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FARM IRRIGATION CONSTRAINTS AND FARMERS' RESPONSES: COMPREHENSIVE FIELD SURVEY IN PAKISTAN

By David M. Freeman,
Max K. Lowdermilk and
Alan C. Early

Water Management Research Project
Colorado State University
Fort Collins, Colorado
September 1978

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VOLUME V
FARMER RESPONSES TO MAJOR CONSTRAINTS:
VIABLE OPTIONS UNDER PRESENT CONDITIONS

Prepared under support of
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Water and Power Development Authority
Lahore, Pakistan

Prepared by

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Water Management Research Project
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Special Technical Report Institutional Framework for Improved On-Farm Water Management in Pakistan	Water Management Research Project Staff	3.00

ABSTRACT

Preceding volumes have demonstrated that sample farmers are severely constrained as they attempt to combine water with other factors of production to produce agricultural products. Water deliveries are capricious in both quantity and timing, lack of adequate land leveling makes for simultaneous under and overirrigation in the same basin, important inputs are frequently unavailable to many smaller owner-operators, the extension service fails to provide accurate information on a timely basis, the Irrigation Department rarely informs farmers of its decisions affecting water supplies on canal commands. There is plethora of regulation but little consistent enforcement. Organizations necessary to mobilize farmer efforts for local community improvement purposes are absent, polarizing conflicts and asymmetrical power distributions frequently constrain cooperation for betterment of local conditions. Nevertheless, farmers do exert themselves within these constraints to produce as much as they can. How they cope, the options farmers exercise to gain control over their erratic water supply, is the focus of the first chapter.

The problems of irrigated agriculture in Pakistan do lend themselves to alternative solutions. Chapter 2 discusses potential alternatives to secure additional irrigation supplies and to increase crop productivity through watercourse improvement, the leveling of fields and the adoption of agronomic practices congruent with the requirements of the high yielding varieties of seed.

Water Management Research Project
Engineering Research Center
303/491-8216

Colorado State University
Fort Collins, Colorado
80523

September 11, 1978

Mr. Mian Mohammad Ashraf
Chief Engineer
Master Planning and Review Division
Water and Power Development Authority
Lahore, Pakistan

Dear Mr. Ashraf:

We are transmitting herewith our final reports in six volumes on the watercourse survey entitled "Farm Irrigation Constraints and Farmers' Responses: Comprehensive Field Survey in Pakistan." These volumes represent a tremendous amount of work by your organization, the U.S. Agency for International Development and Colorado State University. We have enjoyed the long standing working relationship and diligent efforts of your staff in completing this task.

As you are well aware, numerous members of your staff participated in the field data collection program report in these six volumes. At the same time, our field staff in Pakistan has spent numerous man-months in cooperatively accomplishing the field work and some of the initial data analysis. Most of the analysis has been done on the campus of Colorado State University in Fort Collins. Besides the authors of these reports, numerous university staff members have participated in the data reduction and analysis, as well as drafting the preparation of tables.

This study has consumed tremendous resources of this project, but we have felt the effort was worthwhile. Hopefully, your staff will also feel proud of this particular effort.

We sincerely appreciate your leadership in facilitating the completion of this effort and we look forward to continued cooperation in seeking to improve on-farm water management in Pakistan.

Sincerely,

Gaylord V. Skogerboe
Project Codirector

John O. Reuss
Chief of Party

W. Doral Kemper
Project Codirector

UF-86

PAKISTAN

Water And Power Development Authority

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MASTER PLANNING & REVIEW DIVN,

251-A NEW MUSLIM TOWN, LAHORE.

No. M/CE/S&R/Works/1W-WCS/6702

Date September 24, 1978

Mr. Mohiuddin Khan,
General Manager,
MP&RD., WAPDA,
WAPDA House, LAHORE

Subject: Report on "Farm Irrigation Constraints and Farmers' Responses".

I have the honour to transmit herewith the final report of comprehensive field survey carried out on 40 sample water-courses in Pakistan, jointly by Survey and Research Organization, WAPDA and Colorado State University. The survey work was under-taken under the provision of the Agreement No. 704-76-1 dated Nov. 7, 1975 signed between the Government of Pakistan & USAID.

The report presented under the title, "Farm Irrigation Constraints and Farmers' Responses: Comprehensive Field Survey in Pakistan" spreads over six volumes and is in fact a continuation of research work at Mona Reclamation Experimental Project on a wider area covering the entire irrigated area of Indus plains. The findings of this report further elaborate the new strategy that along with the development of present water resources, the prevailing wasteful irrigation practices beyond the outlet must be improved. This report contributes towards highlighting the social constraints in the field of water management thus providing sound guidelines for future planners.

Contd../2.

It would not be out of place to mention that this survey made useful contribution in providing guidelines for the main Watercourse Chak Farming Survey Project to organize its activities in addition to providing trained staff and necessary equipment.

Nevertheless I wish to place on record my appreciation and thanks for CSU Field Party as well as Campus Staff, U.S. Agency for International Development who provided funds for this study and the staff of Watercourse Chak Farming Survey Project who made this monumental task a reality. I avail this opportunity to express my thanks for the interest and valuable guidelines provided by you from time to time without which it would have not been possible to accomplish this arduous task.

24-9-78

(Mohammad Ashraf)
Chief Engineer,
Survey & Research Organization

ACKNOWLEDGEMENTS

Initiating, conducting, analyzing and reporting results of a field study of this size requires the skill and active cooperation of a large number of individuals. It is estimated that more than 30 man-years of planning, training, field work, data reduction, analysis, drafting and reporting have been contributed by Pakistani cooperators with the Water and Power Development Authority, Pakistani staff of Colorado State University in Lahore, part time staff of Colorado State University in Fort Collins, and Colorado State University principal investigators.

The authors wish to acknowledge the financial support of the United States Agency for International Development,[1/] the cooperation of the WAPDA Master Planning and Review Division, Chief Engineer Mian Moh'd Ashraf, and Director of Watercourse Studies Chaudhry Rehmat Ali, the patience and endurance of the CSU Water Management Field Research Team in Pakistan and in Fort Collins, and Wayne Clyma, who helped initiate the original study of a single village near Lahore which ultimately led to this survey.

Special thanks is due to Waryam Ali Mohsin who helped throughout the survey from selection of personnel through data reduction and who inspired everyone associated with the survey to higher pursuits and greater efforts. The initial field team members who became supervisors in the later phase Allah Bakhsh Sufi, Abdul Rehman, Barkat Ali Khan and Nazir Ahmad, plus Zahid Sayeed Khan, Peter Joseph and A. R. Bhatti are due a special thanks for all their long hours of work put forth in

1/The study was conducted with resources provided under Colorado State University contract with the United States Agency for International Development, Contract No. AID/ta-C-1411, supplemented by a USAID rupee grant--Watercourse Survey 204-87-1.

the cause. David A. Lauer deserves special mention for his substantial assistance in coding of the data and with establishment of a system for data management. Gail Woods and James Layton have contributed substantially to this report by virtue of their willingness to render additional assistance. In addition, we extend our deepest appreciation to all of those unnamed Pakistani farmers who so willingly gave of their time and energy to make this research effort possible.

We gratefully acknowledge the helpful review comments submitted by WAPDA personnel, Dr. John Reuss of the CSU Field Party, Dr. Michael Cernea of the Rural Development Division of the World Bank, and Mr. Ken Lyvers of USAID/Pakistan. The authors, of course, accept full responsibility for any errors of fact or interpretation.

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Mohammed Hanif Balouch
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Mohammed Aslam Bashir
Ali Mohammed
Latif Ali Khokker
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Nazir Ahmad Khan
Mr. Ramzan
Mohammed Arshad A. Razzaq

