. Thesis, Cornell University, Ithaca, N.Y. 1964, pp. 138-151.

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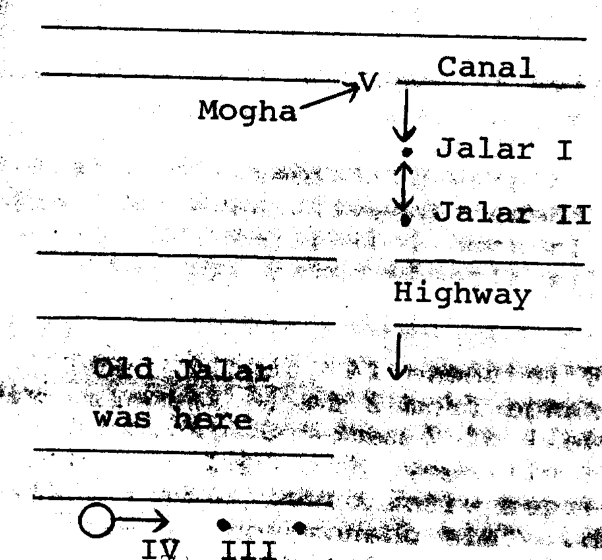

Idealized sketch of how watercourse is cleaned usually twice a year. Jalar I members clean at rate of 2.5 feet per phar (3 hours) from the mogha to Jalar I.
Jalar I to II area cleaned at rate of about 7.5 feet/phar by members of Jalar II.
Jalar II to Jalar IV was cleaned cooperatively by all farmers, except Brotherhood E, participating together. Olf jalar members clean the old jalar site. Remainder of watercourse is cleaned by those farmers separately along or through whose fields the ditch passes.

little maintenance, however, and few, if any improvements. The area cleaned cooperatively starts at the mogha outlet and extends about 2310 feet to Jalar IV, where there is a major junction. The system they have evolved is also related to the kinship groups on the watercourse.

From the mogha outlet to Jalar I, more silt is deposited than on other reaches of the main channel. Farmers of Jalar I, a separate caste group (E) clean one half karum (one walking space or about 2.5 feet of the watercourse) per phar (period of 3 hours) of water received. If a farmer, for example, receives 3 phar (9 hours) of water, he is required to clean a section of watercourse about 7.5 feet in length (3 x 2.5). From Jalar I to Jalar II, members of Jalar II clean the main ditch at the rate of 7.5 feet per phar of the time on the warabundi. From Jalar II across the main highway to a point beyond Jalars III and IV, all watercourse members except the Bhattis clean the main ditch cooperatively. Two members of Kinship Group A usually call the watercourse members for this job about two times a year and give a notice of one or two days in advance of cleaning each time. If farmers do not report for work, or do not send a substitute, they are usually fined Rs.10.00-15.00 and the money is used for sweets to be divided among the other workers. One kinship leader reports that on one occasion when the farmers refused to cooperate, he paid a policeman from nearby station Chung a "tip" to come and order the farmers to cooperate in cleaning the main ditch or "Khal." The cleaning and maintenance of all other ditches is the responsibility of the farmer through whose land the ditch traverses. One of the investigators was present when all farmers except the Bhatti caste group worked cooperatively to clean a section of the main watercourse. About 15 farmers worked about 4 hours on a section almost 250 yards long where silt had deposited.

Cooperative Tubewells

There is only one cooperative tubewell on this particular watercourse. However, along the four watercourses in the village for a commanded area of 1426 acres, there are 26 tubewells of which 14 are operated jointly by farmers in a "seri" type of organization. Most of these tubewells have deliveries of less than 0.5 cusecs, which is some indication that fractionalized tubewell technology is already being adopted by farmers in the area.

The number of shareholders in these 14 jointly owned tubewells in the village area range from 2 to 16 farmers, with an average membership per tubewell of 7 members. Evidence in the watercourse area (i.e., the village) with these joint wells is also being confirmed in a larger watercourse survey undertaken during 1975 in the Punjab. This phenomenon is most likely widespread among small holders in Pakistan.

The watercourse investigated has seven members who own from one-fourth to one-twenty-fourth share in the cooperative tubewell. All members are related through marriage. These seven farmers own a total of only 30 acres on the watercourse. Another tubewell is owned and operated by one family.

Four farmers on the watercourse also own a Massey-Ferguson tractor cooperatively with one-fourth share each. In both the cooperative tubewell and tractor cooperative schemes, the leadership has been provided primarily by leaders of Brotherhood Group A. It is also these same two men who usually organized the farmers for cleaning the main distribution channels; the senior investigator observed on several occasions that farmers of all brotherhoods accord these two leaders considerable respect.

Joint Farming

Twenty-five of the 35 farmers interviewed on the watercourse participate with others in joint farming operations.[31] Usually, two or more brothers and/or a father and his married sons share income and expenses in one joint operation. Two or more nuclear families join together and form a single producing unit. The joint family system operates as a positive force in that this is one way family holdings can be kept. Though fragmentation continues due to inheritance laws, this joint farming system slows the process. The property is usually held in common by the senior male who is a type of trustee. Members of the joint family usually use a common purse for which the elder woman of the family, if not senile, is the keeper of the keys. This system provides an excellent multi-purpose insurance scheme. Small fragmented holdings on this watercourse make joint operations necessary.

Where family members have separate operations, they still share water, work, animals and equipment. Small farmers on the watercourse, who do not farm jointly, often own and operate bullocks jointly, but do not share other expenses or income.

Other informal, social or cooperative activities which take place within and across brotherhood kinship lines are events such as marriages, funerals, circumcision of a male child, building and upkeep of the mosque, contributions to a maulvi who teaches Islamayat to children and performs marriage, funeral, and other religious rituals.

In summary, there are then many formal and informal types of cooperative activities in which farmers engage. However, most informal activities tend to follow kinship patterns, or

[31]Of the total 41 members, 6 were not interviewed, but 28 of the 41 farmers participate in joint operations.

a high level caste group pattern. For example, there are few activities in which Arians and Bhattis both participate because a certain boundary maintenance is observed. Kinship Groups A and B, for example, cooperate more with each other in informal activities than with other Arian Kinship Groups, primarily because they have stronger kinship linkages between them. Reportedly, these groups (A and B) developed four generations ago from two brothers.

There is also positive evidence that formal cooperation exists across kinship groups such as building schools and mosques. Given viable local institutions which indeed provide farmers with necessary services they cannot provide alone, farmers if assisted properly will also cooperate across caste and brotherhood social strata, when they perceive definit benefits. For such activities to be made successful, the change agent must not only be technically competent, but must know how to establish creditability with farmer clients.

Patterns of Conflict

A proverb in Urdu states that the three major sources of conflict are usually "zun" (women), "zur" (money) and "zamin" (land). True to the proverb, a major source of conflict identified among farmers on this watercourse is land. About 12 years ago, the Government attempted to consolidate land holdin with the result that much friction even between kinship groups was created by changed land boundaries. Farmers report that under the consolidation scheme a change was made from the 200-foot by 190-foot size acre to a "killa" (acre) which is 220 x 220 or 1.11 acres. Small separate parcels of land of less than .25 acres exist today as a result of this consolidation scheme, which widened existing cleavages within and between social groups. Farmers consistently reported that the attempt to consolidate holdings created even more fragmentatio than existed before. Two kinship groups are still at odds ove divisions of land resulting from the consolidation scheme 12 years ago and a court case is being lodged according to farmer reports.

During the investigation, a farmer refused to allow a distribution channel across his land to another farmer's field separated by about a .25 acre parcel of land demarcated in the reconsolidation program. Brotherhood Leader A was called, a compromise was finally reached, and a potential fight was avoided. Though farmers reported no major conflicts over wate they no doubt exist from time-to-time. For example, Jalar IV was build by Brotherhood A because of a struggle and lack of cooperation some years ago with members of Brotherhood B. A member of the Brotherhood C group reported conflicts with Brotherhood A over common land supposedly set aside for animal awaiting their turn at Jalars III and IV.

No cases of stealing water were reported by the farmers, but two fresh cuts in the main watercourse were observed near the mogha, where small areas had been irrigated from time to time. Farmers were asked what they would do if water were stolen during their turn on the warabundi. Twenty-three replied that they would first give the offender a stern warning, and if he did not admit his guilt, a fight would occur after which the case would be handed over to the Brotherhood leaders and, if no action were taken, to the police. Eleven reported that they would go directly to the police.[32] One farmer reported that stealing water had never taken place. The action taken most likely depends on the existing relationship between the parties concerned at the time of the incident. There seems, however, to be a very thin line between borrowing water and stealing among relatives.

Since watercourse improvements require collective action, it is important to understand existing forms of cooperation and areas of conflict so as to design programs for which the loyalty and support of all parties can be secured. Though some students of Punjabi village culture suggest that the supreme goal of social life becomes that of protecting one's social prestige and honor (known as "Izzat"),[33] this is simply a form of self interest which can be channeled into constructive cooperative activities when all parties perceive sufficient benefits.

Farmers in the Punjab need the services of well-trained farm-level advisors. Experience indicates that given proper approaches to build up creditability with farmers and the technical competence to deliver the goods, Punjabis will organize for collective action. They need incentives and dedicated professionals who understand their problems and can lead them towards solution.

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[32] A visit was made to the police station one mile from the watercourse to inquire if any case had been registered by any watercourse member over water in the last five years. None was reported by the police station master.

[33] Lowdermilk, Max K., op. cit. See section on "Conflict in Punjabi Culture." A local proverb rendered into English is "Izzat" (one's pride or honor) is more important than bread. Another is that "one's Izzat is in his own keeping."

DEJURE AND DEFACTO[34] DISTRIBUTION OF CANAL WATER

The regulated (pucca) warabundi system was established by the British under the Canal and Drainage Act of 1873. The fixed turn system on the pucci warabundi is sanctioned under Section 68 of the Act and is binding upon all the shareholders of that particular mogha outlet of the canal distributary for farm use. The day of the week and hours of turn of each shareholder are fixed.[35] Through the years many amendments have been made in the warabundi regulations. However, it is evident from a study of these rules[36] that the additive process has made these regulations somewhat cumbersome, difficult to administer and almost unintelligible.

In many parts of the world, there is need for laws and codes related to water distribution to be developed and updated to meet the complex needs of modern agriculture. Radosevich and Kirkwood[37] have made an evaluation of water laws and institutions of a number of nations with large irrigation systems, including Pakistan. They stress the importance of laws which are relevant to today's demands; the importance of ample flexibility and incentives for farmers to utilize water efficiently; provisions for farmers to organize water users associations for maintenance and improvement and control of their system; the importance of laws which can be implemented easily and justly; and the importance of laws which take into consideration local customs and values, as well as national goals. They state that "It is better to have no law than a law which is not obeyed, a condition leading to disrespect for Government."[38] One might add that outdated laws and codes not only create disincentives for farmers (which holds back agricultural progress), but also results in a net loss to society.

Most readers would agree that Pakistan's irrigation system, with its rules and regulations and organizations having over a hundred years of tradition, need to be examined objectively in terms of the needs and requirements of modern

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34"Dejure" refers to what the law is; "defacto" refers to what happens in practice.

35Jahania, Mohammed Hussain, The Canal and Drainage Act with Rules, Mansoor Book House, Lahore - 2, 1968, pp. 73-74.

36Warabundi Rules and Regulations provided by Canal Department to investigators, January 1975.

37Radosevich, G. E. and Craig Kirkwood, Organizational Alternatives to Improve On-Farm Water Management in Pakistan, Draft Report prepared for USAID, Fort Collins, Colorado, 1975 and, Radosevich, G. E., Water Laws and Institutions in Pakistan, Colorado State University, 1975.

38Radosevich, G. E., op. cit. p. 2.

agriculture. There is actually nothing "sacred" in what the British Rulers transplanted to the subcontinent. Theirs was a time far different from today; they as Rulers depended on controls and regulations; they knew little about the great heritage of Islamic water codes; they designed a system of laws when agriculture was largely traditional and when settlers in the new canal colonies were just beginning to cultivate the newly developed lands. Today, there are other realities and challenges such as a free Islamic Nation with new goals; rapidly expanding population; an economy which must depend greatly on the agricultural sector; new high yielding varieties; a private tubewell explosion; waterlogging and salinity; and new headworks and great dams. Since Partition, other civil and criminal laws have been examined and changed to meet the religious, cultural and value systems of a free people for the building of a modern nation. Likewise, water laws and codes, especially those related to on-farm water management improvement, should be examined critically.

An example of one problem at the farm level is the present rate system for canal water as compared with rates published in the 1940's and 1950's. In terms of today's value of the <u>rupee</u>, it appears that the assessment rates for various crops are not only among the world's lowest, but they are less today than in 1951. If this is correct, then there are few incentives for farmers to manage their water more efficiently. Low rates for irrigation water around the world tend to result in wastage of this valuable resource. Table X compares the water rates for selected crops for 1951 and 1974.[39]

A careful examination should be made with cost of production and market price indexes for each crop for the two time periods to ascertain the actual difference in canal rates. These data are not currently available. However, in 1936, the Imperial Council of Agricultural Research of India[40] gave the cost of production of a maund of wheat in Lyallpur as Rupees 2 - 1 - 10 and the market price as Rupees 2 - 6 - 6. If it is assumed that the price of one maund of wheat today is Rs.40.00, as compared to Rs.2.00 in 1936, then the ration is 20 to 1. However, the ratio of the 1951 and 1974 water rates for wheat as shown in Table X is about 2.4 to 1. Even this crude estimate indicates that water today is very cheap. There is also the assumption that costs of production for wheat at current low yields and inputs are also about Rs.40.00/maund. The point to be made again is that two objectives could be gained by increasing the price of water. First, farmers would learn its real value and have incentives to utilize this collective

[39]At the time of this writing no information could be found on the value of the 1951 rupee as compared to the 1974 rupee.
[40]Roberts, Sir William, op. cit., p. 244.

Table X. Canal water rates for selected crops in 1951 and 1974.

