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Farm Irrigation Constraints and Farmer's Responses: Comprehensive Field Survey in Pakistan

VOLUME-IV

MAJOR CONSTRAINTS CONFRONTING FARMERS EXPLAINING THE CONSEQUENT LOW CROP YIELDS

Prepared under support of
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SEPTEMBER, 1978

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No. MP/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. 204-76-1 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.

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

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

ABSTRACT

The preceding Volume III has examined physical, agronomic, and socio-economic factors that operate to undercut agricultural productivity. This volume presents an examination of factors associated with low crop yields with an emphasis on farmer perceptions. Farmers were asked, "Would you describe the major factors which limit your present crop yields?" Farmers were forthright in identifying constraints. The farmer perceives water, more particularly, lack over control of water quantity and timing as a major constraint. Also revealed are problems with credit, lack of information about key soil/plant/water relationships, lack of knowledge about the magnitude of water lost in conveyance and overirrigation, inaccessibility of information and services from government organizations and absence of local organization at the village level to deal with constraints.

Crop yield data, when examined in relation to several constraints, indicate the importance of farm location, water availability, uncertainty of irrigation supplies, unlevel fields, waterlogging and salinity, and climate-soil conditions. Several agronomic and economic constraints such as availability and utilization of major physical inputs and credit are examined. A section is included on the utilization of recommended practices and improved farm techniques and farmer adaption behavior. This material is followed by a description of knowledge and information constraints facing farmers, related to irrigation practices, cropping decisions, and institutional services. The volume concludes with a section describing institutional and organizational constraints. These relate to the irrigation law and regulations, underorganization of farmers,

lack of farm level institutional services, conflict and non-cooperation, and the importance of the distribution of social power and influence.

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 substantia 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.