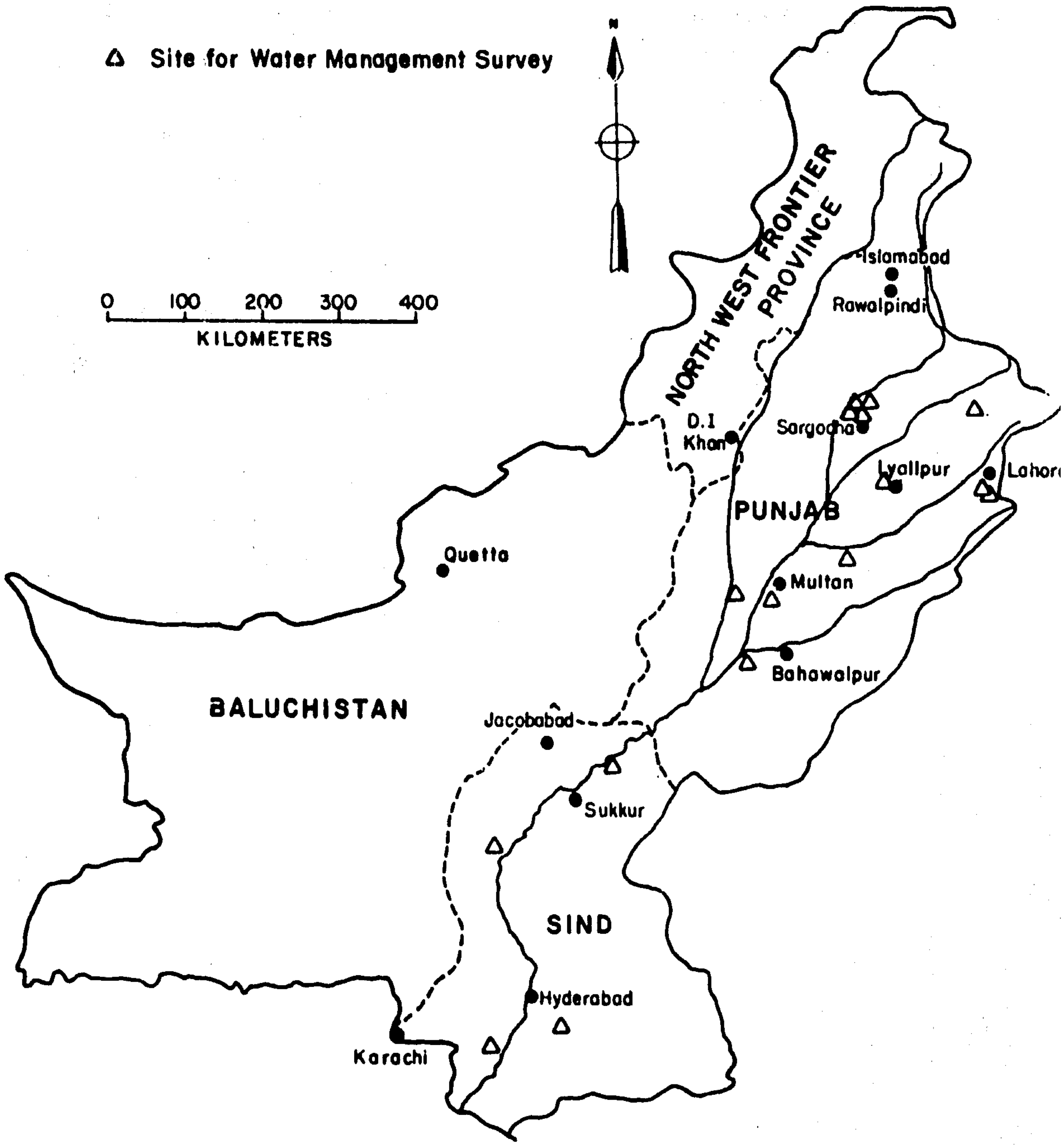

Figure 1. Distribution of 16 field survey sites.

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CHAPTER ONE

THE EXERCISE OF EXISTING OPTIONS

I. WATER CONTROL OPTION 1: WATER PURCHASING AND TRADING

Trading and purchasing of irrigation water is illegal without the express permission of the Superintending Canal Officer (Canal and Drainage Act, 1974:22). Yet, in their attempt to gain control over water timing and supplies, approximately 63 percent of the sample farmers indicated that irrigation water is available from others at times beyond their regular warabundi turn. Table 1 summarizes several sample farmer illegal transactions with canal water--all designed to expand the farmer's minimal control over water supplies. Each of the items listed in the left column of Table 1 is expressly forbidden by law and farmers are uniformly aware of their illegality. Yet, when asked about the nature of their trading patterns, the majority of farmers (51.7%) indicate they will trade water with anyone topographically situated so as to make trades feasible without suffering substantial losses of water in filling ditches. Table 1 shows that slightly more than an additional third of the respondents will trade water but will limit their exchanges to brotherhood (biradari) members. Only about 13% report no trading activities (see Table 2).

Across the overall sample, the propensity to trade partial and full irrigation turns is significantly related to increasing farm size. Tables 3, 4 and 5 reveal that larger farmers tend to trade more than do smaller operators--and the differences are statistically significant. Table 6 documents that the exchange of water encompasses farmers of all tenure status positions, but is most pronounced among owner-operators. Table 7 shows that water exchange beyond the regular warabundi turn occurs across

Table 1. Summary of farmers' reports of extra legal canal water transactions.

Type of extra legal transactions	Number reporting	Percentage reporting Yes	Percentage reporting No
1. Trading partial turns of canal water	352	67.6	32.4
2. Trading full turns of canal water	335	33.4	66.6
3. Buying or selling canal water with other farmers	314	21.7	78.3
4. Buying water allotted by Canal Department for village roads	305	6.6	93.4
5. Buying water allotted by Canal Department for village roads	305	5.2	94.8
6. Trading canal water for tubewell water	309	13.9	86.1

Table 2. Sample farmer willingness to trade irrigation water with farms outside their biradari (kinship) group.

Willingness to trade with non-biradari members	Sample farmer respondents Number	Percent
Trade only within biradari	94	34.9
Trade with anyone available	139	51.7
Do not trade	34	12.6
Other	2	.7
	269	99.9

Table 3. Availability of water from others when turn is over by farm size.

N = 373
( ) = %

	Farm size (Acres) < 2.49	2.5 7.49	7.5 12.49	12.5 24.9	25 49.9	50 74.9	75 99.9	100 +	Row total
Water not available	(11.8)	(10.5)	(8.6)	(5.1)	(1.1)	(0)	(0)	(0)	(36.9)
Water available	(7.2)	(15.3)	(17.2)	(17.7)	(3.5)	(1.1)	(0.3)	(0.8)	(63.1)

χ^2 = 33.935
d.f. = 7
p. = <.001
c = .29

Table 4. Trading of partial irrigation turns (last kharif and rabi season) by farm size.

N = 352
( ) = %

Times traded partial turns	Farm Size (Acres) <2.49	2.5 7.49	7.5 12.49	12.5 24.9	25 24.9	50 75.9	75 99.9	100 +
None	(11.4)	(8.5)	(6.8)	(5.1)	(.6)	(0)	(0)	(0)
1-2	(1.4)	(2.0)	(1.4)	(1.7)	(.3)	(0)	(0)	(0)
3-5	(1.4)	(4.0)	(3.7)	(3.1)	(.9)	(.3)	(.3)	(0)
6-10	(1.7)	(4.3)	(5.1)	(5.4)	(1.1)	(0)	(0)	(.3)
11-15	(1.4)	(1.4)	(2.3)	(1.7)	(0)	(.3)	(0)	(.3)
16+	(1.7)	(5.7)	(5.4)	(6.3)	(2.0)	(.6)	(0)	(.3)

$\chi 2$ = 56.866
d.f. = 35
p = <.02
c = .373

Table 5. Trading of full irrigation turns (last kharif and rabi seasons) by farm size.

N = 335
( ) = %

Times traded full turns	Farm size (Acres) <2.49	2.5 7.49	7.5 12.49	12.5 24.9	25.0 49.9	50.0 74.9	75.0 99.9	100 +
None	(15.2)	(17.3)	(16.7)	(12.8)	(3.0)	(.9)	(.3)	(.3)
1-2	(.9)	(.6)	(.3)	(1.5)	(.6)	(0)	(0)	(0)
3-5	(.3)	(1.5)	(2.7)	(2.4)	(0)	(0)	(0)	(0)
6-10	(.6)	(.9)	(2.4)	(3.6)	(.6)	(0)	(0)	(0)
11-15	(.3)	(.6)	(1.8)	(.6)	(0)	(0)	(0)	(.3)
16 +	(.9)	(4.5)	(1.2)	(3.0)	(.9)	(.3)	(0)	(.3)

χ^2 = 52.879
d.f = 35
p. = .03
c = .369

Table 6. Availability of water from others when turn is over by land tenure status.

N = 373
( ) = %

	Land tenure status Owner operator	Owner cum tenant	Contractor	Pure share tenant
Water not available	(24.7)	(4.0)	(0)	(8.3)
Water available	(43.2)	(10.5)	(0.5)	(8.8)

Table 7. Availability of water from others when turn is over by water-course position.

N = 372
( ) = %

	Head	Middle	Tail	Multiple positions
Water not available	(12.4)	(8.6)	(12.4)	(3.5)
Water available	(21.2)	(17.2)	(20.4)	(4.3)

χ^2 = 1.34
d.f = 3
p. = >.70 (N.S.)
c = .06

Table 8. Availability of water from others when turn is over by water-course type (perennial/nonperennial).

N = 372
( ) = %

	Watercourse status	
	Nonperennial	Perennial
Water not available	(16.9)	(20.1)
Water available	(11.0)	(52.0)

N = 373
χ^2 = 33.01
d.f = 1
p = <.0001
c = .29
phi = 30

Table 9. Availability of water from others when turn is over by degree of power/influence

N = 279
( ) = %

	Percent of potential power/influence scores					
	0-17	18-34	35-51	52-67	68-83	84-100
Water not available	(07)	(07)	(14)	(04)	(05)	(04)
Water available	(08)	(08)	(13)	(08)	(10)	(14)

χ^2 = 14.76
d.f = 5
p. = <.25 N.S.
c = .22

all watercourse positions--there is no relationship between the propensity to exchange water and the farmer's watercourse location. However, a statistically significant greater amount of exchange is found on perennial watercourses than on nonperennial--as displayed in Table 8. Table 9 presents data regarding farmer power/influence and water exchange; there is no statistically significant relationship revealed. "Weaker" sample farmers report water trading and purchasing almost as much as more powerful ones. Likewise, the trading of partial irrigation turns is not significantly affected by power/influence considerations as Table 10 shows. Nor does power appear to be related to the propensity to buy canal water as displayed in Table 11.

Tenure status does appear to be related to the propensity to purchase canal water. An inspection of Table 12 reveals that tenant farmers in the sample are less likely to purchase canal water than are owner-operators or those farmers who both own land and also sharecrop. As the number of private tubewells increases on a watercourse, there is a tendency for purchases of canal water to also increase (see Table 13). This reflects, no doubt, the fact that, for some farmers at least, tubewell supplies are replacing canal supplies and making canal water a salable commodity.

Overall, then, water purchasing and trading constitutes a major activity for sample farmers of all types. Substantial numbers of sample farmers report illegal water exchanges across all farm sizes, tenure statuses, watercourse positions, types of canal supply (perennial/non-perennial) and degrees of power/influence on the watercourse. Larger farmers in the sample are more likely to find water available after their turn is completed than small farmers; pure share tenants are less likely to secure additional supplies, but farmers at all watercourse positions

Table 10. Trading of partial irrigation turns (last kharif and rabi season) by degree of power/influence.