CROPS	1951* RATE/ACRE (RUPEES)	1974 RATE/ACRE (RUPEES)
Wheat	4.25	10.12
Cotton	5.25	16.02
Rice	--	16.86
Maize (grain)	4.00	8.44
Maize (fodder)	2.50	5.89
Sugarcane	11.00	33.74
Berseem	2.50	5.89
Vegetables	--	21.07
Oil seeds	4.25	--
Gram	3.25	--

*Roberts, Sir William and Singh, S.B.S. Kartar, A Text Book of Punjab Agriculture, Civil and Military Gazette Ltd., Lahore, 1951, p. 169 (out of print).

good more efficiently for the Nation. Second, the Irrigation Department and the Nation need more income from this scarce public resource. Extra income could easily be used to improve the system which presently requires more attention--that sub-system that stretches from the mogha outlet to the last farm on a watercourse. Along with increasing revenues from farmers, programs are needed to provide more services for them.

Several of the rules and regulations related to water distribution at the farm level are presented in Table XI simply to indicate what they are and to what degree farmers on one watercourse follow them. Such an investigation is needed on many watercourses in Pakistan in order to learn more about farmers' constraints and how they attempt to overcome these constraints.

Some of the rules and regulations are given in Table XI to show the dejure of canal water for irrigation. The data given are those collected in the watercourse investigated. Other watercourse studies currently underway (1975) also support the conclusion that there is a haitus between dejure and defacto.

Regulated or Authorized Mogha Discharge and Manipulation of Mogha Size

As shown in Table XI under I and III, the mean mogha discharge exceeds the official discharge. An inspection of scores of mogha outlets in Pakistan provide ample evidence of this practice. Many moghas have been manipulated because the farmers are under constraints to increase their water supplies. Farmers were asked "what action would you take if an overseer came to your mogha to reduce the size?" thereby affecting the discharge. Thirty-three of 35 farmers reported that they would negotiate with him (i.e., pay a certain amount). They also reported that in the past they had gotten their mogha enlarged for an amount that was negotiated. The unregulated price for water thus received fluctuates greatly between areas, but often there is a traditional rate.

This practice is also a natural result of the general shortage of water supplies, and both parties carry out these practices. Both overseers and farmers know how to increase pressures and temptations to make a deal. Only when large individual farmers make private deals with overseers does it discriminate against the small farmer. Usually, these practices are a cooperative effort in which the payment in cash or kind is paid in relationship to acres cultivated.[41]

[41]See International Bank for Reconstruction and Development Programme for the Development of Irrigation and Agriculture in West Pakistan, Comprehensive Report, Vol. 10, Annexure 14, "Watercourse Studies," by Sir Alexander Gibbs and Partners, International Land Development Consultants N.V., London and Arnhem, May 1966, p. 106.

Table XI. Selected watercourse rules and regulations: dejure versus defacto operation. (Based on a survey of one watercourse.)

dejure (What the law states) Watercourse regulations	defacto (What in fact takes place) (Reports and observations)
I. Punishable by law to damage or manipulate mogha outlet a. official regulated mogha discharge 1.8 cusecs b. permissible cropping intensity 80% or about 213 acres for kharif and rabi	I. Mogha physically damaged and size enlarged a. actual discharge is more than 3.0 cusecs b. actual cropping intensity observed 157% in 1974-75 or 373 acres for kharif and rabi c. 33 of 35 farmers report that mogha can be manipulated for a negotiable amount
II. Regulated and fixed turns cannot be changed unilaterally by farmers a. trading of turns not permissible	II. Farmers at jalars operate "seri" for frequent changes of night-day turns a. 60 percent of farmers report trading full turns and 86 percent report trading partial turns
b. canal water not to be traded for tubewell and vice versa	b. 10 farmers trade canal water for tubewell water on a regular basis
III. Illegal to use water of one mogha command area for fields on another command area	III. About 22 acres of land where water from mogha investigated is used for the adjacent command area a. physical evidence of connecting ditches and cement pipes to pass water across other watercoures b. 8 acres of investigated mogha command irrigated from adjacent watercourse
IV. Illegal to make unauthorized cuts in main watercourse or build any structure	IV. Farmers have built a pucca nakka in bank of adjacent watercourse (all of this documented by pictures)

Table XI. (continued)

V. Only a prescribed number of field outlets permissible per 25 acres usually one	V. This watercourse has 3 outlets/ cuts at farmers will - about 125/25 acres
VI. Illegal to steal water	VI. Farmers near the mogha made cuts into the main watercourse and irrigated small rice fields at will. Observed and documented during measurements.
VII. Unauthorized remission of water rates cannot be given. Authorized remission cases must be approved by the divisional officer after the case moves from the zilladar to the higher officials. Patwari can only report cases to zilladar. a. farmers on jalar systems pay only 1/2 of abiana	VII. 33 of 35 farmers report extra legal means to have the patwari reduce their "abiana" (water rates) by generous "faslana" and extra tips. a. 7 farmers once on a jalar but now on gravity flow still pay the 1/2 rates
VIII. Watercourse repairs and maintenance to be checked by zilladar who can have fines levied or water supply closed if main ditches are not kept in good repair.	VIII. Farmers work on watercourse only infrequently to remove silt accumulations. No supervision or fine ever levied for lack of watercourse maintenance.
IX. Illegal to bribe patwari or other officials	IX. 33 of 35 farmers report the customary "faslana" and 32 report paying it seasonally. Farmers report interactions with other officials when needed.
X. Canal Department must notify farmers of closures for repairs, cleaning, and rationing purposes.	X. 33 of 35 reported not receiving information in advance; 33 of 35 farmers did not know rationing schedules started during watercourse study.

Under the Canal and Drainage Act, it is an offence to "damage, alter, enlarge, or obstruct any canal or drainage work."[42] Physical examination of the mogha shows that it has been broken. Measurements also show a discharge of about 3 cusecs when three jalar systems are operating, as compared with the regulated discharge of 1.8 cusecs. Reports from farmers about their attempts to increase the discharge confirm this data. It is common knowledge among farmers and students of rural life in Pakistan that farmers often "damage" moghas and also interact with overseers to increase the mogha size. In some areas, there is an established range of rates which farmers report for increasing mogha size in terms of fractions of an inch. There is always a certain mythology of corruption, but physical measurements can easily be compared, as well as the authorized versus the actual discharge for a given outlet (mogha).

Farmers somewhere in the system benefit from such practices, while others suffer because there is only a certain volume to distribute. However, such a lack of respect for the law due to poor enforcement procedures is not only demoralizing to the smaller farmers, but operates as another factor to increase existing social and economic dualism. The interests of the small farmer are now in vogue in Pakistan and around the world. Therefore, more attention should be given to removing some of his particular constraints. Existing laws should be enforced with greater care.

Regulated Waribundi Turn System

The regulated warabundi (known as pucca warabundi) in contrast to the unregulated "kutcha" warabundi, stipulates that each turn is scheduled for a specific period of time on a fixed day. This means that water during this time moves from the mogha toward the tail to each nakka outlet in sequence. The order of turns in a warabundi can either proceed down the watercourse, i.e., in order of distance from the outlet, or around the watercourse, i.e., down one branch and up the other branch.[43] Trading of turns among farmers is not permissible[44] and the exchange of night for day turns is established at a certain time each year for a full year. Also, there is a prescribed number of nakkas per square of land (25 acres).

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[42] S. Masud-ul-Hassan, The Canal and Drainage Laws as amended up-to-date, revised and enlarged edition, Khyber Law Publishers, Lahore, 1974, p. 52.

[43] International Bank for Reconstruction and Development Progra[m] for the Development of Irrigation and Agriculture in West Pakistan, Comprehensive Report, Vol. 10, Annexure 14, op. cit. p. 125.

[44] S. Masud-ul-Hassan, op. cit. pp. 121-216, 29.

Farmers on the watercourse investigated in this study receive canal water at each jalar on a fixed schedule. However, among themselves they operate a "seri", whereby they exchange night for day turns frequently as is needed. In practice, an unregulated system is operated within a regulated warabundi. Table XII presents the results from farmers' reports of trading water.

Table XII. Reported Trading of Water by Farmers

Times traded in 12 months	No. of farmers who trade partial turns	No. of farmers who trade full turns
None	5	13
1-5	10	9
6-10	2	-
11+	18	13
Total farmers	35	35

Observations of farmers' actions partially confirm the data reported in Table VII. At times it was difficult to locate a farmer in time for field evaluation with flumes because one farmer had traded with another. Often, only a part of a full turn is traded in order to complete the irrigation of a field; crop demands often require trading; or, farmers may not need all their water at a particular time. Full turns are often traded because men or animals may be sick when a scheduled turn comes and the jalar has to be operated. Other reasons are sickness of a relative, a death in a family, or other emergencies.

Due to physical constraints, such as some fields too high to effectively irrigate with the jalar, trading of canal water for tubewell water occurs on this watercourse. Ten farmers trade canal water for tubewell water which can reach his fields more efficiently. Others also exchange tubewell water for canal water. No case of selling canal water was reported on this watercourse (but on three watercourses in one village being investigated, canal water is regularly sold and farmers charge rates related to mogha discharge). The physical constraints of the warabundi system tend to be such that trading is very rational.[45] After all, the moisture requirements of plants are such that a fixed schedule often cannot suffice.

[45] See Reidinger, Richard B. "Institutional Rationing of Canal Water in Northern India," Economic Development and Cultural Change, Volume No. 23, 1974. He states that canal codes should be changed to permit trading of water. After all, it would simply make a de facto situation de jure!

Taking water out of turn is known as "warashikni" and the divisional canal officer under section 68 can fine the offender.

Farmers on this watercourse often use water from another watercourse because they own land under both mogha command areas. There is a twilight zone between most adjacent watercourses.[46] These connected ditches were documented with photographs, as were the pipes used to deliver water over another watercourse and under a road. Thirty acres on the watercourse investigated are irrigated in this way at will by farmers. There are fines that can be levied for such unauthorized irrigation.[47] However, the uneven topography is such that the farmer tries in every way possible to get water to his fields. There is a brick cement outlet built into the adjacent watercourse which farmers use to bring water across to the other command area. It is also illegal to make extra cuts in the main watercourse, but this is done at several places near the mogha. In some areas, one has to but ride along in a vehicle to see unauthorized cuts in the mogha or distributary, especially near the tails. When such is detected by the canal officials, they can contact the police for investigation.

One nakka cut from the main watercourse per 25 acres is allowed, but on this watercourse two to three cuts per 25 acres were documented. Water from these main watercourse nakkas serve farmers' field ditches.

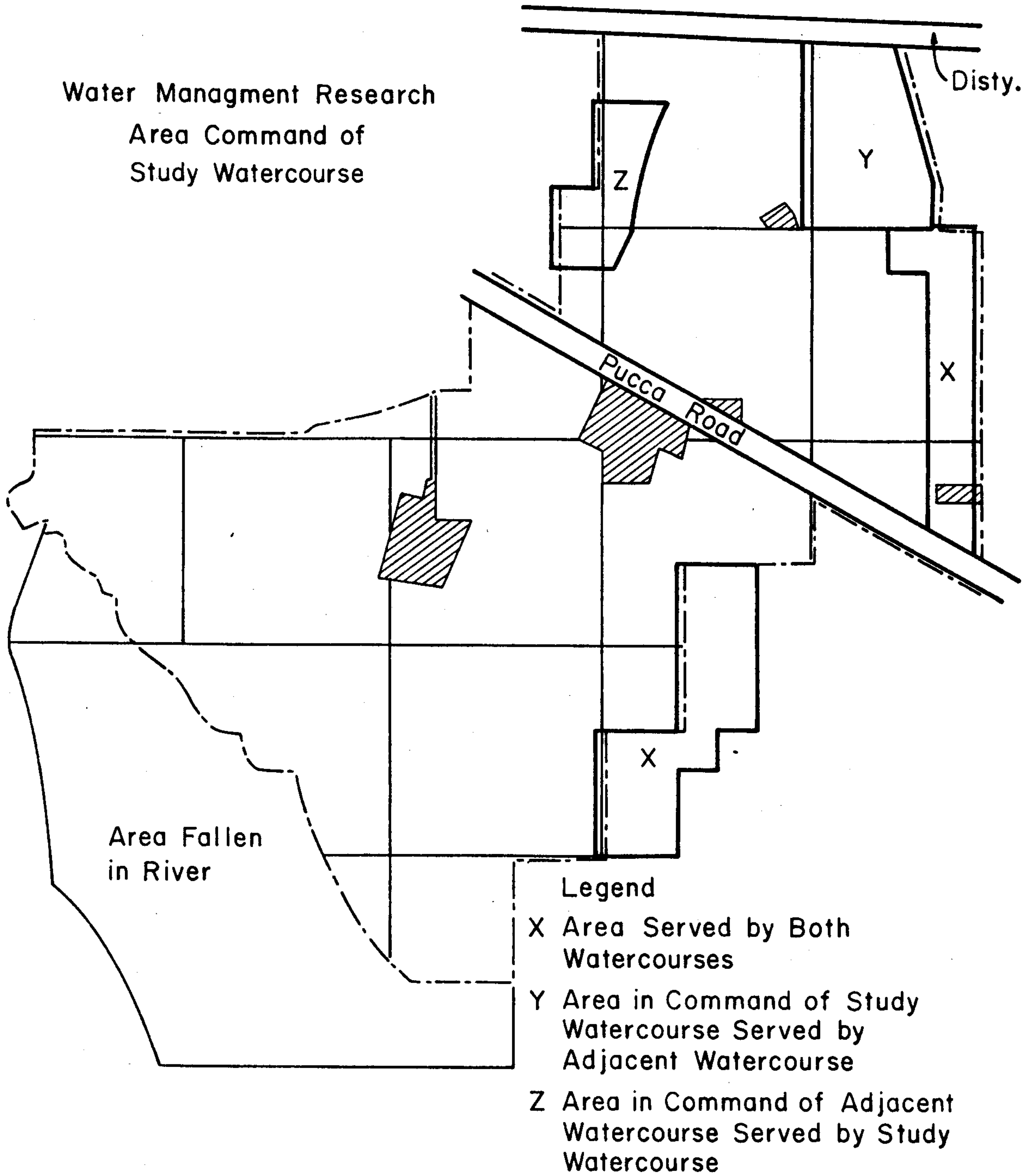
The length of turns on the warabundi should be "strictly proportional." On this jalari watercourse, where losses are very great, as described earlier, this rule is not followed; farmers respectively from Jalar I to Gravity System V receive 103, 186, 174, 93 and 114 minutes per acre of land. Farmers report that this results from the 73 acres of land eroded into the river. The water rights still exist and farmers who have lost their lands due to erosion utilize the extra water on remaining land.