INDIVIDUALS WHO PROVIDED ADMINISTRATIVE SUPPORT OR FIELD ASSISTANCE

Mohammad Ashraf

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Barkat Ali Khan

Nazir Ahmad

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Zahid Sayeed Khan

Mohammad Nawaz Bhutta

Mohammad Farooq Khan Niazi

Mohammad Nisar

Peter Joseph

Mohammad Razzaq Bhatti

Mohammad Ali Bhutta

Aksir Ahmad Janjua

Mohammad Iqbal Gill

Mohammad Hanif Balouch

Ashraf Din

Mohammad Aslam Bashir

Ali Mohammad

Lutif Ali Khokher

Mohammad Zahid

Sheikh Inayat Ullah

Mohammad Zafar Khan

Mumtaz Ali Burriro

Khizar Hayat

Badar Din

Mohammad Saleem Bashir

Mohammad Ramzan

Mohammad Arshad

Abdul Razzaq

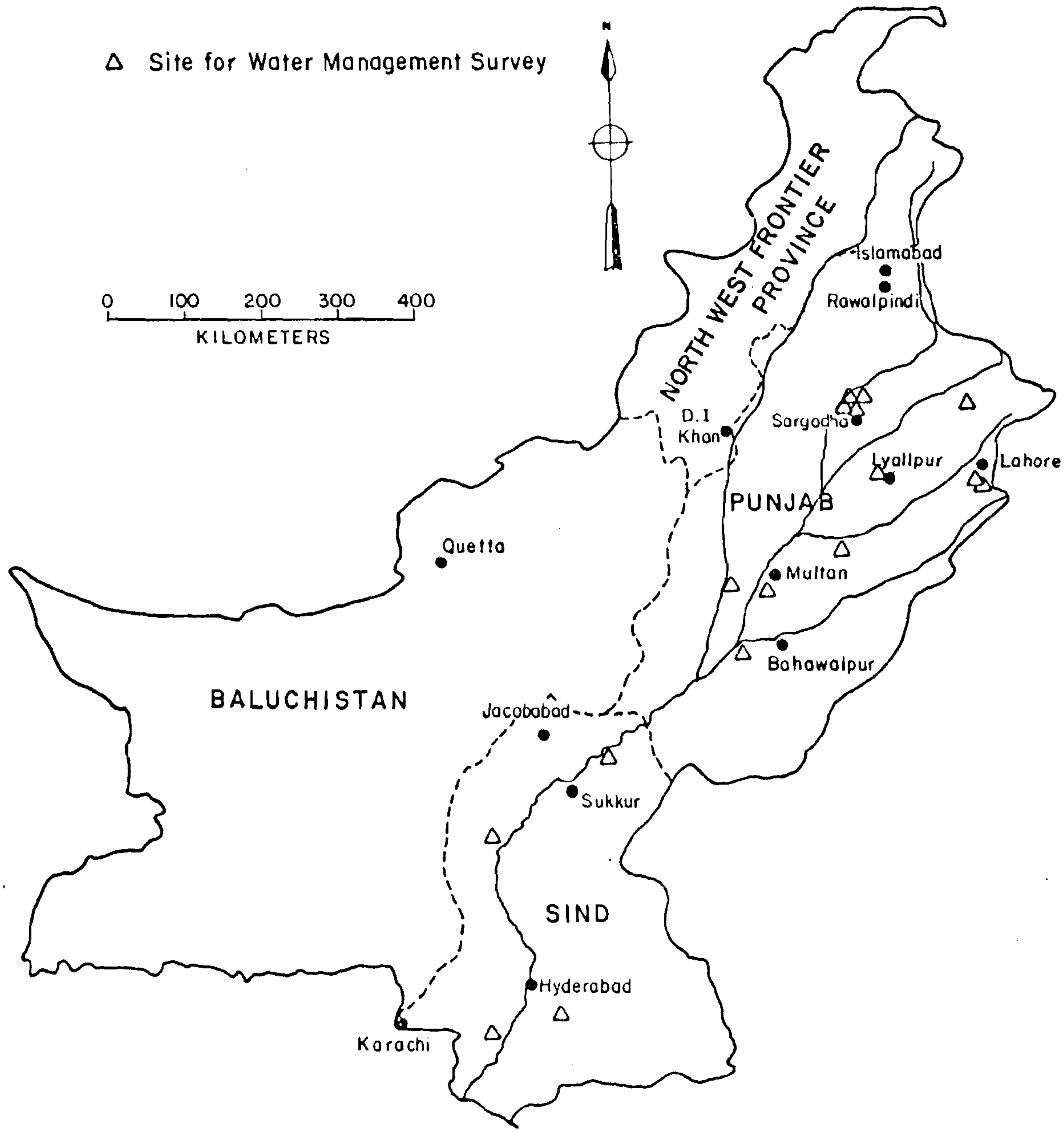

Figure 1. Distribution of 16 field survey sites.

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CHAPTER ONE

INTRODUCTION: FARMER PERCEPTION OF CONSTRAINTS

Preceding sections have presented analyses which demonstrate: 1) that much water is lost in conveyance through watercourses--overall approximately 33 percent per thousand feet; 2) that water is frequently mal-distributed making for much over and underirrigation; 3) that cropping intensities vary directly with water supplies; and 4) that crop yields are direct functions of water and fertilizer availabilities. Yet, what of farmer perceptions? How important are water problems as perceived by farmers?

Sample farmers were asked which problem, among a list of farm problems, posed the most important constraint to increased agricultural production on their farms. Figure 2 displays the overall distribution of farmer responses. Farmers identify problems with water to be the most limiting factor in their attempts to increase agricultural production--by almost three to one they single out water problems as more constraining than all other farm problems combined.[1/]

If one examines Figure 2 data relative to farmer watercourse position, the strong tendency to identify water problems as the major farm constraint holds up. Even farmers located at "head" positions, where, presumably, water supply problems are less severe, selected water problems over all other farm problems combined by a 1.8:1 ratio (See Table 1). Table 1 makes it clear, however, that there is a tendency to be more concerned about water constraints as one moves away from the mogha to "middle", "tail" and "multiple" watercourse positions.

1/There is reason to believe that farmers tended to inflate water problems relative to other farm problems given that respondents knew that researchers were associated with a water management project.