N = 270
( ) = %

Times traded partial turns	Percent of potential power/influence score 0-17	18-34	35-51	52-67	68-83	84-100
None	(7)	(7)	(10)	(2)	(4)	(5)
1-2	(1)	(4)	(2)	(2)	(01)	(1)
3-5	(2)	(2)	(5)	(2)	(2.6)	(2)
6-10	(2)	(4)	(6)	(3)	(4)	(2)
11-15	(4)	(4)	(1)	(2)	(4)	(2)
16 +	(2)	(2)	(4)	(3)	(2)	(6)

$\chi^2 = .32$
d.f = 20
p = N.S.

Table 11. Buying of canal water by degree of power/influence.

N = 227
( ) = %

Does farmer buy canal water from other farmers	Percent of potential power/influence score 0-17	18-34	35-51	52-67	68-83	84-100
No	(08)	(09)	(21)	(09)	(12)	(13)
Yes	(03)	(01)	(02)	(02)	(001)	(01)

Table 12. Buying canal water by tenure status.

N = 314
( ) = %

Does farmer buy canal water from other farmers	Farmer tenure status: Owner/ operator	Owner cum tenant	Contractor	Pure share tenant
No	(51.3)	(9.9)	(.3)	(16.9)
Yes	(15.9)	(4.1)	(.3)	(1.3)

χ^2 = 10.278
d.f. = 3
p. = <.02
c = .178

Table 13. Buying canal water by number of private tubewells on watercourse.

N = 314
( ) = %

Does farmer buy canal water from other farmers	Number of private tubewells on watercourse: 0	1	2	5	6	8	13	20
No	(48.1)	(10.2)	(9.6)	(2.5)	(2.2)	(.6)	(2.9)	(2.2)
Yes	(1.6)	(4.8)	(1.0)	(5.7)	(0)	(4.1)	(4.1)	(.3)

χ^2 = 129.841
d.f. = 7
p. = <.0001
c = .541

Table 14. Tubewell ownership by farm size.

N = 388
( ) = %

Tubewell ownership	Farm Size Acres: <2.49	2.5-7.49	7.5-12.49	12.5-24.9	25-49.9	50+	Total
Not own	(19.1)	(23.2)	(22.4)	(19.1)	(3.1)	(1.1)	(88)
Own electric powered	(.5)	(.3)	(.8)	(1.3)	(.3)	(.5)	(3.7)
Own diesel powered	(.3)	(2.1)	(2.6)	(2.1)	(1.1)	(.5)	(8.7)

χ^2 = 27.65
d.f. = 10
p.= <.005
c = .26

are equally likely to secure supplemental supplies through purchases and trading. Farm size, tenure status, and the number of private tubewells on the watercourse are all positively associated with the propensity to buy, sell, and trade canal water.

II. WATER CONTROL OPTION 2: PATTERNS OF USING PRIVATE TUBEWELLS

Only a small minority of sample farmers own a tubewell--slightly over 12 percent. Table 14 reveals a modest relationship between increasing farm size and the likelihood of owning a tubewell. Refugee farmers, among this sample, show a significantly stronger tendency to own tubewells than do "locals" as shown on Table 15. Almost 37 percent of the farmers report that they can obtain tubewell water via purchase of trades. (see Table 17). In addition, tubewell water is sometimes traded for canal water. Since groundwater is often more saline than canal water, farmers in many areas do not like to exchange their higher quality canal water for tubewell supplies, but Table 17 reveals that almost 14 percent of the respondents do periodically engage in that practice. Those who have mustered the investment capital necessary to install a tubewell tend to be located away from the "head" positions on watercourses as demonstrated by Table 18. This relationship is stronger in the case of nonperennially served watercourses than on perennial ones, but the tendency for tubewell owners to be located toward the "tail" of watercourses is only a "modest" one in the strongest instance.

Overall, then, the data regarding tubewells viewed in context of the preceding discussion of water exchange suggest that, within the strict confines of a rigidly structured canal system over which farmers have little meaningful control above the mogha outlet, farmers have adapted by creating an informal, illegal, quasi-demand system so as to avoid

Table 15. Tubewell ownership by refugee/local status.

( ) = %

Refugee local status	Not own	Own
Refugee	(28)	(8)
Local	(60)	(4)

$N = 385$ d.f. = 1
ϕ phi = .24 p. = <.10
$\chi^2 = 22.61$

Table 16. Utilization of private tubewells by farmers not owning tubewells.

Type of use	Number	Percent
No use	212	63.1
Borrow tubewell water informally	6	1.8
Rent tubewell water	118	35.1
Total	336	100.0

Table 17. Sample farmer reports of trading canal water for tubewell water and vice versa.

Willingness to trade	Number	Percent
Do not trade	266	86.1
Do trade	43	13.9
Total	309	100.0

Table 18. Tubewell ownership and watercourse position controlling for type of watercourse.

( ) = %

Tubewell ownership	Nonperennial Head	Middle	Tail	Multiple* positions	Perennial Head	Middle	Tail	Multiple* positions
Not own	(36)	(18)	(28)	(8)	(28)	(23)	(30)	(6)
Own	(0)	(2)	(5)	(4)	(5)	(5)	(2)	(0)

Nonperennial: N = 104, χ^2 = 7.73, d.f = 2, p. = <.025, c = 26

Perennial: N = 270, χ^2 = 6.7, d.f = 2, p. = <.05, c = .16

*Status calculations exclude values for the multiple positions category.

Table 19. Frequency of water theft experienced in past year by sample farmers in relation to farm size category.

( ) = % of total

Farmer size of holdings (Acres)

Frequency of water theft experienced in past year	<2.49	2.5-7.49	7.5-12.49	12.5-24.9	25.0 49.9	50+	Row totals
None	(11.1)	(15.1)	(17.2)	(11.7)	(4)	(.6)	(60)
1-5	(2.8)	(6.8)	(4.6)	(4)	(.6)	(.9)	(20)
6-10	(2.5)	(1.2)	(1.8)	(3.4)	(0)	(.6)	(9)
11+	(1.2)	(1.8)	(3.4)	(3.7)	(.6)	(.3)	(11)
Column totals	(18)	(25)	(27)	(23)	(5)	(2)	(100)

N = 325
χ^2 = 33.72
d.f = 15
p. = <.005
c = .31

having to accept unwanted water deliveries at inappropriate times and to the best of their ability obtain water when required by their perceptions of crop needs.

III. WATER CONTROL OPTION 3: PATTERNS OF WATER THEFT

Because farmers cannot be expected to reveal their stealing activities, interviews yield data only about the extent to which water theft is experienced and about the mechanisms employed to control it. At least some water theft is experienced by sample farmers of all size categories although the amount varies considerably (see Table 19). There is a definite tendency for larger farmers to experience more theft than smaller operators and the difference is statistically significant.

Frequency of reported water theft is related to the presence of tubewells on watercourses when the influence of perennial versus non-perennial water supplies is controlled (see Table 20). Inspection reveals that there is no relationship between the frequency of water theft reported and the presence of tubewells on nonperennial watercourses. Proportionately, farmers on these watercourses served by both public and private tubewells are about as likely to experience moderate or high amounts of theft as are farmers on nonperennial watercourses with neither type of tubewell present. On the other hand, given perennial availability of irrigation water on a watercourse, there is a tendency for water theft to increase under conditions of either private or public tubewells alone and to drop when both types of tubewells are combined on the same watercourse (see Table 20). This relationship, while modest, is distinctly apparent and statistically significant.

Overall, then, water theft was experienced at least one to five times during the past year by 40 percent of the sample farmers and was experienced 11 or more times by 11 percent of the farmers. Stealing is

Table 20. Frequency of water theft reported by farmers on watercourses related to presence of public and private tubewells.

(Controlling for watercourse type)

( ) = % of total

Frequency of water theft experienced in past year	Nonperennial watercourses: No tubewells	Nonperennial watercourses: Private* tubewells only	Nonperennial watercourses: Both public and private tubewells	Perennial watercourses: No tubewells	Perennial watercourses: Private tubewells only	Perennial watercourses: Public tubewells only	Perennial watercourses: Both public and private tubewells
None	(19.8)	(11.6)	(8.1)	(25.6)	(31.7)	(7.5)	(.4)
1-5 times	(14)	(11.6)	(1.2)	(9.3)	(5.7)	(2.2)	(.9)
6-10	(8.1)	(4.7)	(3.5)	(1.8)	(3.1)	(2.2)	(.4)
11 + times	(7)	(7)	(3.5)	(.9)	(5.7)	(2.6)	(0)

Nonperennial watercourses:
N = 86
χ^2 = 4.11
d.f. = 6
p. = .66 (N.S.)
c = .21

Perennial watercourses:
N = 227
χ^2 = 22.51
d.f. = 9
p. = .007
c = .30

*Note: There were no nonperennial watercourses in the sample with only public tubewells.

Table 21. Farmer fasalana payments (cash or crop) by farm size.

( ) = %

Farm size (acres)

Payment of fasalana	<2.49	2.5-7.4	7.5-12.49	12.5-24.9	25-49.9	50-74	75+
No	(6.3)	(9.9)	(9.6)	(6.6)	(1.8)	(.3)	(0)
Yes	(11.1)	(15)	(17.7)	(17.1)	(3)	(.9)	(.9)

N = 334
χ^2 = 4.46
d.f. = 6
p = .61 N.S.
c = .11

experienced slightly more by farmers on nonperennial watercourses than on perennial ones, but the addition of private or public tubewells on perennial watercourses is associated with increased tendencies to experience water theft.

When a thief is caught in the act of stealing irrigation water, informants consistently revealed that the typical occurrence is to press charges against the offender with biradari "influentials" who then handle any questioning, administer "oaths" at the village Mosque, and punish the guilty with some combination of monetary fines, social "shame", "ostracism", and denial of irrigation water.