Remissions of Water Rates

There are special remissions of water rates under the Canal and Drainage Act VIII of 1873. All farmers on the jalari system are entitled to remission of one-half the abiana (water rate for a given cultivated crop). Seven farmers on gravity system V were once on a jalari system, but for a number of years they have not operated a jalar. However, they still pay the one-half abiana rate.

Several rules allow remission for "kharaba" (crop failures resulting from stoppage of canal supplies, crop diseases, dust

[46] See Map VIII on following page and note areas X, Y, Z.
[47] S. Masud-ul-Hassan, op. cit., p. 28.



Map VIII. Areas served jointly by different moghas.

storms, hail, extensive flooding, rats, locusts, or other pests. The amount of remission is based on the degree of damage and described in the rules in paisas/rupee (100 paisas equal one rupee) instead of percent, i.e., "yield not more than 13 paisas (12-1/2 percent)--full remission; yield more than 13 paisas but not more than 25 paisas (25 percent)--three-fourths remission; yield more than 25 paisas (25 percent) but not more than 50 paisas--half remission; and yield more than 50 paisas (50 percent) but not more than 75 paisas (75 percent)--one-fourth remission."[48] The rules are very complex especially the procedures to get a "kharaba" recorded and finally approved. The numbardar of a given village, along with the canal patwari, record the type of "karaba" and the degree of damage for every field and submit the cases to the zilladar who is authorized to check the fields and record his inspection on special forms. This official recommends the cases to the Sub-Divisional Officer, who forwards the case to the deputy collector, who in turn forwards the case or cases with his recommendations to the Divisional Officer. This lengthy procedure is shortened when there is widespread damage Large landlords with connections and considerable influence can go right to the top. The rules state that any cultivator can appeal in ten days upon return of the "fard Darkwast" (request form) direct to the Sub-Divisional Officer (SDO), or his supervisors where necessary. The SDO and his supervisors can check the zilladari's work.

Farmers report that unless the damage is widespread the lengthy procedures are not worth the effort. As an indication of farmer's views about the procedure, their responses to the question, "What action would you take if the patwari made a false or incorrect entry in his records of your seasonal water assessment?" are revealing. Eighteen of the 35 farmers reported "pay a tip and get the record changed"; four stated they "could do nothing"; and eleven stated they would go to the numbardar and other officials to try to get the record corrected. They report that there are several ways to interact with the patwari and others to get the abiana (water rates) reduced each season. They are as follows: have some crops listed as fallow; list other crops as "failure to germinate", destroyed by natural causes, etc.; have some crops assessed at higher rates entered as other crops with lower assessments; or even have one man's crops listed under the record of another farmer. Thirty-three of the 35 farmers responded positively to the following question: "Is it possible to receive an extra legal reduction in your abiana by interacting with the patwari and payment of a "faslana"[49] or "generous tip?" There is a limit though of how much benefi the farmer can receive.

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[48] Ibid, pp. 127-130.

[49] Faslana is the Urdu term for the customary gift to the patwari for services rendered.

When the patwari, for example, reduces the abiana by a certain amount for the farm for a given cropped area, the farmer pays the amount direct to the patwari and both benefit, but the government suffers. There is no way to estimate how much such transactions benefit the parties concerned, or cost the government in revenue foregone.

Farmers were also asked the hypothetical question, "In these days of rapid rise in cost of living, what would you do if the canal patwari sent word to you that his "faslana" should be increased?" Thirty-two of the 35 farmers interviewed reported that they would increase the "faslana" gift to maintain good relationships.

Reference has been made to "faslana", which is traditional payment to both the Canal Department and the Land Revenue Department patwaris. Much has been written about the power and influence of these local officials who can influence important decisions on two scarce resources (land and water) in rural Pakistan. Roberts,[50] in the 1940's wrote that some new system of selling water should be evolved if only to get rid of the canal patwari and his exactions from farmers. He suggested the volumetric system of water supply at the outlet, a system which the Canal Department has experimented with, but perhaps has not examined over long periods of time in comparison to a control using the traditional system. Such a system also has many other advantages; however, the Department, with its long tradition, does not appear innovative in regard to systems which allow much farmer participation or responsibility.

"Faslana" is widespread in rural Pakistan as any keen observer knows. Only 3 of the 35 reported that they do not give a regular gift to the canal patwari seasonally. The gift is in kind and on this watercourse payments are in rice and wheat. At will, the patwari can send for fodder from his clients and also other small gifts are made available. When he visits, he is a very important official.[51]

The lengthy discussion of duties of the zilladar to supervise and check all the work of the 10 to 14 patwaris under him covers 12 pages in the Canal and Drainage Rules.[52] This is another indication of the potential power of the patwari to receive gifts from farmers for essential services rendered.

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[50] Roberts, op. cit., p. 171.

[51] Both patwaris (land and water) are often called badshah (king) in rural areas. His power and influence is described in a story told by a farmer. In a certain area a deputy director of a division appealed to farmers to cooperate in a certain development activity. After little response, he asked why. Villagers replied, "Sir, if you only had the power and influence as our local patwaris we would all cooperate willingly.

[52] Masud-ul-Hassan, op. cit., pp. 105-116.

There is no way to estimate the value of the faslana paid to the canal patwari who receives a salary of Rs.150-200 per month. His salary is only a small part of his actual income. Amounts paid depend on size of holdings and expected services needed. Farmers on this watercourse report from 10 seer each of wheat and rice to as much as a maund of both crops. If one estimated an average of 20 seer of rice and 20 seer of wheat from each of the 41 farm families on the watercourse, this would amount to about 20 maunds of wheat and 20 maunds of rice.[53] One can estimate the amount in rupees by current prices.

A patwaris circle, or halqa, includes from 3000 to 5000 acres. If we assume 4000 acres and an average of about 400 acres per watercourse in Pakistan, this represents about 400 farms given an average size of 10 acres. This is to indicate roughly the number of clients served by the patwari. Given these crude estimates and the "fuzzy" nature of the faslana, one could come close to the annual take home pay of the patwar[i] for his services. It should be stated that the Sir Alexander Gibbs and Partners Study[54] of watercourses in Pakistan a numbe[r] of years ago also estimates 20 seer payments from farmers to the patwari.

Farmers report that the payments of faslana to the canal patwari are small in comparison to the exactions made by the Land Revenue patwari when they have to interact with him over land and property matters.

Farmers also interact with the canal overseer and other officials. The question was asked to the 35 farmers, "What would you do if the overseer were to come and notify you that the mogha outlet size is too large and must be reduced?" All but three farmers stated that they would consult collectively with other watercourse members and negotiate a settlement with the official. Farmers then interact strongly with officials to receive "extra water." it is common knowledge that they break moghas, make unauthorized cuts in the main watercourse and sometimes minor canals, siphon from canals, utilize water from one command area for another, obtain concessions in water rates, buy water allotted to district roads from beldars, purchase water allotted for common village ponds, schools, mosques, village mains, and even steal water from each other. This "water hunger" is also evident in the rapid spread of tubewells in Pakistan. The writers conclude that farmers participate in some of the illegal activities due to both the physical constraints of the system and the institutional constraints. The present system, both physically and institutionally, is one that must be substantially improved to meet

[53]This is only 1 of 4 watercourses in one village so from one village the patwari receives about 70-80 maunds each of ric[e] and wheat.

[54]Sir Alexander Gibbs and Partners, Vol. VIII, op.cit., pp. 106-

modern demands. Improved supervision and enforcement of rules would help some classes of farmers. However, this would not improve on-farm water management practices substantially. The goal must be to design and implement improvements and codes that are relevant to modern agriculture such as to utilize each unit of water efficiently for increased crop production. The only formula known for agricultural progress is to provide farmers sufficient production possibilities so they can continue to reduce per unit costs by increasing per unit output. Water must be recognized as a major input and Pakistani farmers need much assistance in utilizing this commodity more efficiently.

Cleaning of Main Watercourse

The cleaning and maintenance of the main watercourse from the mogha is the responsibility of the farmers served by the mogha. There are provisions to levy fines and even stop the water supply "whenever and so long as any watercourse is not maintained in such proper customary repair as to prevent the wasteful escape of water."[55] Farmers interviewed reported no supervision of watercourse maintenance or repairs. No fine was reported as ever being levied, or closure of delivery due to poor maintenance.

As described, farmers do organize to clean the watercourse. Even a casual observation of the poor maintenance of this watercourse (and scores of other watercourses throughout Pakistan) is sufficient to conclude that farmers need much supervision and more incentives to maintain and improve watercourses. Both the patwari and the zilladar are to check the condition of the watercourse.[56] The duties, for example, of the two zilladars when on tour include "using their influence with zaminadars (landlords) to persuade them to put in order any watercourse which they find in a bad state of repair. Should they refuse to do so, he should report the matter to the SDO, who will warn the owners jointly in writing that unless within a given time they do so, after personal inspection by himself or the Deputy Collector, the watercourse will be closed by the Divisional Officer under the Rule 17, Section 32(a) Act VIII of 1873."

This watercourse (as well as hundreds of others observed) has huge silt mounds in the reach from the mogha to the first branch, countless trees and is covered with vegetation. A casual examination reveals leaks and "pipe" holes created by rodents which feed on insects found in the fertile root zone of plants.

[55]Masud-ul-Hassan, op. cit., page 21.
[56]Ibid, pp. 103, 115-116.

Kemper[57] and others, in a very careful examination of one watercourse, identified over 150 leaks through the banks when the watercourse carried both tubewell and canal water. This was reduced to only 25 leaks when only canal water was flowing and the water level had receded about two inches. In general, the upper portion of the watercourse banks have by far the greatest permeability due to insect and rodent activity. Lowering the operating water level by two inches commonly decreases the loss by a factor of two or three. Since cleaning the tall grass from a watercourse allows the water to move faster, a given flow requires a smaller cross section and results in lowering of the water level in a watercourse. Such cleaning activity at five week intervals can bring returns of one acre-foot of water delivered at the field per 17 hours of a laborer's time as compared with costs ranging up to Rs.400.00 per acre-foot of water delivered to the fields from private tubewells (e.g., Rs.4.00/hour for a 0.4 cusec given a delivery efficiency of 0.3 equals about Rs.400.00/acre-foot). When water begins to overflow the banks, farmers recognize the problem and generally clean the watercourse. However, much more of the water is being lost than is necessary for several weeks prior to the overtopping condition. Farmers generally do not have a clear understanding of the magnitude of this loss.

Farmers, without more knowledge of losses resulting from poorly maintained watercourses combined with incentives and technically trained supervisors, cannot be expected to do much more than is presently accomplished in order to keep watercourses maintained. The silt mounds themselves present a tremendous problem for farmers, who traditionally continue attemp[ting] to remove the silt until they can no longer hoist the material to the top of the mounds. One wonders if farmers might not take more interest in the total watercourse from mogha to the tail if the warabundi was started from the tail, rather than at the head near the mogha?[58] Various approaches, both technical and organizational, need careful experimentation.

The references cited which describe the Canal and Drainag[e] Act document and many of the rules and regulations related to the distribution of water along the watercourse, such as "cutting banks of canals, erecting unauthorized bunds in water-courses, installing unauthorized outlets, opening outlets out of turn, enlarging outlet size, applying water outside the outlet area, taking water out of turn, allowing water to run to waste, etc."[59] A careful study of the Act and its Amendment[s]

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[57]Kemper, W. D., et al., "Where Water Goes in a Watercourse," Investigation at WAPDA Mona Experimental Research Station. (In 1975 Annual Report, Water Management Research Project, Colorado State University, Fort Collins, Colo., Appendix 13.

[58]Suggested by George Radosevich of Colorado State University in private conversation.

[59]Masud-ul-Hassan, op. cit.

leaves the impression that both the physical system and the institutional regulations need to be objectively examined in light of the modern demands for developing a progressive agricultural sector.

Irrigation Department Communications with Farmers

In a nation so dependent on canal irrigation, it is essential that farmers be informed on a regular basis of any changes in water supplies or regulations which affect them. Such knowledge undoubtedly affects their decision-making about cropping patterns and cropping intensities for a given season. Such information as rationing closures, closures for regular and emergency repairs and cleaning, for forecasts of expected seasonal supplies would help farmers reduce their risks by allowing more rational planning. As an example of the lack of information, at the time of this writing there are reports that the crop assessment rate might be changed to a flat rate similar to that established in the Sind. Farmers should not only know about this, but their views should be solicited through surveys.

When there are closures of canals, the Divisional Officer has the responsibility to provide a written notification to be conveyed through the officials to the patwari, or in his absence, the numbardar to the farmer. According to the rules, this is to be signed as a receipt and posted at a conspicuous place in the village.[60] Canal officials of the area reported to the investigator that notifications were made available to villagers and that newspaper announcements and radio broadcasts were used to communicate information to farmers. Annual closures are in theory fixed and farmers should know about them. However, in practice these dates are also often changed.

Thirty-one of the 35 farmers reported that they never receive information about canal closures. Four farmers reported that sometimes they were told by minor canal officials, or heard the news on the radio. During the investigation, due to an acute shortage of water for Rabi 1974-75, a water rationing system was begun. Farmers learned of this for the most part when the water supply was stopped. Thirty-three did not know about the published rotation schedule issued by the Canal Department. Two farmers read about it in the Urdu press. The investigator obtained a copy of the schedule and made it available to the leaders of all brotherhood groups on the watercourse. However, the actual rotations were often different from those listed.

No farmer ever recalled a seasonal canal position report that would give some idea about the expected volume of water to be received, such as "good", "fair" or "poor". It must be

[60] Ibid, op. cit., p. 70-71.

realized that press releases reach only a small percentage of largely illiterate farmers. No farm family on the watercourse received a newspaper regularly, and only four farmers reported reading a newspaper from time to time. However, 15 of the 35 farmers owned radios and 22 reported listening regularly to certain programs.

Little imagination is required to understand the potential of the transistor radio in terms of adequate advance information to farmers. Communication by radio is direct, rapid, low cost and one in which many exposures of a single message can be given to the audience over a large area. Given the rapid development of radio stations in most regions, canal position reports could become as useful as weather reports. If it is important to give flood reports in the various canal circles during emergencies, how much more important is it to provide information on a continuous basis that will help farmers make more rational decisions?

In actual practice, few farmers in Pakistan ever know when canal supplies will be closed or reduced. As one farmer stated, "We simply look to the mogha for our information and to Allah. We simply sow and pray!"

Problems and Costs of Jalar Waterlifts

In areas where the land is higher than the water surface elevation in the watercourse, the ancient jalar waterlift system is utilized to raise the water for irrigation. A feature of this watercourse is the presence of four "jalars" which lift the water for delivery to the majority of the land served by the watercourse. However, the lifts are not used all the time. Some fields near the tail of the watercourse are served mainly by gravity flow. When the canal water level is sufficiently high, more of the fields can be irrigated by gravity flow. One counterbalancing effect of an increased canal level is the resultant submergence of the "mogha," which results in a lesser discharge than it would provide under free flow conditions. The farmers' operation of the "jalar" thus depends on the water level in the canal, as well as the crop demands for water and the seasonal land preparation irrigation needs for "rauni" irrigation. It was also noted that on cold nights during the "rabi" season, the "jalars" were used infrequently.

Each "jalar" system has a definite membership based on the kinship group or "baradri" and a "warabundi" of allotted hours and days of operation. Table VII shows the weekly irrigation schedule, or "jalar" and gravity system operation, which is sanctioned by the Irrigation Department. Within this "pucca" or sanctioned "warabundi", the farmers operate a "kutcha warabundi", which means that there is much trading of irrigation turns between "jalar" members and even occasional trading between "jalar" systems. The four "jalar" systems and one gravity system receive variable amounts of irrigation time per acre. Table XIII indicates that the average minutes per acre is 127, but that the range of values is from 93 to 186 minutes per acre. One of the major reasons for this wide range is the retention of water rights for the estimated 72 acres of land that have been eroded into the river. The upper limit and the average value appear to be quite high, but the discharge of the "jalars" range from 0.4 to 0.7 cubic feet per second (cusec) and the conveyance losses are often 50 percent, or higher, depending upon the circumstances of location and branch conditions. With 0.2 to 0.35 cfs of water at the field outlet of "nakka", a 3.5 inch irrigation application on one acre could take as long as 10 to 18 hours, if the field is in a level condition. With this size of application, only 9 to 17 acres could be irrigated in a week of "warabundi" time, as opposed to the theoretical 56 acres per week for the 3.5 inch application and the 1.2 cusec authorized discharge at the "mogha." Due to the effort expended by the farmers in raising the water for irrigation, the Irrigation Department grants two concessions to the farmers on the "jalari" system. First, they are required to pay only half of the regular "abiana" or crop rate per season for irrigation water. Secondly, they are provided a concession of 50 percent increase in the size of the authorized discharge at the "mogha." This would make the authorized discharge for this watercourse equal to 1.8 cusec. Further concessions have apparently been arranged, as flows exceeding 3.0 cusecs have been measured at various times for sustained periods of time.

Table XIV shows the actual times during the week and during each day that the "jalars" 1 through 4 and the gravity system 5 receive water. Since system 5 was once a "jalari" system, several of the farmers who have good relationships with persons on one of the 4 lift systems occasionally use the corresponding "jalar" to lift water for their irrigation turns. Usually, three of the systems operate at one time. This makes approximately 1 cusec available at the "mogha" for the operation of each of the systems. Since the maximum discharge that any of the three systems can produce on a sustained basis is 0.7 cusec each, the normal flow at the "mogha" for the "jalars" averages 0.9 cusecs less than the maximum, or approximately 30 percent of the "mogha" discharge is not used. This relationship is confounded by the speed at which the bullocks are driven on a sustained basis; how many animals are used at one time; the occurrence, amount and duration of rainfall; and whether two or three of the systems are in use. There are times when only one system is utilized for a lack of water in the canal system, and other times during which the canal is closed and none of the systems are used. It is impossible to ascertain the actual number of hours the jalars are used. (A record system has been established.) Farmers can only estimate the turns used in the past 12 month

Table XIII. Irrigation schedule for water course by day and system.

Day of Week	Jalar I	Jalar II	Jalar III	Jalar IV	Gravity	Total
Monday	-	24	24	9*	15	72
Tuedsay	-	24	--	24	24	72
Wednesday	-	24	15	24	9	72
Thursday	20	4	24	4	20	72
Friday	24	--	24	--	24	72
Saturday	24	--	24	--	24	72
Sunday	24	--	24	--	24	72
Total Hours	92	76	135	61	140	504
Estimated acres served	53.5	24.5	46.5	39.5	74.0	238
Minutes	5520	4560	8100	3660	8400	30240
Minutes/ acre	103	186	174	93	114	127

*The nine hours of use on Jalar IV actually belong on the gravity system, but due to special arrangement with family members who own Jalar IV one farmer uses the Jalar 3 phar or 9 hours.

Table XIV. Jalar and Gravity System Schedule

Day of Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				B 10:00 1	1	1	1
Jalar				S 10:00			
Number and Gravity (5)	2	2	2 B 15:00				
	3		3	3	3	3	3
	B 12:00 *			S 10:00			
	4 S 21:00	4	4	4			
	B 06:00 5 S 12:00	5	S 13:50 5	B 10:00 5	5	5	5

*One farmer operates #4 Jalar from 12:00 to 19:00 on Monday though he is on the Gravity System #5. He is a relative of the brotherhood which owns Jalar #4. "S" denotes Stop and "B" denotes Begin.

period as recorded for Punjabi and English months in Appendix I. Additional variability in the discharge of the "jalar" depends upon the state of repair of the "jalar" buckets, and the number and size of the buckets on the circumference of the wheel.

Farmers on the "jalari" system generally keep more draft animals than the customary pair of bullocks per 12.5 acres.[61] Farmers on this watercourse average 1 pair per 8.24 acres. Animals are generally worked for 3 hours and replaced by a "fresh" team. This is continued as long as the farmer's turn lasts. A single camel is often used in the place of a pair of bullocks or used with a pair of bullocks to provide the power equivalent of two pairs. Some farmers cooperate in rotating bullock turns on a given "jalar," but these are usually close relatives, or those engaged in a joint farming operation.

The costs involved in lifting the water a mere 0.5 to 1.5 feet are difficult to estimate. Farmers are aware of the tremendous effort required by them to lift all their water, and many reported that the "jalars" were "killing" them in terms of extra animals, labor, fodder and hardships of operation on cold nights. Having remained at the watercourse for several nights to observe the operation, an appreciation was gained for the effort, patience, and sheer drudgery required for this task. A cost estimate was attempted on a per hour basis, using labor rates based on current employment opportunities for non-skilled labor locally and using the bullock rates based on the cost of a 7-8 hour round trip to Lahore with a load of fodder. The cost estimates are presented in Table XI, which are compared to the canal water assessments for gravity water. The cost estimate is based on the utilization of only one pair of bullocks at a time and, therefore, remains a conservative estimate of the costs. This estimate of Rs.7 per hour for the average water delivery rate of 0.70 cfs means that the water is costing Rs.10 per acre-inch of water lifted at the jalar and Rs.20 per acre-inch of water delivered at the remote field assuming 50 percent delivery efficiency; the cost is Rs.70 for a 3-1/2 inch average irrigation application.

If the 4 jalars operate a total of 364 hours per week and 24 weeks per year, then the cost to farmers on the watercourse is Rs.61,000. For 20 weeks per year, the cost is Rs.51,000 and for 16 weeks per year Rs.41,000.

61Five farmers on this watercourse have partial or complete ownership of tractors and have no bullocks. If the tractor units were converted to bullock pairs, the average for the watercourse would be 6 to 7 acres per pair, just half the customary rate.

Table XV. Estimated Jalar cost.

Item and Description	Amount/hour
1. Labor - one man @ Rs. 8.00/eight hour day	1.00
2. Bullocks one team @ Rs. 40/day	5.00
3. Replacement cost of jalar current prices, 10 years life, 100 days/year (Rs. 500 ÷ 100 ÷ 24)	.21
4. Interest on capital investment Rs. 5000 @ 10% rate, 100 days/year (Rs. 5000 x .10) ÷ (100 x 24)	.21
5. Estimated extra cost of maintenance extra bullock team or camel replacement, Rs. 25000 replacement cost, work life 6 years (2500 ÷ 6) ÷ (100 x 12)	.35
6. Interest on extra team or camel Rs. 25000 @ 10% rate, 100 days/year (25000 x .10) ÷ (100 x 12)	.21
Estimated Cost Per Hour Rs.	7.0

Table XVI. Estimated cost of operation of low lift electrically powered pump.

Item and Description	Amount/Hour
1. Operation of pump Rs. 17 ÷ 576 hours/month operation	.03
2. Maintenance and Supervision Rs. 200 ÷ 576 hours/month operation	.35
3. Replacement cost of motor and pump assumed amount price Rs. 10,000, 10 year life, 350 days/year, 20 hours/day (Rs. 10,000 x 1) ÷ (350 x 20)	.14
4. Interest on capital investment Rs. 10,000 @ 10% rate, 350 days/year, 20 hours/day (Rs. 10,000 x .1) ÷ (350 x 20)	.14
5. Installation and annual electrical connection maintenance Rs. 500 ÷ (350 x 20)	.07
Estimated cost per hour	0.73 Rs.

In either of the cases above, the cost is gigantic compared to the estimated Rs.973 per season abiana water rates.[62] The average charge for rabi season 1974-75 was Rs.4.10 per acre and Rs.5.62 per acre for kharif.

Table XVI provides the estimated cost of operation of a low lift electrically powered pump if used as a replacement for a jalar. The calculation for power requirement of the electric motor for H feet of lift and Q cusec delivery is made by the following equation:

$$\text{Hp (motor)} = \frac{\text{Q (cusec)} \times \text{H (ft)} \times 448.8}{3960 \times \text{pump efficiency} \times \text{motor efficiency}}$$

Assuming that Q equals 0.7 cfs, H equals 1.5 feet, the pump efficiency 0.6 and the motor efficiency 0.7 (both conservative efficiency factors), the horsepower required of the motor is 0.28, for 3 cfs Hp equals 1.21.

An estimate for the cost of operation of an electric motor was provided recently in the vicinity of the water-course at Rs.14 per month per horsepower.

The assumed cost of a low lift pump and motor is Rs.10,000 and the annual cost of maintaining a connection is Rs.500. The employment of one man to supervise and maintain the pump is assumed at Rs.200/month. The estimated cost is Rs.0.73 per hour to pump for all 4 jalars of 2 at any one time as compared to the present operation cost of Rs.7.0 for one jalar only.

[62] The rabi crops on the watercourse 1974-75 are: 114.3 acres; oats (fodder) 4.4 acres; sugarcane 3.8 acres; maize (fodder 4.4 acres; berseem (fodder) 43 acres; other (gardens, vegetables) 5.7 acres times the abiana rate/acre amounts to Rs.1945.70 ÷ 2 or one-half the regular rate = Rs.972.85 per acre average (Rs.972.85 ÷ 347.2 acres) Rs.4.10. The same calculations were made for kharif.

Estimated Yields of Crops

Yields of wheat and rice were estimated by intensive questioning of the respondents.[63] No crop cutting records were available at the time of the survey. Nevertheless, there is some evidence that farmers can estimate yields fairly accurately.

The average yields of wheat (22.3 maunds)[64] and rice paddy (23.8 maunds) reported by the farmers (see Table XVII) are higher than the average yields for the Shadab Project area estimated in a survey conducted in 1970. Wheat yields in that survey were estimated at 15 maunds and paddy at 20 maunds. These reported yields are also higher than the average yields of the Punjab, which respectively in 1973-74 for high yielding wheat and Basmati rice paddy were 18 and 16.4 maunds.[65] However, in terms of potential yields for irrigated agriculture in other countries, these yields are among the lowest.

Yields of fodder crops, such as maize, bajra, oats, berseem, etc., were not estimated because farmers do not weigh the fodder consumed by draught and milch animals. However, farmers reported the average yields of some of these crops per canal. Rabi maize and oat fodder crops range from about 2000 maunds to as much as 600 maunds per acre of green matter, with an average of about 310 maunds. The Shadab survey reports about 500 maund/acre for Rabi fodder crops (berseem, oats, and maize) and about 300 maunds for Kharif fodder crops (maize, jawar). Yields of these crops can be greatly increased with more fertilizer used properly.

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[63] In a sample survey of 350 farmers conducted in 1970 by the senior investigator in Khanewal Tehsil, yields/acre of wheat, estimated from farmers' reports were almost identical with crop cutting data (Lowdermilk, Max, "Diffusion of Dwarf Wheat Production Technology in Pakistan's Punjab," Ph.D. Dissertation, Cornell University, Ithaca, New York, 1972, pp. 441-442). After total acres of a crop are known, one must find out the payments in kind to blacksmith, carpenter, barber, religious leader, canal and Mal patwaris, etc., special village assessments, the number of consumers in the home--estimate of home consumption, amounts marketed, payments for harvest, etc., and calculate back to the total first reported by the farmer and divide the total production by the number of acres. Actual crop cutting surveys should give better estimates and should be conducted when possible on the study watercourses for Kharif and Rabi crops.

[64] A maund is about 82 pounds.

[65] See Hafeez Saeed, Agriculture and Rural Development, Press Corp. of Pakistan, Karachi, 1973, pp. 4, 12.