IV. WATER CONTROL OPTION 4: SECURING CONCESSIONS FOR IRRIGATION OFFICIALS

Farmers, in the course of their business, must deal with several lower level officials representing the Department of Irrigation. Chief among these are the patwaris (who assess crop revenues), the overseers (who allocate and repair mogha outlets), the pansals nawees (gauge readers who send daily reports about the flow of water in major and minor canals). These officials take no responsibility for implementation of warabundi rotation of turns, or for watercourse conditions, but they each possess capabilities to help or hurt the farmer.

It is the duty of patwaris to check crops at times of crop failure and keep records of all crops cultivated on every acre of land on watercourses in his circle. The major work of the patwaris is to make crop assessments for canal revenue. Since water, under Muslim law, is a gift of Allah and therefore cannot be justly taxed, revenue is collected to maintain the canal system by assessing each crop at a flat rate per acre. The patwari makes assessments and the numbardar collects the appropriate amount from each farmer. Not unexpectedly, farmers and patwaris can make revenue arrangements to their mutual benefit and they typically do so.

Farmer informants in all sample villages reveal that patwaris frequently "write off" a portion of the crop as having "failed." The patwari and the farmer can then split the "savings"--both parties gaining at the expense of the government. The tax is abiana and to obtain a reduced abiana payment, farmers pay fasalana, a traditional gift usually in kind to the patwari in return for the concessions. Less than a third of sample farmers claim not to regularly pay fasalana (see Table 21) and there is no statistically significant difference by size of farming operation. Informants, however, consistently agree that the amount of fasalana payment is graduated in accordance with size of farmer land holdings. The patwari's share of the concession is negotiated on a case by case basis, generally falling in the range of a fifty/fifty split in the case of smaller operators. Larger farmers seem to retain more than a 50 percent share for themselves.

Patwaris have five optional ways to justify a reduction in farmer abiana payments: 1) cultivated land might be falsely declared fallow; 2) seeds can be falsely declared as not having germinated; 3) healthy plants can be falsely declared as having been decimated by disease; 4) hailstorm damage can be falsely claimed; and 5) an incorrect declaration of canal washout and flooding can be entered into the record. A major consideration for the patwari is to keep the amount of his concessions within limits such that higher officials are not embarrassed by gross and clearly unjustified amounts, something that would make for investigations. Therefore, reductions in assessments generally fall within the 25 to 50 percent range and no more. If a patwari were to give an especially generous concession to one party, he must cut back on his generosity with other farmers in that village or risk exceeding safe limits of revenue shortfall that can be justified to superiors for a particular village.

Only in a small minority of sample villages did informants indicate an awareness of village farmers attempting to secure concessions from pansals nawees. It would appear that villages located toward the head of a canal have little need to request extra amounts of water to be placed in the canal. In the two sample villages, representatives from which did reportedly approach a pansal 'awees, informants speak of gifts--approximately 100-125 maunds of wheat collected from all watercourse members--presented to each official in return for which an unknown extra quantity of water was released into the canal during the night. One might hypothesize that the further a watercourse is located from the head of a canal, and the greater the number of moghas upstream which have been enlarged (see below), the greater the propensity of farmers to deal for "concessions" from a pansal nawees.

Overseers, officials in charge of the mogha (canal outlet to watercourse) attract much more attention from sample farmers than do pansals nawees. Because it is illegal for village farmers to alter the mogha in any way, the overseer must be called upon to repair a mogha defect naturally caused or intentionally created by downstream farmers or the overseer himself. Overseers are approached by farmers with requests for illegal mogha enlargements.

It is not uncommon for farmers in sample villages, wanting a mogha "repaired," to collect from among themselves Rs. 1000 for "tipping" the overseer as an incentive to get the job accomplished. Bribes necessary to obtain a mogha enlargement are negotiated individually with representatives of each petitioning watercourse. The two major factors in calculating the size of the bribe appear to be the amount of cultivated acreage on the watercourse and the extent of the enlargement requested. Payments to the overseer for unauthorized mogha enlargements have ranged in sample villages from a minimum of Rs. 800 to Rs. 6,000.

In sum, then, sample farmers and key informants reveal that the majority of sample farmers reduce their abiana crop assessment by paying fasalana to patwaris. Farmers in most of the sampled watercourse units have organized contributions at one time or another to secure a mogha enlargement from the overseer. In addition, overseers are frequently bribed to make justifiable and needed mogha repairs. Bribing lower level officials to prevent officials from exploiting them, and to secure concessions is commonplace as shown in Table 22. Farmers were asked what they would do if faced with a commonly occurring problem situation. By large majorities, sample farmers indicate that they would resort to extra-legal bribes to resolve the situation. Use of regular channels of bureaucratic authority to resolve the problem without resorting to bribes, was endorsed by small minorities of respondents in all instances. In the cases concerned with threatened reduction of mogha outlets and incorrect recording of water rates there are significantly greater tendencies of larger operators to resort to bribery than small farmers (see Table 22).

Table 22. Farmers' modes of resolving "problems" with lower level irrigation authorities by size of land.

		Land holding size (Acres) ( ) = %							
If one wants reduction of abiana assessment		2.49	2.5-7.49	7.5-12.49	12.5-24.9	25.0-49.9	50.0-74.9	75+	Total
x_2 = 15.63	Do nothing	(6.1)	(6.5)	(5.5)	(4.9)	(1)	(.3)		(24)
p = .33 N.S. c = .21	Use legal means	(1.6)	(1.6)	(1.6)	(1.9)	(1.3)			(8)
N = 309	Use bribery	(8.7)	(16.5)	(20.4)	(16.5)	(3.2)	(1)	(1.3)	(68)
If patwari requests one to increase one's fasalana									
x_2 = 19.32	Do nothing	(8.1)	(7.2)	(5.9)	(7.8)	(.9)	(.3)		(30)
p = .15 N.S. c = .24	Use legal means	(1.2)	(3.7)	(3.1)	(1.2)	(.6)	(.3)		(11)
N = 320	Use bribery	(7.8)	(13.4)	(18.1)	(15)	(3.1)	(.6)	(1.5)	(59)
If overseer threatens reduction in mogha size									
x_2 = 30.73	Do nothing	(7.1)	(6.1)	(3.5)	(5.2)				(22)
p = .006 c = .30	Use legal means	(1)	(2.3)	(2.9)	(.6)	(.3)	(.3)		(7)
N = 310	Use bribery	(8.4)	(16.1)	(21.3)	(19.4)	(5.2)	(1)	(1.3)	(71)
If patwari incorrectly records water rate									
x_2 = 46.71	Do nothing	(5.9)	(3.2)	(2.4)	(3.2)	(.9)			(16)
p = .0001 c = .35	Use legal means	(3.8)	(6.5)	(5.6)	(3.5)	(2.4)	(.9)	(1.2)	(24)
N = 339	Use bribery	(8.0)	(16.5)	(18)	(15.9)	(1.8)	(.3)		(60)

CHAPTER TWO

EXAMINING AN ADDITIONAL OPTION: POTENTIAL FOR ADOPTING A COMPREHENSIVE WATERCOURSE IMPROVEMENT PROGRAM

I. FARMERS' VIEWS ABOUT WATERCOURSE AND LAND LEVELING IMPROVEMENTS

Farmers were amazed, when they learned in informal discussion with members of the survey team, at the huge quantity of water that is actually lost due to poorly maintained watercourses and unlevel fields. About mid-way through the watercourse survey, investigators were asked to solicit information from the farmers about a proposed pilot project for improvement of sample irrigation systems. This chapter reports on sample farmer responses to the several questions which were added to the schedule on this subject. Farmers were asked about their knowledge of actually proposed land leveling and water management programs and their source of such information. Also, they were asked about perceived benefits and the conditions under which they would consider participating, were improvement programs initiated.

Prior to the watercourse survey in 1975-1976, a Precision Land Leveling Program had been established in Sind and the Punjab Provinces with assistance from USAID. Also, there was some talk of a water management program for the rehabilitation of watercourses at the time of the survey. The following percentages of farmers learned about the two programs through the following means shown in Table 23.

Table 23. Sources of information about programs.

Programs	No. Farmers	Not Heard	Other Farmers	Village Leader	Agricultural Department	Radio	Other
				(percent)			
Precision Land Leveling	135	51.1	28.1	1.5	0	17.8	1.5
Water Management	151	76.1	11.3	0	4.6	7.3	.7

The number of farmers who heard about precision land leveling is unusually high in that land leveling activities had been in progress for sometime at or near Sites 102, 103, 104, 105, 106, 107, 108 and 109 for about one year. Farmers, in general, have shown much interest in precision leveled fields. The radio, and other farmers, are the most typical sources of information. Fewer farmers had heard about the water management project. Those who had heard about this program are located at Sites 102, 103, and 105. At 105 site, one experimental watercourse had been improved, and at sites 102 and 103, plans were underway to begin improvements. Again, the most important sources of information are the radio and other farmers. The majority of the farmers who knew about the two programs had heard about them within the last year.

When asked the perceived benefits of precision land leveling the following replies were given:

Savings of water -	45%
"Easier to irrigate" or "less time to irrigate"-	26%
"Water is distributed evenly"-	12%
"Higher yields"-	9%
"Other benefits"-	3%
"Don't know"	6%

When asked about the perceived benefits of the water management program, 79 percent of the respondents reported "easier to irrigate and savings of water," 5 percent reported "high yields," and 7 percent reported "fewer losses". Farmers were also asked if they would co-operate in the two programs if made available for their areas. The following shows the responses of the reporting farmers to, "Will you cooperate?"

Farmers' Responses	Land Leveling Program (n=57)	Water Management Program (n=69)
1. Will cooperate	21	20
2. Cooperate if others do	5	3
3. Undecided	16	7
4. Up to Government	5	-
5. Will not cooperate	5	3
6. Will provide labor	-	32
7. Other	5	4

No great validity can be placed on the responses, especially those related to cooperation, this information does indicate that some farmers have heard of the new programs and perceive some benefits from them. If farmers in Pakistan were given proper incentives to organize and would clean and maintain their watercourses with more regularity, as a recent World Bank Report[2/] states, they probably could save 3 to 5 million acre feet of water a year! At the farm inlet this would more than equal the water available from Tarbella.

II. FARMERS' ATTITUDES AND REPORTED INCREASES IN ACREAGES OF CROPS GIVEN AN INCREASED WATER SUPPLY

We have seen that cropping intensities and patterns are influenced by water quantities and the reliability of irrigation supplies. Farmers

2/World Bank, Vol. III: Annex on Water Management, op. cit., preface.

reported in interviews and discussions, that given extra supplies of water, they would increase present cropping intensities, develop or reclai culturable waste lands and change their cropping mixes. Small farmers reported that they would increase food crops to meet their needs; larger farmers reported that they would cultivate more acreage of cash crops such as cotton, rice, wheat or sugarcane (see Table 24). In areas near a fodder market, these crops with a good demand would also be increased because these farmers report that fodder provides a steady income throughout the year and payments are made against weekly deliveries of fodder.

In an attempt to discover farmers' responses to increased supplies of irrigation water, farmers were asked to assume hypothetically that a doubling of water supplies was possible. Then they were asked to report their estimates of increased acreages over present acreages of selected crops. Their responses are examined by type of watercourse, supplemental tubewell supplies, agro-climatic regions, crop dominant command areas, and by farm size classes. This information may provide some rough estimates of how farmers would actually respond to increased supplies made available through a comprehensive farm water management improvement program.

III. CROP INCREASES AND TYPE OF COMMAND

Table 24 provides a summary of the increases in acreage of selected crops by perennial and nonperennial command areas. Note the percentage of perennial command farmers who would increase the following crops by 50 percent or more: wheat 21%; sugarcane 19%; rice 16%; cotton 14% and other crops including vegetables, tobacco, garden, etc. by 12.5%. The nonperennial farmers, in contrast, would increase their present acreages

Table 24. Summary of farmers' estimates of increases in crops cultivated given a doubling of water supplies

Type Watercourse & Crops	Farms Reporting*	Estimated Percentage Increases in Selected Crops								
		No Increase	10 %	11-20 %	21-30 %	31-40 %	41-50 %	51-75 %	76-100 %	Over 100 %
Perennial										
Wheat	253	27.3	45.3	.8	.7	.3	2.7	1.2	16.3	4.1
Rice	238	53.4	31.5	.8	.1	.4	.4	-	7.6	8.5
Cotton	233	47.6	45.3	.4	-	-	.9	-	7.4	7.0
Sugarcane	246	48.0	35.7	2.0	.4	-	-	.9	9.8	8.1
Fodder	242	71.1	18.2	.4	.4	-	.7	.5	7.4	1.3
Other	77	57.7	26.0	-	1.1	-	-	-	10.5	2.5
Non-Perennial										
Wheat	111	27.0	15.7	.9	6.5	1.9	2.8	1.9	22.2	24.1
Rice	108	38.8	15.7	-	1.8	-	-	-	16.7	36.1
Cotton	105	48.6	4.8	2.9	2.9	1.9	1.9	-	18.1	20.0
Sugarcane	107	46.7	13.1	-	-	-	-	-	13.1	25.2
Fodder	106	69.8	3.7	-	2.8	-	1.9	.9	14.2	6.6
Other	41	57.5	2.4	-	7.3	-	-	-	14.6	17.1
Perennial & Non-Perennial										
Wheat	364	27.2	36.3	.8	2.5	.8	2.7	1.4	18.1	10.2
Rice	364	50.0	24.3	.6	.6	.3	.3	-	8.7	15.3
Cotton	338	47.9	26.0	.6	.9	.6	1.2	-	10.7	12.1
Sugarcane	353	47.6	28.6	1.4	.3	-	-	.6	10.8	12.1
Fodder	348	70.7	13.8	.3	1.1	-	1.1	.6	9.5	10.8
Other	118	57.6	20.3	-	2.5	-	-	-	11.9	7.6

*Note that differences in % of non-perennial VS perennial command farmers who would increase present acreage by 50% or more are: Wheat-27%, Rice-37%, Cotton-24%, Sugarcane-14% & other crops-19%

of these crops by 50 percent or more: rice 53%; wheat 47%; cotton and sugarcane 38%; fodder 22% and other 32%. The difference in percentages between nonperennial vs. perennial command farmers who would increase their present acreages by 50 percent or more is: rice 37%; wheat 27%; cotton 24%; fodder 11%; and other crops 19%. This, of course, suggests a major water constraint on nonperennial command farmers and suggests that in areas where groundwater supplies are good, tubewells would greatly increase cultivated acreages of important crops.

IV. VILLAGE SITES AND CROP INCREASES

Each village site is shown in Table 25 by the percentages of farmers who reported that they would increase present crop acreage by 50 percent or more. This, of course, does not show those farmers who would increase acreages by less than 50 percent, which is the case of most major crops. Note that of farmers on eight command area sites (101, 102, 103, 106, 107, 109, 105 and 108) no farmer reports that he will increase any crop by as much as 50 percent or more. Four of these eight sites (106, 109, 105 and 108) are all on commands supplemented with public tubewells. Also, sites 102 and 107 have a high density of private tubewells. This suggests that with the presence of a fairly good water supply situation, there would be no major increases in the present acreage of crops given another doubling of supply.

Perennial command sites 112, 113, and 116 have no irrigation supplements from tubewells, and, of the 3 watercourses at site 104, only one has a private tubewell. Site 104 farmers would increase wheat acreage by 50 percent or more with little increase in cotton and fodder. This is not a cotton area, and already fodder is the dominant crop, though rice is also cultivated. Both rice and wheat are important for home

Table 25. Percentage of sample farmers who would increase present crop acreages by fifty percent or more with a doubling of irrigation supplies by village site.

Village Sites	Percentages of Farmers Who Would Increase Present Acreage 50% or more.									
	# of Farms	Wheat	# of Farms	Rice	# of Farms	Cotton	# of Farms	Sugar-	# of Farms	Fodder
Perennial										
101-2wc	15	-	11	-	12	-	14	-	12	-
102-1wc	9	-	5	-	9	-	8	-	9	-
103-1wc	16	-	16	-	15	-	16	-	16	-
104-3wc	35	31	34	18	32	9	35	11	36	8
106-1wc	10	-	10	-	10	-	10	-	10	-
107-3wc	53	-	51	-	53	-	52	-	52	-
109-2wc	13	-	13	-	13	-	13	-	13	-
110-3wc	21	24	21	19	11	-	21	5	21	10
112-3wc	30	67	26	31	27	56	26	54	23	35
113-3wc	26	73	26	73	26	73	26	62	25	28
116-4wc	30	7	25	12	25	-	25	-	25	12
Non-Perennial										
105-1wc	7	-	8	-	7	-	8	-	8	-
108-1wc	9	-	9	-	9	-	9	-	9	-
111-2wc	20	25	20	75	18	39	19	63	19	37
114-4wc	37	73	33	64	33	64	34	65	35	34
115-6wc	38	48	38	18	38	32	37	22	35	9
Overall	364	30	346	24	338	23	353	22	349	13

consumption for these predominantly small holders. Sites 112 and 113, with no tubewells, would increase all crops dramatically with almost equal focus on wheat, cotton and sugarcane. Site 110, though, has a high density of private tubewells but one watercourse is noncommanded, and there is culturable waste that can be brought under cultivation. These farmers would focus more on wheat and rice. Presently, these are the dominant crops on the three commands.

As for the nonperennial commands, sites 105 and 108, with public tubewells, have supplemental supplies of about 1.8 and 3.0 cusecs (108 has one public and two private tubewells). Therefore, we note that farmers at 105 and 108 sites would not radically change present crop acreages. Site 111 has a public tubewell with a discharge of about 1.7 cusecs per watercourse. One public tubewell at this site serves two watercourse command areas. However, at site 111, the most radical crop increases as reported by farmers are rice, cotton, berseem and sugarcane, all of which have very high water demands.

In all command areas, from 20 to 30 percent of the farmers would increase all crops except fodder by 50 percent or more.

V. CROP INCREASES OF TUBEWELL SUPPLEMENTS FOR COMMAND AREAS

In order to show the importance of tubewell supplements in relationship to farmers' reports of expected increases in acreage of selected crops by 50 percent or more, Figure 2 is presented. Those farmers on commands with public tubewells and those on commands with 3 or more private tubewells report no crop increases of 50 percent or more. However, when we move to the nonperennial commands, except for one command area with both private and public tubewells, we find substantial increases in most crops.