Table XVII. Estimated yields per acre in maunds of wheat and rice paddy by farm size.

Farm size class (acres)	Number of farmers	Range in yields	Wheat per acre	Number of farmers	Paddy per acre	Range in yields
10	13	13-35	21.5	8	25.2	20-40
10-25	14	10-35	22.0	10	25.0	20-30
10	8	20-33	25.0	7	21.0	10-40
Range			10-35 maunds		10-40 maunds	
Median			20 maunds		22 maunds	
Mean			22.3 maunds		23.8 maunds	

Demonstration of Potential Wheat Yields

A demonstration program was conducted during the Rabi season of 1974-75 on water and fertility inputs to wheat production. The plots were established on farmers' fields at this study watercourse. The plots were chosen on level fields (within the tolerance of 0.1 foot high to low elevation) and ranged from one quarter acre to two acres in size.

Half of each plot was maintained under the farmer's traditional treatment of 50 lbs. of nitrogen per acre and traditional irrigation practice. The demonstration of a portion of the plot used a treatment of high fertility (from 100 to 150 lbs/acre of nitrate and from 37 to 75 lbs/acre of P_2O_5) and irrigation application according to soil moisture depletion.

The yields of strains from the traditional and improved practices are shown in Table XVIII. The increment in yield due to improve fertility and improved water management practices averages 24.5 maunds per acre for Chenab 70 variety and 17.0 maunds per acre for the SA-42 variety. The maximum yield obtained was 62.4 maunds per acre.

The average 24.5 maunds per acre increment in yields for Chenab 70, which is worth approximately Rs.735, was provided at a cost of Rs.300 for fertilizer (4 bags/acre at Rs.75/bag) and at an average savings of 8 to 12 acre-inches per acre of irrigation. For SA-42, the average increment was 17 maunds/acre, worth approximately Rs.510, and provided at a cost of Rs.300 and with water savings of from 4.7 to 6 acre-inches per acre. This confirms the special view that farmers tend to overirrigate wheat, when that excess water could be used for alternative crop production.

Table XVIII. Demonstration Wheat Yields.

Plot	Variety	Traditional treatment (mds/acre)	Improved treatment (mds/acre)	Increment (mds/acre)
1	Chenab 70	26.4	49.8	23.4
2	Chenab 70	33.8	62.4	28.6
3	Chenab 70	22.5	43.9	21.4
4	SA-42	20.3	37.0	16.7
5	SA-42	19.1	36.5	17.4

FARMERS' ATTITUDES AND PERCEPTIONS OF IRRIGATION PROBLEMS AND PRACTICES

A number of physical problems and constraints of the watercourse system have been discussed in this report. During the investigation, actual observations were made of farmers' irrigation behaviors. An attempt was also made to understand farmers' views about these problems. This preliminary attemp suggests some explanations of why and how farmers make decisions about irrigation practices. In brief, is there a rationale to explain their irrigation behavior?

Water Losses

The losses of water on this watercourse are substantial as already documented. Farmers were asked to give their idea as to the three major sources of loss of water from the mogha (outlet) to their fields. Their responses are given in Table XIX. The most frequent reason given for losses by 18 farmers was dead storage, while 8 reported leaks and spills. Observations on the watercourse with 11.62 miles of field ditches, which have bottoms generally below the elevation of the fields, support the view regarding dead storage. Likewise given small field ditches with little freeboard, and unlevel topography, farmers have to pond the water in the channel in order to raise the water level to irrigate higher fields, which leads to numerous spills (which were documented with pictures). Likewise, there are 1231 "kutcha nakkas," of field outlets, on this watercourse for 238 acres; these "nakkas" are potential locations for leakage. The leaks, spills and seepage through the thin watercourse banks often damage crops on both sides of the watercourse channel from too much water. When all the responses are totaled, it is obvious from Table XIX that farmers agree that dead storage, as well as leaks and spills, constitute major water losses. Seepage from watercourses was listed by farmers only 7 times and most likely only about 40 percent of all losses result from this problem.

Unlevel fields, which was listed 13 times, is the third major reason given for water losses. The topographical map o page 15 shows the level of fields. Farmers were asked if the considered their fields to be level at the time of the inter- views. Twenty-two farmers, or 63 percent, replied that thei fields were not level and required leveling. An indication o the problem is also seen in the small field sizes which rang from .01 to .25 acre in size. Though fragmentation of fiel is a problem, these individual parcels are divided into smal units with bunds for basin irrigation. The purpose is to control the water. Farmers were further questioned, how oft do they try to level their fields with a bullock drawn "kara wooden board or a tractor blade? Table XX shows farmers' reports of last leveling and the period after which they

Table XIX. Farmers' views of major losses.

Order of importance	Dead* storage in ditches	Leaks and spills	Seepage in ditches	Unlevel fields	Vegetative growth on ditches	Silt	Other	Total responses
First	18	8	1	5	1	2	0	35
Second	11	10	3	2	3	5	1**	35
Third	2	12	3	6	5	3	(6)***	35
Total	31	30	7	13	8	9	7	115

*Dead storage is that water which remains in a field ditch after an irrigation because the ditch is lower than the field elevation.
**Refers to sealing of water.
***Six farmers did not report a third reason.

Table XX. Last leveling of fields and estimated period after which fields usually need leveling.

When leveled?	Recently	After 1 crop	After 2 crops	2-3 years	4-5 years	6 or more years	Farmers responding
Last leveling	6	6	8	7	3	5	35
Usually level after		2	12	15	5	1	35

usually level fields. These reports suggest that farmers seldom level fields after each crop and give insufficient attention to leveling. They may consider it is easier to keep the basin areas small when using the traditional "karah" or "karahi" (one team "karah"). Farmers were observed in some fields leveling land cooperatively with 2 teams on a "karah" and individually with a 1 team "karahi." They were leveling fields where bunds were being changed or where row crops had been planted the previous "kharif" season.

Some farmers were observed incorporating the silt from the watercourse in their fields. Farmers near the mogha, where a greater volume of silt is deposited, generally reported leveling after one or two crop periods.

The lack of attention to leveling may result from the lack of sufficient technology, especially surveying, to bring a field to a dead level. Farmers usually try to level high spots with the hand tool, "cussie," as they irrigate. They often remark that "water tells us quickly when fields are level or not." A typical irrigator spends much time during an irrigation to get water over high spots in a field. At the tail of the watercourse, the senior investigator observed a farmer for over four hours as he attempted to irrigate a field with a small head of water. He was busy constantly trying to force "water to run up hill," or so it seemed.

Farmers have been encouraged for about 50 years by the Agriculture Department to use the "kiari" system, which requires that farmers divide an acre into small basins. Accordingly, the Canal Department recommends the number should be 8 per acre for efficient irrigation! Roberts,[66] over 25 years ago, wrote that this required excessive labor and tends to weaken ditch banks and create extra leaks. He suggested a modern plan 25 years ago which would require only one large ditch and 5 field ditches for 25 acres on a square of land. This is shown in Figure 4, with the arrows indicating the direction of water movement. This system requires a ditch to divide each acre, but the total length of all watercourses for the 25 acres is 6050 feet or 1.14 miles. The existing system on this watercourse investigated has 1 mile of ditches per 20 acres. Thus, Roberts' proposed system is hardly an improvement. However, 25 acres may not be possible except for large landlords. Some other system should be designed for farmers with smaller holdings.

Roberts, known as the father of "modern agriculture" in the Punjab, mentioned that 8 "kiaris" per acre were too many as it required too much labor and tends to weaken the banks and cause leaks. His plan for a square and its watercourses is shown in Figure 5 with a main watercourse and 5 field ditches for 25 acres. If water arrives at A B, the first

[66]Roberts, op. cit. pp. 167-168.

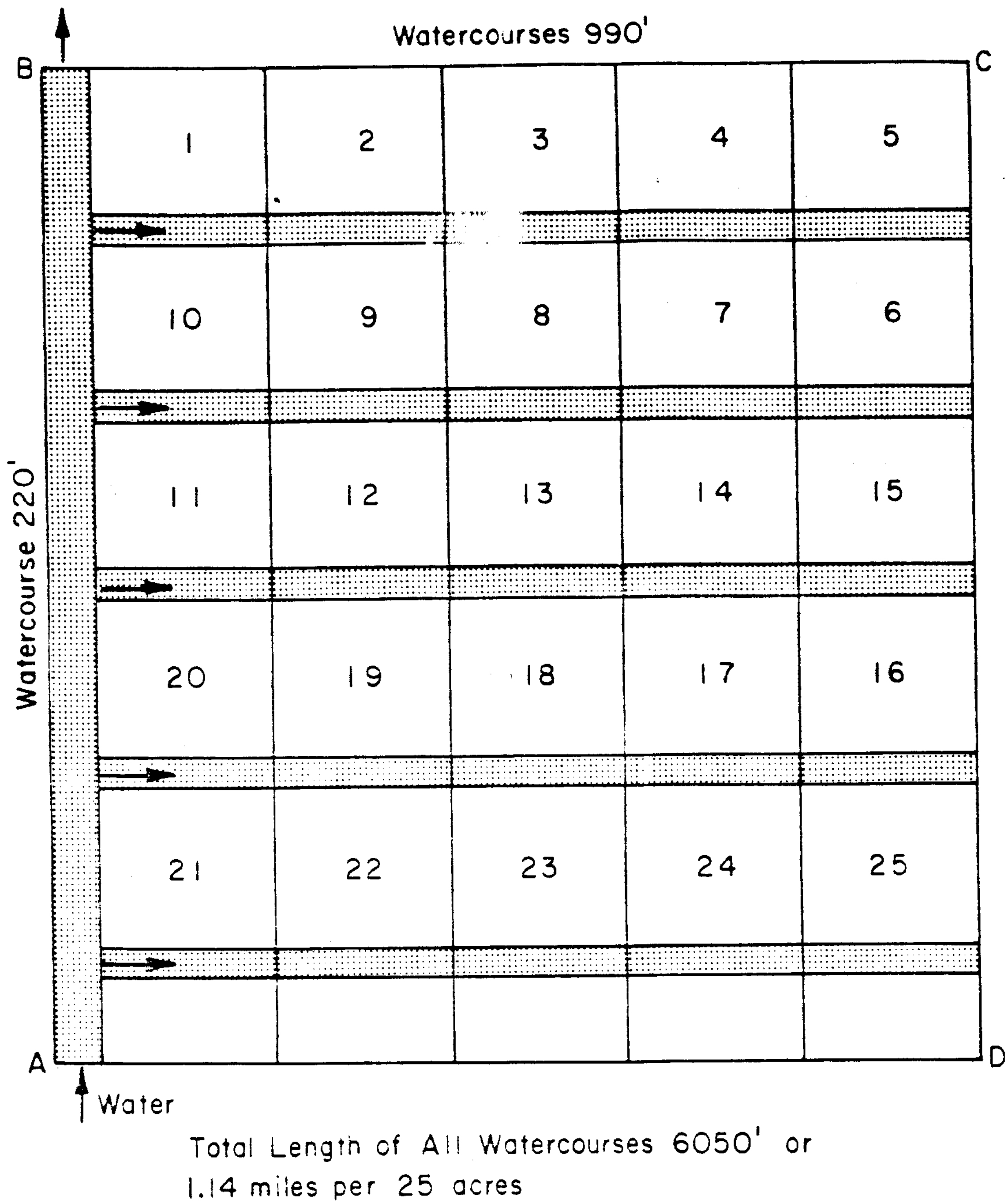

Figure 4. Roberts' 1950 "modern" layout of watercourse for 25 acre plot. Roberts, op. cit. p. 168.

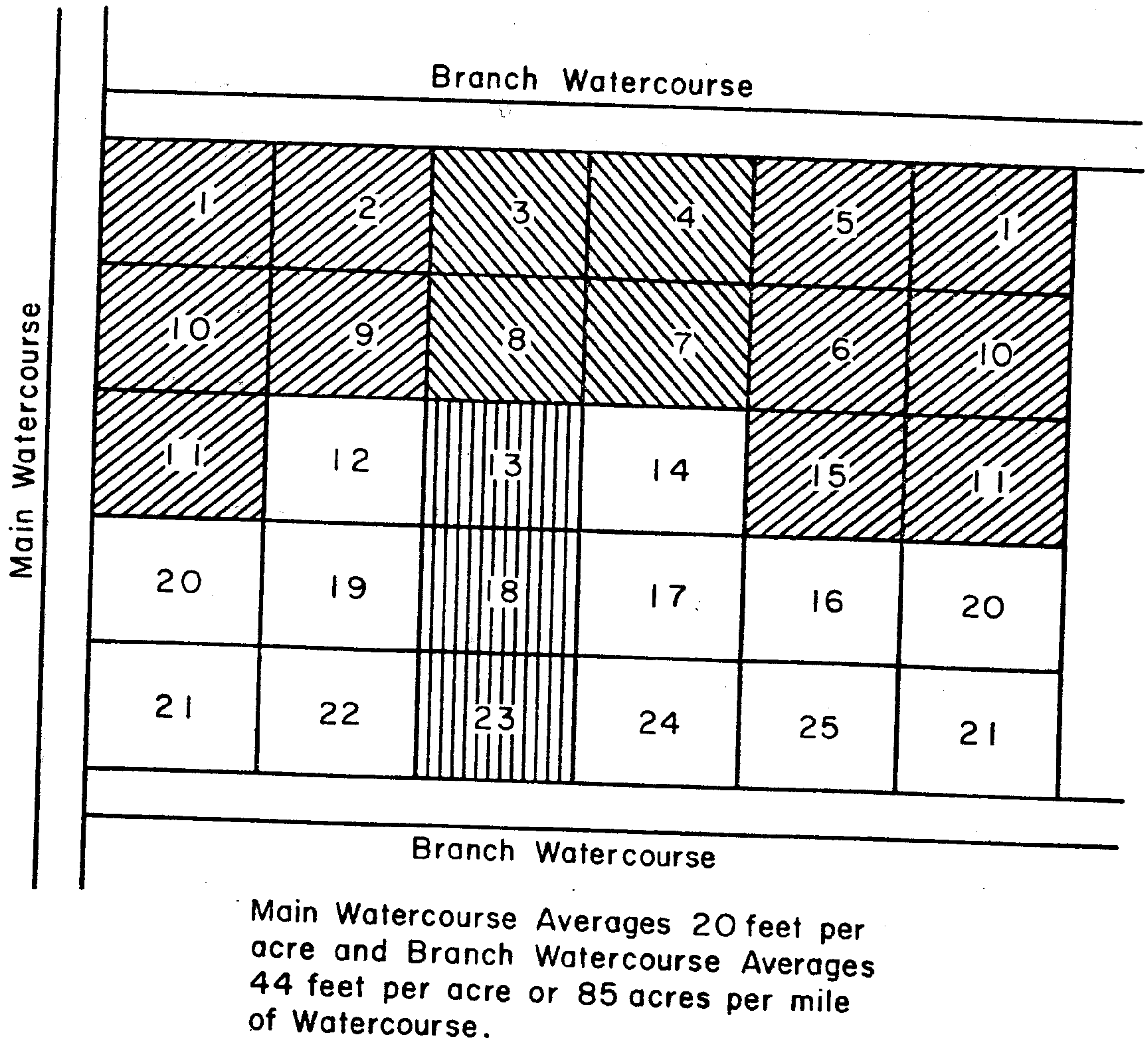

Figure 5. Recommended design for field layout in Pakistan.

acre irrigated would be 21 then on to 25, and then 20 to 16, etc., and acre 5 would be irrigated last. Note that the watercourse divides each acre.

Modern irrigation research has shown that water can be more efficiently applied by changing the geometry of field layouts (Figure 5). A long, relatively narrow border, precisely leveled, allows water to be applied uniformly with the time to irrigate an acre one-third to one-half the time for traditional fields.[67] Less land is taken up in permanent bunds. Farming operations are more efficient, especially with tractors or machines, as fewer turns are required. Fewer field corners exist with more uniform stands and higher yields. The number of acres per mile of watercourse has now been increased to 85, representing a reduction in watercourse length of over 65 percent over Roberts' model and 75 percent over common watercourse lengths. In a number of instances where the layout in Figure 4 has been installed, farmers on their own initiative have investigated or attempted land consolidation in order to place all their land in one contiguous block for more efficient field layout. Studies in Taiwan and Japan have shown that significant land consolidation has resulted from farmer initiative when farmers perceived advantages to contiguous parcels. In several countries farmers have tended to accept government initiated consolidation schemes once they have perceived definite benefits.

The additional land area for cultivation, by going from the existing system to a modern system, would be 1.03 acres per 25 acres, or a 4 percent increase in cultivated area. All the bunds for the borders are temporary and may be cultivated, resulting in increased area. This would imply that the irrigated area in Pakistan could be increased by more than one million acres by redesign of watercourses and field layout.

What is a Good Irrigation?

Farmers were asked what they considered a good irrigation at "rauni" (preirrigation), for wheat in depth of application? When adequate water is available, their concept of inches of water applied is the depth of ponded water at the end of an irrigation on a given field. Naturally, they have little knowledge of acre-inches actually applied, because they lack a means of measuring water. Their crude estimates, shown by using their hands, range between 3 to 4 inches. Fifty-one percent reported about 3 inches, while the remainder reported more than 3 to 4 inches.

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[67] Ali, Arshad, Wayne Clyma and Alan C. Early, 1975, "Improved Water and Land Use Management Through Precision Land Leveling." Paper prepared for presentation at the International Conference on Waterlogging, Lahore, October, 1975.

Actual measurement made for rauni irrigations on 20 fields average 2.75 acre-inches. Roberts[68] reported in 1951 that usually farmers using the jalar systems apply about 2.4 acre-inches. Recent CSU investigations in other areas, which are not on a jalar system, revealed that farmers often use 5 or more acre inches for rauni pre-sowing irrigations. This i usually excessive, but farmers, when asked, report that the practice of "dab" (repeated plowing and planking the fields before sowing) is necessary to destroy weeds. Farmers truly practice the meaning of the Punjabi proverb, "as many times as one plows, so much more is the increase of the crop." The do not understand the concept of minimum tillage to avoid fur ther breakdown of the soil structure which is already poor du to lack of organic matter. They evidently do not fully under-stand how much moisture is lost due to repeated plowing befor planting. However, they have a concept of a "kullah vattar," which is moist seedbed, and a "vattar" that has been lost.

Farmers, at the time of rauni irrigations during the survey, faced the additional problem of canal water rationing which may have limited the amount of water they could apply for pre-sowing. Farmers often apply two pre-sowing irrigatio called "pucca" rauni and "kutcha" rauni, of which the former is a heavy irrigation and the other is light. This is part o the process of plowing and planking sometimes as many as eigh times to perform "dab", or killing weeds after they germinate In addition, the weed seed carried in irrigation water is sub stantial. It is, however, the impression of the investigator that excessive labor is utilized in this inefficient process, which also wastes moisture and breaks down soil structure to a point where crustation later presents other problems (such as poor aeration of the soil leading to poor crop seed ger-mination and plant emergence, which is one of several factors causing poor crop stands).

Farmers have no means of reporting usual or optimum irri gation amounts required for crops after rauni, except numbers of irrigation. Table XXI shows farmers' reports of usual and optimum irrigations for various crops. In terms of actual inches of water required for a crop after rauni, this tells u nothing because irrigations vary in quantity applied during the season. Note the wide variations for the same crops reported by respondents.

There are many factors that the farmers need to know, such as consumptive use demand, leaching requirements, demand at various growth stages, monsoon rains in July and August, a winter rains. However, irrigation recommendations by researc stations and the Agriculture Department[69] are still, for the

[68] Roberts, op. cit, p. 160.

[69] See Joint Recommendations for Wheat Production in 1974-75, Agricultural Department, 1974, Lahore, pp. 2013. (Even num-ber of irrigations are given for high yield varieties of wheat.)

most part, given in numbers of irrigations as Roberts[70] did in the 1940's. This simply suggests that there is a critical need to devise some workable system to help farmers irrigate more efficiently. This suggests that a farm level irrigation advisor with proper technical training is needed. To our knowledge, there is no Urdu extension pamphlet available in Pakistan today which gives any guidelines as to how much, when, and how to irrigate crops.

CSU researchers, in cooperation with Pakistani Research Institutes and trials in farmers' fields, are conducting experiments to discover consumptive use of various crops in several ecological zones of Pakistan. Once these data are made available, the difficult task is to devise ways and means to train farmers. Farmers cannot be trained, even in elementary methods of determining how much water to apply to crops at certain growth stages, without on-farm water management advisors to provide continuing assistance.

How Deep Does Water Infiltrate and How Deep Do Roots Penetrate?

Do farmers have a clear concept of how far a certain depth of water will infiltrate into the soil profile? Farmers were asked to report their opinions or estimates as to "what depth would water penetrate if ponded on their fields during October-November 1974." The estimates given by the farmers are shown in Table XXII.

It is most interesting that 21 farmers, or 60 percent, reported depths of from 0.5 to 1.5 inches, only. Does this mean that farmers do not have a clear concept of moisture storage, or water passing through the root zone? No real problems related to hardpans were detected on the soils of this watercourse. Much more understanding of this general concept of farmers is needed because of its relation to practices of overirrigation, which not only may reduce crop yields, but also leads to waterlogging and salinity problems, as well as leaching of valuable nutrients.

In order to probe further, farmers were asked to estimate the depth of penetration of root systems for selected crops in their soils. The estimates in Table XXIII also provide interesting information and raise other questions. This implies that along with the farmers' concept that water infiltrates to only about 1.5 to 2.0 feet, root systems have also penetrated to very shallow depths. Generally, farmers have the idea that the cotton root system penetrates to a depth of 1 to 1.5 feet, berseem to only about 4 inches,

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[70]Roberts, op. cit. p. 156 (Average irrigations actually tell us or the farmers little because we don't know what an average irrigation is.)

Table XXI. Farmers' reports of usual and optimum irrigations for selected crops (U = usual and O = optimum).

Crops No. of Irrigs.	Cotton U	Cotton O	HYV wheat U	HYV wheat O	Local wheat U	Local wheat O	Maize fodder U	Maize fodder O	Oats U	Oats O	Berseem U	Berseem O	Rice U	Rice O
1-2	23	1	--	--	1	--	2	--	--	--	--	--	--	--
3-4	10	21	9	--	28	--	18	6	23	3	--	--	--	--
5-6	1	12	24	12	5	25	14	21	10	24	--	--	--	--
7-8	--	--	1	17	1	--	1	4	--	4	--	--	--	--
9-10	--	--	--	5	--	2	--	4	2	4	--	--	--	--
11-12	--	--	--	--	--	--	--	--	--	--	--	--	15	--
13-14	--	--	--	--	--	--	--	--	--	--	24	--	--	--
15-16	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17-18	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19-20	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20--	--	--	--	--	--	--	--	--	--	--	10	25	13	28
?/NR	1	1	1	1										
	35	35	35	35	35	35	35	35	35	35	35	35	7	7

Table XXII. Farmers' estimates of depth of penetration of water if five inches were ponded on their fields

Depth feet	Number reporting	Depth feet	Number reporting
0.5'	1	2.0'	6
1.0'	12	2.5'	2
1.25'	1	3.0'	2
1.50'	7	don't know	5

Table XXIII. Farmers' estimates of depth of root system penetration for selected crops.

Crops	<2.5"	3-4"	4.5>6.5"	7-12"	15-16"	24"	36"
Cotton	1	--	4	17	9	3	1
Berseem*	17	18	--	--	--	--	--
Sugarcane	1	5	16	11	2	--	--
Wheat	13	16	6	--	--	--	--
Rice	7	18	10	1	--	--	--

*Seven farmers reported 1-1.5 inches/ 8 reported 2.0 inches for berseem and for cotton 16 farmers reported only 12 inches depth. (Intervals above are groups as they are to save space.)

Table XXIV. Farmers responses to "When water is available how do you decide what particular field need irrigation?"

Rank	By date of last Irrigation	By appearance of soil Surface	By appearance of Plants	By Plant Size	God's will or Don't know
Most Important	11	14	9	1	--
Next Important	2	15	14	--	4

sugarcane to about 12 inches, and wheat along with rice to maximum depths of about 6 inches. Is it conceivable that farmers do not have a concept of overirrigation and losses of water and nitrogen by leaching through the root zone? Do, in fact, farmers have a concept of storage for moisture for crops with long and extensive root systems?

"When to Irrigate?"

How does a farmer decide to irrigate his fields? We have already described the physical constraints, but within these constraints the irrigator must decide on which crops he will apply water at a given time. Farmers were asked how they decide when a crop needs irrigation? Their reports are ranked "most important" and "next important", and are presented in Table XXIV.

Forty percent of the farmers reported "by the appearance of the soil surface," while 31 percent reported "by the date of the last irrigation." Twenty-six percent reported "appearance of plants." No farmer reported checking the subsoil for moisture. When questioned about judging from visual observation of the surface soil, several farmers replied "we know our soils." In asking what specific characteristics they observed from plants indicating stress, farmers were vague. When leaves begin to cup may be a safe indication for some crops such as cotton or maize, but for other crops it may indicate such stress as to approach the permanent wilting point. This area needs much more investigation before farmers can be taught field methods for estimating water needs of crops.[71] Some crop plants give good indications of moisture stress such as cotton and maize.

Farmers can be taught to check their soils by using the touch and feel system of moisture needs. The irrigation scheduling system can be used by farmers, but it must be technically correct and simply presented. The writers have found that farmers can learn to read moisture needs in cotton plants quite quickly. There may be indicator plants which can be used along with crop plants to give the farmer some rough idea of moisture deficiency. Also, in most soils of the Punjab, a 1/4 inch metal rod with a handle helps to determine depth of moisture when used as a probe.

[71]The senior investigator, in 12 years of work with farmers, has yet to find one case where a Government extension field worker had trained a farmer in field methods of estimating moisture needs of crop plants. This simply indicates the need for trained on-farm irrigation advisors.

Irrigations at Critical Stages of Growth

In an attempt to discover if farmers are aware of critical growth stages to apply water, they were shown pictures of four growth stages of cotton and asked to identify, by indicating the pictures, showing stages which needed "more", "less", "same" or "no" water. Farmers' reports are given in Table XXV.

Nine of the farmers made no distinction at all in the four stages and reported they would apply the same quantity of water for all stages. Sixty-three percent reported less water at the seedling stage and only 6 reported no need of water at stage IV. Most of the farmers would apply more water at stage III. At stage IV, when bolls are fully formed, additional water is not required; however, 9 famers (26 percent) reported applying the "same" and 10 would apply "most" at this stage and 10 would apply "less." Field observations over time confirm the fact that farmers continue to irrigate cotton long after the plant has matured, and often continue to irrigate up until November. Sometimes this is because berseem or "senji" has been intercropped with cotton; other farmers report it is because they irrigate for preparing the land for rabi crops; still others admit that they have no place to put the water so they apply it indiscriminately. Farmers on this watercourse often plug the mogha when there is no demand for water. Certainly, a better use could be found for this water by making changes in cropping patterns. Clyma and Corey[72] suggest that excess water can even be stored in improved village ponds where fish culture could be introduced, as well as having a reservoir for extra water during peak crop water demand periods, or when the canal supply is low or closed.

Farmers were further asked to give their ideas of the most critical irrigation for wheat after rauni. Sixteen, or 46 percent, reported "kor" or first irrigation; 5 reported all stages; 2 replied "don't know" or "God knows." Twelve reported the period just before, or just at, heading as the most critical for increased yields. Watenpaugh and Hussain[73] give this as the most important single irrigation. The "kor" irrigation is also critical because it provides some control for white ants which attack and destroy root systems, especially in light soils which are dry.

Recent data from experiments by CSU field staff and cooperators indicate that the first irrigation at 14 to 21 days after planting is the most critical irrigation for

[72]Clyma and Corey, op. cit.