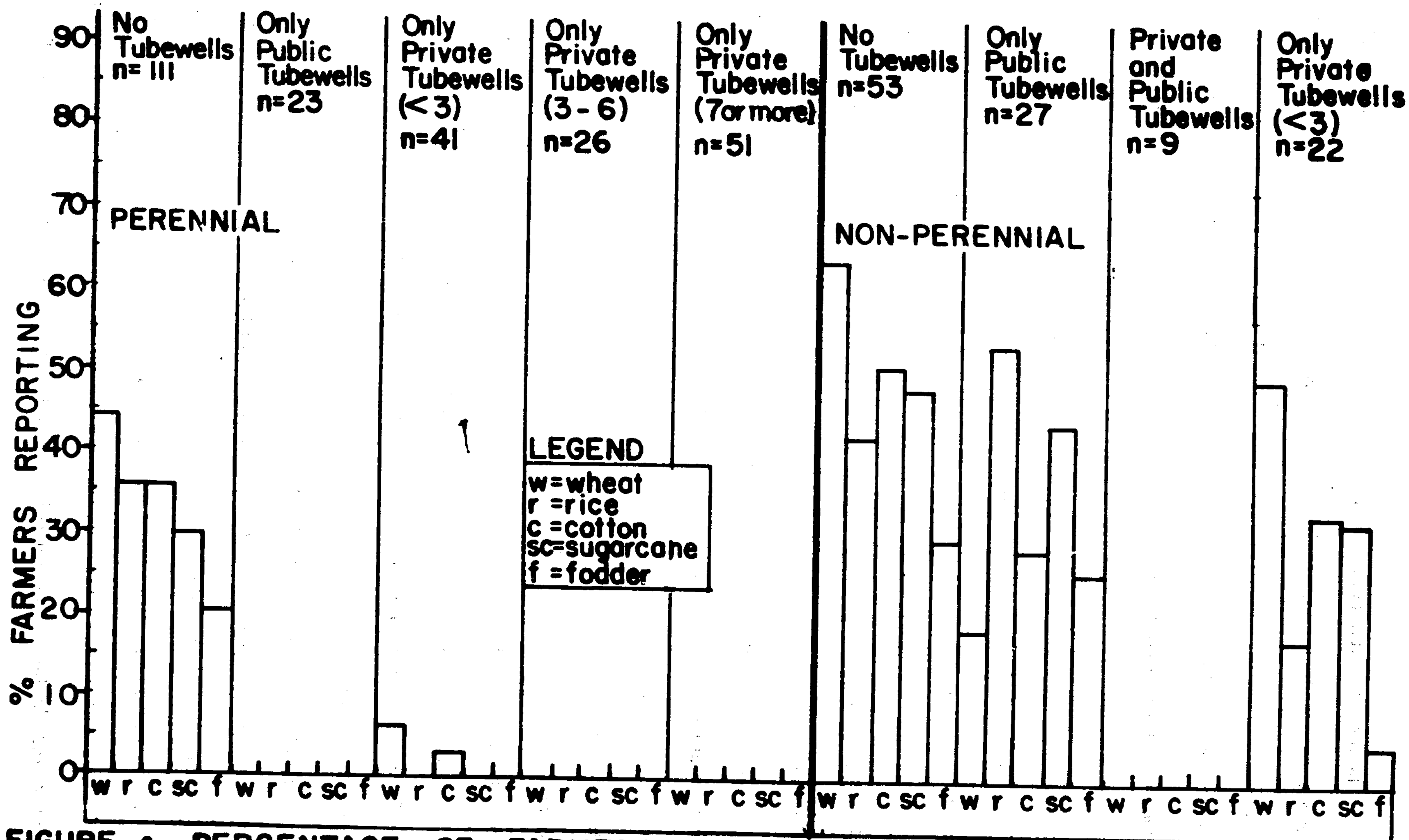

FIGURE 2. PERCENTAGE OF FARMERS WHO WOULD INCREASE PRESENT ACREAGE BY FIFTY PERCENT OR MORE WITH A DOUBLING OF WATER SUPPLY

Though private tubewells may exist on many watercourse commands, farmers seldom have equal access to them. Farm locations, topography, credit or capital, and distributions of influence often determine who can benefit from private tubewlls. When both perennial and nonperennial command sample farmers are combined, and acreage increases expected are cross tabulated with farmers' reports of availability of tubewell water, we note several points (see Table 26). For example, from 32 to 42 percent of the farmers, who report that tubewell water is "not available," report expected increases of 50 percent or more in wheat, cotton and rice, and 28 percent report this for sugarcane. Only a small percentage of the farmers, who report tubewell water "easily available," report increases.

Likewise, when farmers' use of tubewells is cross tabulated with the percentage of farmers who would increase present crop acreages over 50 percent, we find statistically significant differences between farmers "who do not use tubewells," those who purchase tubewell water, and those who own tubewells (see Table 26). Though types of commands are not shown separately, no tubewell owner on perennial watercourse commands estimated increases of 50 percent or more in any of the acreages of crops, and only one farmer, of 76 who reported purchasing water, reported increases of 50 percent for wheat and rice.

VI. FARM LOCATION ON COMMAND AND CROP INCREASES

Given the greater total losses of irrigation water in the conveyance system for farmers located at tails of command areas, given a doubling of water supplies, one would expect tail farmers to report more radical increases than head farmers. Table 27 shows, that for all crops except fodder and "other," perennial command area tail farmers in greater

Table 26. Percentage of farmers who would increase selected crops by 50 percent or more given a doubling of irrigation water by supplements to canal water supplies.

Tubewell Supplements	Percentage of Farmers Who Would Increase Present Acreage By Fifty Percent or More						
	Farms Reporting	Wheat	Cotton	Rice	Sugarcane	Fodder	Other
Availability of TW Water							
Not Available	155	42	34	32	28	17	15 (n=59)
With Difficulty	61	25	16	19	20	14	19 (n=26)
Easily Available	117	12	7	11	8	4	19 (n=26)
		*	*	*	*	*	*
Use of Tubewells							
No Use	203	43	36	32	32	20	20 (n=81)
Purchase Water	111	13	9	14	9	5	13 (n=23)
Owns Tubewell	43	5	-	8	10	-	17 (n=12)
		**	**	**	**	**	**
Number of Private Tubewells							
None	201	42	32	30	30	18	24 (n=78)
Under 3	80	24	21	29	24	12	17 (n=23)
3 - 6	33	-	-	-	-	-	- (n= 5)
7 or More[a]	16	10	-	8	2	4	- (n=12)
		**	**	**	**	**	**

* Denotes statistical significance using X^2 with 2 df at .004 or greater.
**Denotes statistical significance using X^2 with 3 df at .004 or greater.
a/Includes one noncommanded area not included in Figure 2.

Table 27. Farmers on watercourse commands who would increase acreage of selected crops by fifty percent or more if supplies of irrigation water doubled by position on watercourse command reaches.

Type of watercourse command	Percentage of Farmers Who Report Increasing Present Acreage of Crops by 50% or More By Location of Farm*					
	# of Farms	Head	# of Farms	Middle	# of Farms	Tail
Perennial Commands						
Wheat	71	10	59	37	47	28
Cotton	47	9	55	30	41	22
Rice	45	11	58	24	45	24
Sugarcane	48	4	59	25	46	23
Fodder	47	7	58	14	44	2
Other	14	21	19	21	10	10
Non-Perennial Commands						
Wheat	47	57	21	43	11	36
Cotton	45	47	19	32	11	36
Rice	45	45	20	40	11	36
Sugarcane	45	47	20	50	11	36
Fodder	44	21	21	33	10	20
Other	16	19	10	50	4	100

*Adjusted measured watercourse command position.

percentages would increase present acreages by 50 percent or more, given a doubling of irrigation water. However, the situation is not as clear for the nonperennial command farmers who receive only seasonal canal supplies. While they report more radical acreage increases than perennial command farmers, there is little difference between head, middle and tail farmers.

The major conclusion to draw from this, that given improved delivery by the farm subsystem and other improvements such as land leveling and improved irrigation practices, tail farmers on perennial watercourses could be expected to substantially increase present acreages of cash crops, as would farmers at all locations on non-perennial commands.

VII. INCREASES IN CROP ACREAGE BY AGRO-CLIMATIC REGIONS AND CROP DOMINANT COMMANDS GIVEN INCREASED WATER SUPPLIES

A dominant factor in farmers' estimates of crop increases is the availability of tubewell water to supplement the canal supplies. Table 28 provides information about the impact of agro-climatic regions, disaggregated to crop-dominant commands, on increased acreage given doubling of water supplies. The "low deficit" sites are in Gujranwala and Lahore Districts. The three rice-fodder commands (site 104) in Lahore District, with only one private tubewell to supplement canal supplies, show substantial expected increases in wheat, rice and sugarcane, given increased water supplies. However, the rice-wheat and fodder-wheat farmers report no increases of 50 percent or more for any crop. Of the 54 farmers reporting in the medium low evaporative region (Lyallpur and Sargodha Districts), none report radical increases in any of the crops. The mixed orchard dominated commands are all supplemented by public tubewells. Whereas the sugarcane-wheat dominant commands have only two private

Table 28. Farmers on commands who could increase acreage of selected crops by 50 percent or more if supplies of irrigation water doubled by agro-climatic regions

Agro-Climatic Regions (P=Perennial) (NP=Non-Perennial)	Percentage of Farmers Who Would Increase Present Acreage of Crops by 50 Percent or More of Selected Crops					
	# of Farms	Wheat	Cotton	Rice	Sugar-cane	Fodder
Low Evaporative Deficit Regions						
Rice-Wheat - P	15	-	-	-	-	-
Rice-Fodder - P	35	31	9	18	11	8
Fodder-Wheat - P	16	-	-	-	-	-
Medium Low Evaporative Deficit Region						
Sugarcane-Wheat - P	15	-	-	-	-	-
Mixed-Orchard - P	30	-	-	-	-	-
Mixed Orchard - NP	9	-	-	-	-	-
Medium High Evaporative Deficit Region						
Cotton-Wheat - P	62	-	-	-	-	-
Mixed-Orchard - NP	20	17	66	100	57	89
Cotton-Wheat - NP	37	93	64	64	68	34
High Evaporative Deficit Region						
Rice-Fodder - P	24	8	-	13	-	13
Cotton-Wheat - P	30	67	56	31	11	35
Sugarcane-Wheat - P	26	73	73	73	54	24
Cotton-Wheat - NP	38	47	32	18	22	11
Totals for P	260	16	16	16	14	9
Totals for NP	98	48	42	41	42	20

tubewells, the lower reaches of the command areas are slightly waterlogged, thereby providing some moisture for crops from groundwater.