[73]Watenpaugh, Howard and Hussain, Mohd. Crop and Irrigation Guide for Pakistan Punjab Area, Directorate of Land Reclamation, Mughal Pura, Lahore, April 30, 1966, Appendix.

Table XXV. Farmers' report of when cotton requires "more", "less", "same" or "no" water for four growth stages.

Responses	Stage I Seedling	Stage II First flower	Stage III Full flowering some bolls (peak)	Stage IV Bolls fully formed (cut-out)
"Same" all stages	9	9	9	9
"Less" than other stages	22	13	--	10
"Most" water	4	13	26	10
"No" water	--	--	--	6
Total	35	35	35	35

Table XXVI. Farmers' reports of major farm problems.

Type of problem	Most important	Second important	Third important	Total
Water	30	2	3	35
Fertilizer price	1	18	4	23
Credit fertilizer	-	1	3	4
Non-available good seed	-	2	8	10
Lack of plant protection	-	2	6	8
Lack of extension	-	1	-	1
Problems in getting tractors	1	5	3	9
Lack of land	1	-	-	1
No response	2	3	8	13
Total	35	35	35	105

Pakistan conditions. The second most important is at the time of grain filling.

"How Do You Decide to Stop an Irrigation?"

Farmers were asked how they decide when to close the nakka (field outlet) for a given irrigation on their fields. Sixteen, or 46 percent, of the farmers reported, "when water covers all the high spots"; and 16 reported, "when water reaches the far border." Only 3 reported "when a few marlas[74] are left to irrigate."

Farmers reported that they stop the water before it completely reaches the far border only when fields are level. Evidently, the major ways farmers decide to complete an irrigation is when all high spots are covered and water is completely ponded within the borders. Sitting with farmers while fields were being irrigated, one is amazed at their patience in waiting for the small volume of water to reach the fields and the energy expended in using a cussie[75] to coax the water onto and over high spots. While the farmers were irrigating, they were often busy trying to level their fields with the cussie. Some farmers were busy in checking leaks where other nakkas had been closed. Until one has actually sat with farmers to wait for the water to finally arrive from the jalar after about two hours, and observe an irrigation of an acre requiring more than five hours, he cannot appreciate the efforts of the farmer as he attempts to utilize this extremely low discharge rate of water.

Farmers' Perceptions of Major Problems

Farmers were asked to report their major farm problems. Table XXVI summarizes their responses. Their reports show that "water" is given by 30 of 35 farmers as the most important problem. Since the watercourse survey focused primarily on water problems, this could have influenced their responses. However, a study of the physical problems related to this jalar system of irrigation suggests that in fact it is a major problem. Farmers throughout the two months talked about many problems, but water was foremost in their conversations, especially the extra costs of time and labor for jalars and the small volume of water which required long periods to reach a field and irrigate an acre. The second most important problem reported was the price of fertilizer and the third was nonavailability of good seed, especially wheat seed.

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[74] A marla is 1/160 acre--one reported 1-2 marlas, 2 reported a few marlas and 5 marlas. On another watercourse, farmers reported so many stool lengths. A small stool about 2 feet wide is used for sitting near the hearth and it is used as a measure.

[75] "Cussie" is the shovel-like hand implement shaped like a digging tool.

two farmers. Farmers reported that they could not get extension personnel to come to spray their crops and that insecticides "are too expensive." Rice, maize and sugarcane borers were detected on several fields.

Seed

The same situation prevails in regard to wheat and rice seed of a known quality. Farmers generally provide their own seed. They complain that good hybrid maize and berseem seed are usually not available in the markets and that seed is generally inferior.

Institutional Sources of Credit

No institutional credit is available for insectices, seed, or tubewell water, though five farmers did receive loans for fertilizer; four farmers have applied for tractor loans, but state that the procedure is very complicated, long, and "costly." Only four farmers know the names of any bank personnel and these are the four who are trying to get loans sanctioned for tractors. The usual major sources of credit for farmers are relatives and friends. Several studies in the Punjab have shown that institutional credit with supervision is greatly needed for both short and long terms, especially short term loans.[78] Such a program is now in its initial stages through the bank system of Pakistan. This emphasis on rural banks and agricultural programs is a positive aspect of the nationalization of banks and, if successful, can become an effective instrument to help farmers improve their production possibilities.

Given the time constraints for this preliminary exploratory study, it was impossible to place more focus on inputs and credit services. Much attention should be given to labor and other inputs so as to arrive at the present costs of production for major crops in Pakistan. Although very necessary now that price structures have changed, this would require a separate and more intensive effort.

Comment

A set of nontraditional inputs should also be examined. These include the impact of agricultural research programs at the farm level, along with vehicles for technology transfer to farmers. These and other institutional inputs farmers cannot provide for themselves. Their importance cannot be

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[78]Lowdermilk, op. cit., pp. 270-276, Eckert, Jerry B., "Fertilizer Practices Among Growers of Dwarf Wheat in Pakistan's Punjab." Discussion Paper, Lahore, Pakistan. The Ford Foundation, September 1968, pp. 7-10 (mimeographed).

minimized in any planned strategies for change, especially in on-farm water management. Improvements might be carried out even with compulsion, but to sustain a program and to assure maintenance of watercourses, etc., requires farmer participation. Given this cavet, one focus of this initial study was to examine the on-farm activities of the extension service and to discover farmers' levels of management knowledge for certain critical practices. Also, a brief section will follow on farmers' present adoption behaviors. Following this, the reported yields of selected crops will be presented, which may supply evidence of why farmers are not increasing their yields.

FARMERS' KNOWLEDGE OF INSTITUTIONAL SERVICES AND CONTACTS WITH PERSONNEL

A simple technique was used to ascertain farmers' knowledge of personnel from agencies established to assist them. The names of existing personnel were made available, their period of service in the area, locations of their offices, and residences. Each farmer was asked to give the name of the worker.[79]

Table XXVII shows the number of farmers who had knowledge of the officials, as well as contacts with them over the last three month period. It is obvious from this information that farmers not only for the most part had no contact with workers other than the patwari, but most farmers had no idea of who the appointed worker was, or his name. Twenty-three of the 35 farmers could give the name of the patwari because he is an individual in the village with influence, as described earlier. The Agricultural Assistant and the Field Assistant were not seen on the watercourse during the investigation and the Development Assistant came only a few times to make a courtesy call to the outsiders, but not to advise the farmers. Farmers often complained that they have no one to provide them the advice and services they need. The few contacts the AA, FA, and DA made in the three month period, according to the farmers, were with two or three farmers. As an investigation by Mohammad Ilyas reported in the Pakistan Times entitled, "An Inquiry Into The Workings Of IRDP I and II," on July 12-13, 1975, revealed workers are seldom if ever in the fields with farmers for the most part. Of course, bank officials other than field workers and fertilizer agents are not expected to advise farmers in the field, but nevertheless farmers knew more about them and had more contacts with them than with the AA or FA of the Agriculture Department.

This situation is quite evident among those who know farmers and interact with them in the Punjab. A very intensive study by Lowdermilk[80] in 1970 with 350 farmers from 35 villages in Khanwal Tehsil (Multan District) revealed the same problem. An examination of field workers' training, technical support facilities, morale, supervision, knowledge and approaches with farmers is documented in the same study.

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[79] If a Government worker had recently been reposted, the name of the previous worker was accepted.

[80] Lowdermilk, op. cit. pp. 244-282 and Appendix on "Extension System of Khanwal Tehsil." In 1970, 81 percent of the farmers had no contact with extension staff in six months prior to the study. Seventy-five percent did not know the Field Assistant's (FA) name; 49 percent did not know his office-residence location; 40 percent did not know the Agricultural Assistant's name and 69 percent did not know his office location.

Table XXVII. Farmers' knowledge of and contacts with agricultural personnel.

Official or Department	Knows official's name or someone in Agency Office by number	Number of contacts in period of last three months			
		None	1-2	3-4	5
Agricultural assistant	1	34	3	___	___
Field assistant	2	34	1	___	___
Development assistant	8	27	5	2	1
Bank	4	31	3	___	1
Co-Operative department	1	34	1	___	___
Fertilizer store	9	26	6	___	___
Canal Patwari	23	12	___	2	2
Canal Zilladar	___	35	___	___	___
Overseer (canal)	___	35	___	___	___
Sub-Divisional Officer (canal)	___	35	___	___	___

The lack of well-trained farm-level advisors dedicated to agricultural improvements is perhaps one of the most critical problems in the Agricultural Sector today. The problem is complex and there are no simple short-term solutions. To blame workers, or the Department, is simplistic and naive. Essentially, this is an institutional problem with roots in the past and to begin providing advisory services which farmers need will require institutional reorganization and intensive training of field staff and their supervisors. Agricultural Research Institutes, Educational Centers and the Agriculture Department must combine to develop a system of knowledge transfer to farmers. The vehicles for transfer fo the most part represent human capital that must be developed for the task of bringing technology and information to farmers in order to assist them in improving production possibilities. Perhaps, the most important factor in on-farm wate management improvements for increased production will be the extension factor. Evidence indicates that farmers must have this service and that they are ready. Farmers on their own, under conditions of traditional agriculture, tend to reach a certain level in the art simply on a trial-and-error basis. However, given the complex interactions of many traditional and nontraditional factors of production required for modern agriculture, the farmer needs assistance in decision-making. A continuous stream of new ideas and innovations must be brought to the lonely man behind the plow if he is to change his behavior. It is sheer fantasy to expect that the results of research in on-farm water management, or any research findings, will simply deliver themselves to the farmer client

Farmers' Management Knowledge

As described previously, farmers have little knowledge of when and how much to irrigate, infiltration of water in soil, or depth of root system penetration. A simple management knowledge test of several recommended practices for hig yielding wheat varieties was administered to farmers. This same test utilizing forced choice techniques was administered to 350 farmers in a 1970 sample survey.[81] Of the 35 farmers, 7 percent reported the recommended seed rate of 1 maund per acre; 69 percent reported the recommended seeding method of drill, "keria" or "pora";[82] 63 percent reported the recommended nitrogen rate of 2 bags of urea or more when wheat follows fallow on medium fertile soils; only 63 percent coul give the proper amount of phosphate fertilizer to apply; and 46 percent reported the correct seeding depth.

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[81] Lowdermilk, Max K., op. cit., pp. 320-321. The farmer's levels of management knowledge for these practices are sim lar to those of the present study. However, there is a fo year time period between the two surveys. This may indica that knowledge transfer systems for farmers are very weak.

[82] "Keria" and "pora" are two improved traditional methods of seeding crops which are superior to broadcast methods.

This indicates that farmers need knowledge and the correct knowledge will help them reduce risks. After about 10 years of experience by the senior investigator with the high yielding wheat varieties, it can be stated that both knowledge and practice are poor. And more focus has been given to the new wheat than any other single crop in Pakistan; thus, the reader must draw his own conclusions.

Farmers' Adoption Behavior

Given the information and comments presented, some understanding of the present level of adoption of various innovations was attempted. Nine agricultural innovations were selected, which the Punjab Agriculture Department workers in the area are supposed to diffuse among farmers. Three new high yielding grain varieties were chosen, which were introduced in 1971. Six practices were selected which the Department has recommended in the Punjab for at least 25 years (i.e., row planting of cotton, line planting of rice, insecticides for rice and cotton, use of rabi wheat drill, and use of phosphorus). Table XXVIII shows the numbers and percentages of the 35 farmers who have put the practices to trial and how have adopted such practices into their farm operations.

Given the one exception of cotton, which is only cultivated in a few acres for home use, the reports of farmers as indicated in Table XXIX (except for wheat and use of phosphorous fertilizer) are extremely low. About half the farmers cultivate Mexi-Pak variety wheat, which was not included. This information speaks for itself and indicates that farmers are not only years behind in irrigation practices, but other practices as well.

Further investigation revealed that farmers are using the following practices: about 60 percent use some high yielding wheat variety; 29 percent use improved seedbed preparation for wheat (deep plowing); 29 percent seed wheat with keria,[83] pora[84] or drill; 17 percent reported they would use at least 2 bags (101 lbs. N) urea for the 1974-75 wheat crop; about 80 percent will use 1 bag of urea for 1974-75 wheat crop; only 8 percent reported they would use split applications of nitrogen for wheat; and, probably influenced by the interviews, 46 percent reported they would now use at least 1 bag of DAP for rabi wheat just being seeded at the end of the investigation. These reports are also not encouraging.

Farmers were also asked about their use of several other practices to judge the level of technology presently being used. They reported the following rates of uses of the

[83]Keria is the practice of making a furrow with a small local plow and hand seeding.
[84]Pora is dropping seed into a long funnel mounted behind a small local plow.

Table XXVIII. Trial and adoption of nine selected innovations by 35 farmers.

Innovation	Trial: No. of farmers who tried	Trial: % who tried	Adopted: No. of farmers who adopted	Adopted: % of farmers who adopted
1. Chenab 70 wheat	18	51	13	37
2. S.A. 42 wheat	12	34	27	20
3. Irri-Pak rice	3	9	2	6
4. Cotton row planting	2	6	1	3
5. Rice line planting	1	3	--	--
6. Insecticides for cotton	3	9	1	3
7. Insecticides for rice	6	17	1	3
8. Use of phospherous fertilizer	14	40	8	23
9. Use of Rabi wheat drill	3	9	3	9

Table XXIX. Utilization of purchased fertilizer inpputs by farmers/killa* for wheat, rice and fodder crops by farm size in bags applied.

Farm size class (acres)	No. of farmers	None			1 bag Urea**			2 bags Urea			1 bag DAP***		
		Wheat	Rice	Fodder	Wheat	Rice	Fodder	Wheat	Rice	Fodder	Wheat	Rice	Fodder
< 10	13	2	4	11	11	19	2	0	0	0	0	0	0
10 ≤ 25	14	1	0	11	11	12	3	2	1	0	0	0	0
25 > 50	8	0	1	3	6	5	5	2	2	0	0	0	0
Total No. Farmers	35	3	3	25	28	26	10	4	3	0	0	0	0

* Killa is 1.1 acre.