The medium high evaporative deficit areas include sites in Multan, Bahawalpur and Muzzafargarh Districts. The cotton-wheat dominant perennial commands include sites 102 and 107 where all four watercourses are supplemented by six or more private tubewells. These farmers report no drastic changes in acreages of crops.

A large percentage of the reporting farmers in the high evaporative deficit regions would increase their present acreages of all crops substantially except for the one rice-fodder dominated command at site 116. This is the site where much waterlogging has taken place due to excess canal water supplies; only 2 of 24 farmers report increasing wheat by 50 percent or more and these are both tail farmers. However, it should be noted that the cotton-wheat and sugarcane-wheat and the rice-wheat nonperennial command area with 6 watercourses has only 4 private tubewells plus Persian wells for supplements to canal supplies.

In summary, except for the cotton crop which is cultivated primarily in the medium high and high evaporative deficit regions, the major factor influencing expected increases in crop acreages is the water supply situation.

VIII. FARM SIZE CLASSES AND EXPECTED ACREAGE INCREASES IN CROPS WITH ADDITIONAL WATER SUPPLIES

Table 29 shows the percentages of farmers of all size classes who report they would increase present crop acreages by 50 percent or more. Note that there is an inverse relationship between farm size and estimated crop increases. None of the 23 farmers cultivating over 25 acres report increases, but a large percentage of smaller farmers report radical crop

Table 29. Percentage of farmers by farm size classes who estimate a 50 percent or greater increase in present acreage of crops given a doubling of irrigation supplies.

Farm size classes (acres)	Percentage of farms which would increase present acreage of crops by 50 percent or more											
	# of farms	Wheat	# of farms	Cotton	# of farms	Rice	# of farms	Sugar-cane	# of farms	Fodder	# of farms	Other
		%		%		%		%		%		%
2.5	69	43	64	28	64	25	63	27	64	17	22	27
2.5 - 7.49	92	28	87	23	91	25	91	22	90	15	38	13
7.5 - 12.49	94	33	85	26	93	30	92	25	91	12	26	23
12.5 - 24.99	86	24	80	21	77	21	85	21	81	11	24	25
25.0 - 49.99	16	-	15	-	15	-	15	-	15	-	7	-
50.0 and above	7	-	7	-	6	-	7	-	7	-	1	-
Totals	364	30	338	23	346	24	353	21	348	13	118	19

increases primarily of wheat followed by rice, cotton and sugarcane, all of which, excepting the wheat crop, have high water demands. The major reason for this is that the farms of 25 acres and more land area have greater access to tubewell water supplies. For example, about 66 percent of farmers with 25 acres or more report easy availability of tubewell water as compared to about 30 to 35 percent of the farmers with holdings under 25 acres. Likewise, 37 percent of the farmers with 25 acres or more own private tubewells individually or jointly, whereas less than 10 percent of farmers holding less than 25 acres own tubewells. Therefore, sample farmers with improved water control through tubewells are already pushing the limits of their cultivated acreage.

IX. ESTIMATED INCREASES IN CROP YIELDS

An expected farmer response to water management improvements is higher crop yields per acre. Water management, however, must include much more than the supply of additional water. A package of new practices must be made available to farmers. This should include reduction of water losses through improved farm conveyance systems, improved methods of applying water, land leveling, new cropping practices, and improved availability of essential inputs such as fertilizer, improved seed, insecticides, and low cost improved farm implements. In order to transfer such a package to farmers, greatly improve credit facilities and extension services will be needed.

Data (see Table 30) do show that when farmers have greater control on irrigation supplies they obtain higher yields per acre. Benchmark data for given watercourse commands where improvements have taken place are needed for "before and after" studies to ascertain the costs and benefits of a package of practices.

Table 30. Average yields of wheat, rice, and cotton per acre and water supply situations.

Type Water Supply Situation	No. Farms	Wheat Yields MDS/ acre	No. Farms	Rice Yields MDS/ acre	No. Farms	Cotton Yields MDS/ acre
1. Only canal supplies	139	18	62	14	69	7
2. Canal plus public tubewell supplies	33	20	13	19	12	8
3. Canal plus purchase of private tubewell supplies	113	21	35	21	54	10
4. Canal plus ownership of private tubewell	42	24	9	23	27	13

These data show the importance of supplemental irrigation supplies, and the importance of increased control over supplies, for increased crop yields. This suggests that if more water is made available through a water management program, one can expect yields of crops to rise even without improvements in the application of water. Private tubewell owners have maximum control because they can irrigate at will. Yields of private tubewell owners are 30 percent greater for wheat than farmers with only canal supplies. Rice yields per acre are 64 percent greater and cotton yields almost 86 percent greater for private tubewell farmers as compared with farmers receiving only canal supplies (see Table 30).

Public tubewells as supplements to canal supplies make more total water available but do not usually operate on demand. Each farmer is supplied public tubewell supplies at his regular warabundi turn which usually comes every 8 days. Therefore, the percentage increases of public tubewell farmers over farmers with no supplemental irrigation supplies is less than that of either farmers who purchase private tubewell water or who own private tubewells. In comparison to farmers with only canal supplies, public tubewell farmers have average wheat yields only about 11 percent higher and average yields per acre for rice and cotton are respectively only 36 and 14 percent greater.

As shown in Volume IV, Table 28, farmers who have more control over irrigation supplies also utilize more inorganic fertilizer. For example, private tubewell owners, in comparison to farmers with no tubewell supplies, utilize from 12 to 15 more nutrient lbs of nitrogen per acre for wheat, rice, and cotton. Likewise, they utilize from 12 to 18 nutrient lbs more of phosphate fertilizer for these crops.

The 51 farmers who received institutional credit for fertilizer for 1975-76 cropping period had per acre yields of wheat of 23 maunds as compared to 19 maunds per acre obtained by the 246 farmers who received no institutional credit (see Volume III, Table 96).

Farmers need more than water, additional fertilizer or credit for inputs to achieve optimum yields. On one watercourse, demonstration plots were designed to show the yield difference between traditional and improved practices (Lowdermilk, Clyma, Early, 1975, p. 73). The traditional treatment received the usual level of nitrogen applied by the farmer (50 nutrient lbs), and the improved treatment received 100 to 150 nutrient lbs of nitrogen and 37 to 75 lbs/acre of P_2O_5. Traditional methods of seeding, irrigation, and other cultural practices were followed by farmers on the traditional plots. On the improved plots, a rabi drill was used for seeding and irrigation water was applied in accordance with crop demands. On improved plots, from 4.7 to 6 acre inches per acre less water was used than on the farmers traditional plots. The yield data are presented below in Table 31.

Table 31. Demonstration wheat yields using traditional and improved practices (maunds/acre).*

Variety	Traditional Treatment	Improved Treatment	Increased due to Improved Package of Practices
Chenab 70	26.4	49.8	23.4
Chenab 70	33.8	62.4	28.6
Chenab 70	22.5	43.9	21.4
SA - 42	20.3	37.0	16.7
SA - 42	19.1	36.5	17.4

*Lowdermilk, Clyma, Early, 1975, p. 73.

Given an adequate package of practices and improved extension services, the yields achieved by farmers in these demonstration plots could become widespread in Pakistan. Any program for improvement of farm water management must be comprehensive, and services, such as rehabilitation of watercourses, land leveling, credit, fertilizer inputs, and extension, must be well integrated if higher yields are to be realized--especially for smaller farmers.

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ENGLISH GLOSSARY

Agro-Climatic Zone - A region where climate makes a well defined demand for water and a general cropping pattern prevails on a majority of the farms.

Alidade and Plane Table - Engineering telescope and table tripod tools used for preparation of maps to scale in the fields.

Alkaline Soil - A high PH soil that contains sufficient sodium to cause deleterious effects on most crops.

Application Efficiency - The quotient of soil moisture deficiency and nakka discharge in inches equivalent multiplied by one hundred to construct a percentage value.

$$Ea = \frac{\text{soil moisture deficiency}}{\text{nakka discharge (in depth of water equivalent)}} (100)$$

Authorized Supply - The design discharge of water from a mogha.

Barrage - Headworks with movable gates that allow flood waters to pass over their crests. Not to be confused with storage dams.

Barren Land - Land which is not cropped due to salinity, waterlogging, lack of water, presence of sand dunes, etc.

Brotherhood (Biradari) - A lineage group of families related as brothers sons, uncles, etc. typically with common interests on various issues. A subdivision of a caste group.

Bunded Unit - The smallest field unit irrigated as a separate unit, surrounded by a small earthen ridge or bund.

Canal Colony - Large areas of land brought into production by Irrigation Department and settled by cultivators.

Caste - Ancestral, occupational grouping of people implying prestige gradations.

Centrality of Power - The amount of power/influence attributed to watercourse farmers by 25% sample of farmer/judges. A watercourse centrality value expresses the percentage of all farmers who score at a specified level or above.

Command Area - The area served by a watercourse or set of watercourses in a village.

Concentration of Power - The extent to which power/influence is distributed equally on a watercourse.

Conflict Cleavage - Line of division between opponents over an issue.

Conveyance (Delivery) Efficiency - The percentage of water passing the mogha which reaches the field nakka outlet. The nakka discharge is divided by the mogha discharge and the quotient is multiplied by 100 to create a percentage value.

Cropped Area - The sum of the acreage under rabi or kharif crops in a watercourse command area.

Cropping Intensity - The number of crops grown on a given field in a given year times 100 to express a percentage value. Applied to a farm, it is the acreage of all crops grown in a year divided by the area on which they were grown times 100.

Cropping Pattern - The combination and sequence of crops grown on a given farm over a years' time.

Cross Cutting Cleavage - Opponents on one conflict issue are allies on other conflict issues. Makes for cooperation and negotiability of issues.

Cultural Command Area - The cultivated area of a watercourse command area which can be served by gravity irrigation.

Cutthroat Flume - A water measuring flume device especially suited for low gradient watercourse channels.

Delivery Efficiency -- See Conveyance Efficiency.

Delta - Amount of water applied for an irrigation.

Depth of Application - The average depth of water applied to a field obtained as the product of nakka discharge (in cusecs) times the time of application in hours divided by the area irrigated in acres.

Discharge - the volumetric rate of water flow or delivery, expressed as cubic feet per second (cusec)

Discharge Factor - The mogha outlet design capacity from distributary to watercourse expressed as discharge per 1000 acres of command area.

Distributary - The smallest water channel maintained by the government. The size hierarchy of channels would be, in descending order, major canal, minor canal, distributary. Moghas may be placed on any of these channels.

Duty - The area irrigated per unit of water per season of the year.

Evaporative Moisture Deficit - Estimated annual atmospheric evaporation.

Evapotranspiration - The total water lost to the atmosphere via evaporation and plant transpiration.

Farm Irrigation Efficiency - The proportion of water, passing the mogha, which is stored in the root zone of a crop, calculated as the product of the conveyance efficiency and application efficiency times 100 to create a percentage value.

Gross Command Area - The portion of the entire village area that is commanded by gravity canal irrigation; includes roads, schools, graveyards, canals, etc.

Groundwater Recharge - Deep percolation which replenishes the water table.

Headworks - A division with controllable gates on a major canal dividing water into two or more minors.

Landlord - Owner of land who does not cultivate the land.

Link Canal - Largest of the canals -- each carries water from the western to eastern rivers as part of the Indus Basin Replacement Project mandated by the Indus River Treaty with India (1960).

Local (person) - Person living, or whose family has lived, at present location since before partition of British India into India and Pakistan.

Minor - A water supply canal smaller in discharge than a major canal but greater in capacity than a distributary.

Non-perennial - A single season, kharif, water supply situation for a watercourse command area.

Overlapping Cleavage - Opponents on one conflict issue are opponents on all conflict issues. High polarization. Issues become difficult to negotiate. Hurts cooperation.

Percolation - The downward movement of water through soils.

Perennial - A year round water supply situation for a watercourse command area.

Persian Well - A water lifting device used on a deep open well comprised of a chain of buckets or earthen pots powered by a pair of bullocks or a camel moving in a horizontal circle.

Potential Evapotranspiration - The maximum evaporative demand which a given climate can place on a given crop when there is no constraint on water availability and crop maturity.

Private Tubewell - A small discharge irrigation well individually or jointly owned by farmers

Province - Administrative unit such as Sind, Baluchistan, Punjab and Northwest Frontier areas.

Public Tubewell - Large discharge tubewells installed and operated by WAPDA and Irrigation Department.

Refugee - Person displaced from India at partition.

Saline Soil - Soil which contains a sufficient percentage of soluble (non-sodium) salts to impair crop growth.

SCARP - Acronym for the Salinity Control and Reclamation Project areas where public tubewells are used for lowering watertables and augmenting water supplies.

Seepage- The lateral movement of water through soils.

Soil Moisture Deficiency - Estimated inches of soil moisture depleted due to evapotranspiration.

Tenant - A non-landowner who cultivates a block of land on a share-cropping basis with a landlord.

Time of Application - The duration of an irrigation application of turn.

Tubewell - An irrigation well.

Union Council - A governmental subdivision of a tehsil comprised of approximately 8 to 10 villages.

WAPDA - Acronym for the Water and Power Development Authority - a government corporation.

Watercourse - A water supply channel placed on a 16 foot wide government right of way, constructed and maintained by farmers to deliver water from a mogha outlet to a farmers field ditch.

Watercourse Command Area - The area served by the water passing through an authorized mogha.

Waterlogging - Soil condition where water table is at or above the ground surface.

GLOSSARY OF URDU/PUNJAB AND LOCAL ENGLISH TERMS

Abadi - Land set aside for a village site.

Abiana - Water rate.

Agricultural Assistant - Supervisor of field assistant level extension workers in the Agricultural Extension system. Usually has a Bachelor of Science degree in agriculture.

Bagh - Orchard.

Bajra - Spiked millet.

Bakhsheesh - Gratuity.

Barani - Rainfed cropping.

Berseem - Egyptian clover.

Bhusa - Wheat straw used as animal feed.

Biradari - A brotherhood lineage group of families related through brothers, sons and uncles within the same caste. Typically members take common interests on issues.

Bund - Small earth ridge.

Caste - Ancestral, occupational grouping of people implying prestige gradations.

Chaj Doab - Land between Jhelum and Chenab Rivers.

Chak - Block of land set aside as smallest administration unit.

Chula - Earthen hearth.

Crore - Ten million, 100 Lakh.

Dab - Preplanting, irrigation and cultivation to control weeds.

Deh - Administrative division below Tehsil.

Deputy Commissioner - Administrative officer at the district level.

Desi - Indigenous, unimproved.

District Revenue Collector - Revenue officer for the District Revenue Department.

Divisional Canal Officers - Administrative head of a divisional branch of a canal command system.

Doab - Land between two rivers in Punjab.

Executive Engineer - Mid-level Irrigation Department or WAPDA Official.

Field Assistant - Local lowest level extension worker, education usually 10th class plus one or two years of general training in agriculture.

Fasalana - Payment for reduced water rates.

Guara - Cluster bean.

Gur - Indigenously prepared country sugar.

Gunta - 1/40 of an acre.

Halqa - Circle of villages of which a canal patwari is in charge to make water dues assessments.

Hakim - Local doctor.

Hari - Share cropper or tenant.

Henna - English translation "Myrtle" and known by botanical name Lawsonia alba. Used as a local orange dye.

Hukka - Waterpipe.

Hul - Local plow.

Jhallar - Persian well adapted to low water lifts.

Jhenab - Land unit used in Sind for one-half acre.

Jowar - Sorghum.

Kacha - Unripe, unimproved, earthen, random, poor quality.

Kanal - 1/8 of an acre.

Kassi - Hoe-like shovel used by irrigators.

Khal - Watercourse, conducts water from mogha to fields.

Khati - Process of removing silt from the watercourse.

Kharaba - Crop failure, declaration for reduced water rates.

Kharif - Warm season cropping, approximately April-October.

Khasrah - Register on revenue due on units of land.

Kiari - System recommended by Agriculture Department for compartment of a field into very small basins for irrigation.

Killa - Area of land equal to 1.11 acre.

Kistiwar - Random layout of land in bunded units.

Karah - Indigenous two team bullock pulled scraper for moving earth.

Karahi - Same as karah but powered by one bullock team.

Lakh - One hundred thousand.

Lucerne - Alfalfa.

Mal - Property.

Mandi - Chartered market center.

Maraba - A square of land made of 25 parcels, usually acres or squares.

Marla - 1/160 of an acre; 1/20 of a kanal.

Muhavir - Person or family migrated from India.

Maund - Unit of measure, 82.3 pounds equivalent to 40 seers.

Mauza - Village, smallest division of government.

Moeen - Non-agricultural castes who perform services for a share of agricultural produce (also kami).

Mogha - An ungated outlet of fixed size passing water from irrigation canal to a watercourse.

Mukamis - Local resident.

Nakka - Outlet from branch watercourse; inlet to a field.

Numbardar - Village headman -- function of government who collects land revenues.

Nikal Water - Water left in watercourse at the end of a complete rotation of warabundi.

Overseer - Irrigation Department functionary over patwari, responsible for maintenance and repair of moghas.

Pansal Nawees - Irrigation Department gate keeper.

Pahar - Turn of water of five hours.

Patwari - Title of revenue officer for Irrigation Department and Land Revenue Department.

Patti - Division of a village under the responsibility of a numbardar or village leader.

Pora - Seed tube attached behind plow for seeding crops.

Pucca - Ripe, improved, concrete, specified to order, high quality.

Parchas - Chits of paper used for notifying farmer of revenue assessments.

Rabi Hul - Bullock pulled mouldboard plow.

Rabi - Cool season cropping; approximately November-March.

Rauni - Presowing irrigation.

Rechna Doab - Land between Ravi and Chenab rivers.

Rej - Irrigation prior to land preparation.

Rosewari - Irrigation schedule to a particular block of land on a particular day.

Saip System - Traditional system by which village artisans exchange their goods and services with landed agriculturalists for a portion of the crop.

Sarkari Khal - Watercourse constructed by farmers on a 16 foot right-of-way provided by the government for the purpose of conducting water from the mogha outlet to the individual farmers field ditches.

Seer - Unit of measure, smaller than kilogram, 2.08 lb. Forty seer equal one maund.

Sem - Waterlogged soil condition.

Shamlat - Village common land usually used for grazing.

Sohaga - Wooden plank or beam drawn by bullocks used in land preparation.

Square - 25 acre, 27.5 acre of 16 acre block of land depending on location.

Subdivisional Officer - Irrigation Department Official under the Executive Engineer.

Superintending Canal Engineer - Irrigation engineer who heads up a canal command hydrologic unit.

Tehsil - A sub-unit of a district.

Tehsildar - Official at Tehsil level.

Thal Doab - Land between Indus and Jhelum rivers.

Thur - Salinized soil condition.

Tonga - Horse drawn two-wheeled carriage.

Union Council - Political subdivision of a tehsil.

Vattar - Farmers' concept of optimum soil moisture condition for plowing.

Wahn - Watering of a field for first ploughing for seedbed preparation.

Warabundi - Schedule of irrigation turn rotations agreed to by farmers either informally (katcha warabundi) or under formal agreement through the Irrigation Department (pucca warabundi).

Warashikni - Taking irrigation water out of turn.

Zilladar - Junior member of Superior Revenue establishment of Irrigation Department.

Zamin - Land

Zamindar - Landholder - farmer