** Urea, brand name. "Baber sher" company daud-Hercules. Weight 50 kilos 46% N or 50.6 lbs. of actual N.

*** DAP is di-ammonian phosphate--contains 50.6 lbs. of P_2O_5 and about 20 lbs. of N.

following items: use of Raja steel plow--46 percent; use of bullock cultivator--17 percent; some use of tractor for cultivation (usually hired)--66 percent; rental of tractor for trolling for market business--43 percent; use of wheat thresher--9 percent; use of tractor for leveling (rear blade)--20 percent; own rubber tire bullock cart--57 percent; and own bullock powered fodder chopper--23 percent.

Farmers are finding some of these innovations useful, such as the tractor for cultivation, and taking fodder to market, and the improved bullock cart for marketing purposes. All farmers have either a hand-powered or bullock-powered fodder chopper, since fodder is a major crop. As many as 50 percent of the farmers also use high yielding wheat varieties, nitrogen fertilizer, and the mound board plow. Other than these innovations the use of others is still at a low level. It is difficult to know why adoption levels are still low. Usually, adoption rates are related to a number of characteristics unique to particular innovations such as profitability, overall advantage, divisibility, complexity, congruence with other practices and technical soundness, also labor saving visibility, and ease of communication are important factors. Very few innovations meet most of these criteria; the high yielding wheat varieties are one exception. Most technologies are more complex, and the "package approach" increases the complexities, due to the interdependence and interactions of several components. Improved water management innovations tend to be complex in the sense that a systems approach is a requisite. As well, many on-farm water management improvements are of a collective nature because canal water is a public good. Intensive extension efforts are therefore required to organize and train farmers.

Farmers have to see benefits demonstrated by other farmers to be worthy of acceptance. Experience indicates that at best a 25 to 50 percent increase in yields is necessary. Given a well designed package for most crops, at least a 100 percent yield increase can be demonstrated, and with the high yielding varieties, as much as 200 percent. It is well known that one factor, or input, alone, will seldom demonstrate radical yield increases, and for the most part, agricultural innovations have been introduced in the Punjab one at a time. The package approach is new and to date few researchers have used team approaches to design packages which show radical yield increases. As well, the vehicles of transfer to farmers are weak and workers do not yet know how to help farmers implement package approaches.

Constraints, such as credit and capital, are also related to adoption. All innovations were included in an index and levels of adoption by the farmer are shown in Table XXX with three farm size classes. As expected, larger farmers received the highest scores because capital is a constraint to the adoption of many innovations listed earlier. This indicates that more efforts are needed to assist smaller farmers.

Table XXX. Adoption index and farm size classes installed.*

Farm size class (acres)	Number of farmers	Mean score	Median score	Range of score
≤ 10	13	6.77	6.5	2-11
10 ≤ 25	14	10.43	10.0	6-15
25 ≤ 50	8	12.25	13.0	8-18
Total	35	9.51	9.0	2-18

*An adoption index using separate and often unrelated innovations provides little information, because each innovation is often uniquely different. Either each innovation should be studied separately, or a package of interrelated practices should be analyzed as a unit.

Table XXXI. Farmers' radio listening preferences.

Types of programs	First choice	Second choice	Third choice	Total
Musical	3	5	2	10
Drama/Poetry	2	1	-	3
Farm program	13	10	3	26
World News	2	5	6	13
Local News	1	2	13	16
Religious	9	7	4	20
None	5	5	7	17
Respondents	35	35	35	105

Effective Sources of Information for Farmers

Given the limitations of the present on-farm advisory services for farmers on this watercourse, there are few effective links for agricultural information. In recent years, there has been a rapid diffusion of the transistor radio,[85] which can be utilized as a channel for some types of information. Fifteen of the 35 farmers interviewed own radios and 22 report listening to programs up to 30 minutes during the previous week. Twelve of these farmers report listening for single 30 minute periods, or more, from 3 to 7 days a week. Sixteen farmers heard the farm radio program from Radio Lahore one or more times during the previous week. Nineteen farmers could report the approximate time of the program aired each day at 18:45 hours, and several could describe the details of the programs heard.

Farmers were asked to rank their radio listening preferences and Table XXXI shows that the farm radio program, religious programs, and local news are the most preferred programs.

It must be remembered, though, that the mass media radio, while being rather widespread and low cost in terms of dissemination of information, is primarily effective in making farmers aware and interested. Radio is much less effective in convincing farmers to put innovations to trial, or helping them to evaluate alternative practices for complete adoption. Farmers need advisors at the farm level for these stages of the adoption processes to assure that farmers move from awareness, interact in new practices, and are able to evaluate such practices in order to make decisions about moving from trial to final adaption.

In most villages, there are not only influentials resulting from large holdings, political connections and good linkages with officials, there are also certain individuals who can be termed "information receivers." Sometimes, such persons are the village shopkeepers, market middlemen, or others who have a propensity to know the latest news. There are also some who gain prestige by being "information senders"

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[85]See Lowdermilk, op. cit. pp. 70-71 as to importance of radio in the diffusion of dwarf wheat in 1970. In the future, television should not be overlooked as a media in rural areas. Near the cities of Lahore, Sargodha, Rawalpindi, Multan, etc., many TV sets are being adopted by larger landlords. Even city viewers have interests in their lands and the two-step communication theory should not be discounted (i.e., a viewer or listener receives a message and further passes it through his personal communication network to countless others).

or "local radios." This indicates the importance of utilizing modern channels of communication. This is known in communication theory as the two-step model,[86] where messages are received by an individual and passed on to others.

Very few farmers read newspapers. Of the 35 farmers interviewed, only 4 reported "sometimes purchasing newspapers" and of these only one had read a newspaper in the last week. Carefully designed printed extension materials for water management could become useful, but such efforts are now only in the initial stages in the Punjab. This has been discussed in detail by Lowdermilk[87] in 1970. The major problem may be the lack of training or imagination in the preparation of extension material for farmer audiences. Also, a lack of understanding of its importances as an extension tool, or lack of funds, may be problems to examine. In a nation that must depend so much on the efforts of millions of widely spread farmers, it is a paradox that both research and publications of research findings for farmers is given such low priority. Relevant agricultural knowledge is essential to farmers for decreasing their risks and improving production possibilities. Systems to bring developmental knowledge for farmers is sometimes neglected in planning for agricultural programs.

Another source of ideas and information for farmers is travel and contacts with the urban influences of town and city.

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[86]Lowdermilk, op. cit. pp. 69-71, 159-160, and 368-369.

[87]Lowdermilk, op. cit. pp. 200-201; 230-233; 392. This also gives a resume of other researches. Also see pp. 432-433 where data is provided for 1970 to show the meager supply of Agricultural Department publications for farmers. Funds were provided the Bureau of Agricultural Information for only 13,000 copies of the Ziariat Nama for the Punjab and for only 1,000 copies of the Journal of Agricultural Research. One could estimate how much impact these publications would have for a total of about two million farms in the Punjab alone. One must never be misled by those who think that "ignorant" illiterate farmers do not "read". Though illiteracy in the rural areas may be 85 percent, or more, even illiterate farmers (certainly not ignorant) benefit from printed materials through those in their households who do read. With the spread of education, literate sons and daughters read for illiterate parents. For an example, on the watercourse 77 persons have completed primary level, 40 have completed middle, 26 have completed matric or high school and 13 are enrolled or have been in colleges. If printed extension material were made available it would have a great impact on the farmers of this watercourse. Extension materials should be carefully designed to meet the primary need of increasing levels of living through increased per acre yields.

A number of studies[88] have shown the importance of urban contact and exposure; in fact this is one positive aspect of a strong road-building program in development. Farmers on the watercourse travel frequently to Lahore City and market places. Farmers were asked how often they traveled to Lahore in the previous three month period. Four reported going daily to deliver milk; 3 go twice a week; 4 go weekly; 7 reported trips twice a month; and 15 report about one trip a month. Two farmers report "many trips" per three months! Actually, over 30 percent report trips at least weekly and over 50 percent travel at least twice a month. Most farmers on this watercourse do travel frequently by bus and tractor to the urban areas.

[88]Discussed in Lowdermilk, op. cit. pp. 68-69, 194, 223, 277 and 284-285.

Appendix I

Estimated operation of jalars/month out of four possible turns/month.

Punjabi month	Corresponding English date	Estimated times used per month of 4 turns	Description of needs to operate
PO (1-30)	Dec.16-Jan.13	1/4	Depends on winter rain sowing rate wheat, oats.
MAG (1-28)	Jan.14-Feb.11	1/4	Little demand usually most don't operate nights.
PUGGIN(1-30)	Feb.12-Mar.13	1 1/2/4	Wheat needs more water operate jalars daytime not nights
JET (1-30)	Mar.14-April 12	2/4	Temp. increase-demand wheat irrigation increases at heading stage. Berseem also needs more water. Day operation.
Besahk(1-31)	April 13-May 13	2/4	Begra-maize pre-irrigation and wheat day operation
Jhet (1-32)	May 14-June 14	4/4	Pre-irrigation, cotton, maize, jowar, bajin, temp. increase
Hard (1-31)	June 15-July 15	4/4	Depends on monsoon rains, need water-start rice, berseem needs more water
Sawan (1-32)	July 16-Aug.16	4/4	Rice; berseem; fodder demands
Baidon(1-31)	Aug.17-Sept.16	4/4	Rice demands
A'su (1-30)	Sept.17-Oct.16	4/4	Rice demands
Ketan (1-30)	Oct.17-Nov.15	4/4	Pre. irrig. early wheat, oats, winter veg. sow berseem
Mager (1-30)	Nov.16-Dec.15	4/4	Pre. irrig. rauni for wheat - oats still sow berseem

Variables to consider in jalar operation	Rainfall, level of water in canal systems pre irrigation periods, temperature increase and decrease, peak demand periods for crops.

APPENDIX II

Distribution of culturable commanded area by outlet type and province in Pakistan.[1]

	Systems serving only perennial outlets	Systems serving only non-perennial outlets	Systems serving both types of outlets	Total
Punjab				
Outlets	7,647	11,021	29,402	48,070
Acreage	3,226,616	3,653,941	12,769,214	19,649,711
Ac./outlet	421.9	331.5	434.3	408.8
Sind				
Outlets	17,490	11,469	1,239	49,998
Acreage	3,631,963	2,817,806	603,741	12,053,510
Ac./outlet	493.5	250.0	487.3	401.8
Pakistan				
Outlets	25,137	22,290	30,641	78,068
Acreage	11,858,579	6,471,747	13,372,955	31,703,221
Ac./outlet	471.8	290.3	436.4	406.1

Total commanded culturable irrigated area is 31.7 million acres, divided among 78,068 watercourses for an average of just over 406 acres per watercourse. Four hundred seems a good working approximation.

Since average farm size is ten acres, one can assume that the watercourse unit averages 40 farms. Since farm households average 6.85 perso total farm population is 275. An additional 31 percent of rural populat is engaged in such occupations as landless laborers, shopkeepers and artisans. Total population within the watercourse is thus 395 persons, approximately one person for every culturable commanded acre.

Since villages average 1200 people they must average 3 watercourses. So organizational unit can be watercourse (40 farms) or village (120 far plus 3 watercourses).

Dr. Jerry Eckert's estimate of private tubewells in Punjab and all Pakis (compiled from a variety of sources).

Punjab

1954-55	1,216	1964-65	28,746
1955-56	1,495	1965-66	36,217
1956-57	1,893	1966-67	44,888
1957-58	2,108	1967-68	54,930
1958-59	3,184	1968-69	63,891
1959-60	4,084	1969-70	72,852
1960-61	6,767	1970-71	81,814
1961-62	9,619	1971-72	90,456
1962-63	15,258	1962-73	99,025
1963-64	21,776		

Pakistan

1954-55	1,300	1964-65	34,400
1955-56	1,600	1965-66	43,500
1956-57	1,900	1966-67	52,872
1957-58	2,200	1967-68	65,336
1958-59	3,300	1968-69	75,720
1959-60	4,600	1969-70	85,729
1960-61	8,000	1970-71	94,638
1961-62	13,000		
1962-63	18,400		
1963-64	25,000		

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APPENDIX III

GLOSSARY OF URDU TERMS

Abiana - Canal water rates

Bajra - Spiked millet

Baraderi - Brotherhood or kinship system

Beldar - A laborer employed by the Canal Department for upkeep of roads and canals

Berseem - Egyptain clover, a fodder crop

Cussie - Shovel-like digging tool farmers use

Dab - System practiced in connection with seedbed preparation of wheat for controlling early rabi weeds

Faslana - The traditional payment to the Patwari and other canal workers for services rendered

Halqa - An area of several villages

Islamayat - Subject of Islamic religion taught in schools and colleges

Izzat - Pride

Jalar, Jalari - Form of Persian wheel used for lifting water from shallow depth

Jowar - Andropogan - Sorghum

Karah - An implement used by two teams of bullocks and used for leveling land

Karabu - Remission of land revenue and water rates for crop failures

Karam - Measure of distance, two paces

Kharif - Monsoon or summer crop

Kiara - A compartment of a field for irrigation purposes

Killa - An acre

Kor - First watering after sowing

Kullah Vattar - Moist seedbed

Mangi - To request - a custom of requesting others to give assistance in farming activities

Marla - 1/160 of an acre

Maulvi - Religious leader

Maund - 82-2/7 lbs.

Nakka - The field inlet opening for irrigating basins

Numbardar - Government appointed local official of villages

Panchayat - Former council of village elders for village decision-making and settling of disputes

Patwari - Village revenue or irrigation subordinate, a village accountant or registrar

Phar - Period of 3 hours

Pora - Method of sowing seed with a funnel-shaped seed tube attached behind the plough

Pucca - Masonry, Metalled, ripe

Rauni - Water applied shortly before sowing

Robi - Winter crops

Seri - A Punjabi term which refers to individuals forming partnerships for specific tasks

Wandara - Clockman who keeps irrigation turn times

Wangor - A local custom of trading work

Warashikni - Taking water out of turn

Warabundi - The rotation system of irrigation turns

Zamin - Land