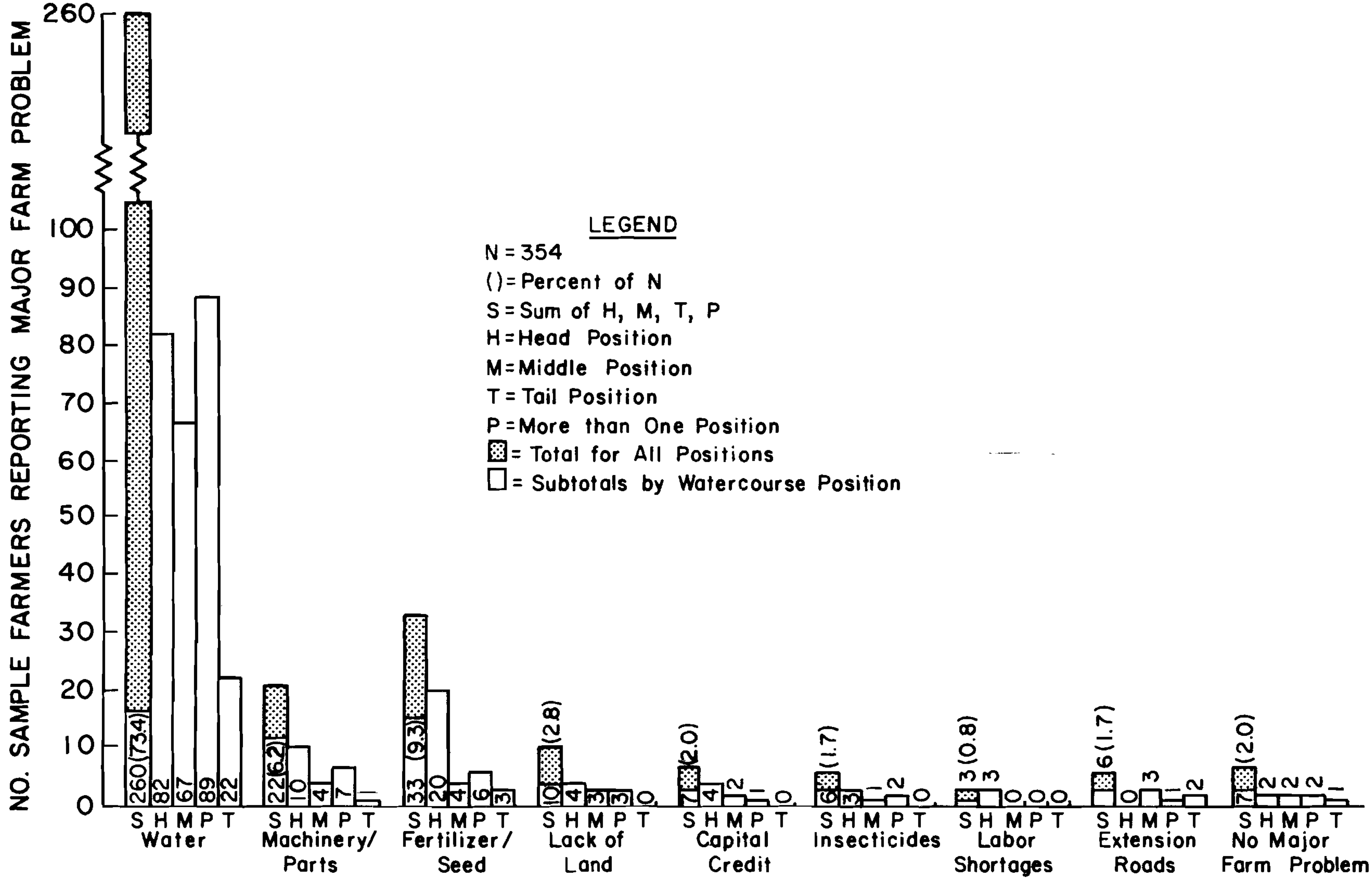

FIGURE 2. SAMPLE FARMER PERCEPTION OF MAJOR CURRENT FARM PROBLEM BY POSITION OF LANDHOLDING ON WATERCOURSE

Table 1. Farmer perception of major current farm problem by watercourse position.

Watercourse position	Ratio of sample farmer selected water problems vs. all other farm problems combined.*
Head	1.8:1
Middle	3.5:1
Tail	3.1:1
Multiple Positions	4.1:1

*Ratios constructed from Figure 2 data.

A detailed breakdown of farmer perceptions is afforded by Table 2 which reveals the effect of canal type (perennial/nonperennial) and the presence of tubewells along with watercourse position. Where there is no tubewell supplementation of canal supplies, farmers display an increasing tendency to perceive water as the major problem as they shift to locations away from the mogha. Looking down the columns of Table 2 it becomes clear that farmers on nonperennial canals, who are not served by tubewells to supplement canal supplies, display a distinctly heightened tendency to perceive water problems as their most critical. This is most easily observed by examining the ratios recorded at the bottom of each Table 2 column. Each ratio is simply a statement of the proportion of the farmers identifying water as the major problem relative to the proportion of farmers identifying all other farm problems combined.

If one takes the next step and compares farmers of the two extreme categories--those on perennial watercourses plus tubewell supplementation as against those farmers on watercourses with only seasonal canal supply

Table 2. Farmer perceptions of major farm problem by watercourse position controlling for canal type and presence of tubewell

Major Farm Problem	PERENNIAL CANALS										NONPERENNIAL CANALS										Row Total
	With Tubewells					Without Tubewells					With Tubewells					Without Tubewells					
	Head	Middle	Tail	Multiple Position	Total	Head	Middle	Tail	Multiple Position	Total	Head	Middle	Tail	Multiple Position	Total	Head	Middle	Tail	Multiple Position	Total	
Water	30	29	30	1	90	23	21	31	11	86	16	9	12	4	41	12	8	16	6	42	259
(percent)	(12.3)	(11.9)	(12.3)	(.41)	(36.9)	(9.4)	(8.6)	(12.7)	(4.5)	(35.2)	(16)	(9)	(12)	(4)	(41)	(12)	(8)	(16)	(6)	(42)	(75.3)
Machinery/ Parts	9	2	5	0	16	0	0	1	1	2	0	2	0	0	2	1	0	1	0	2	22
(Percent)	(3.7)	(.82)	(2.1)	-	(6.5)	-	-	(.41)	(.41)	(.82)	-	(2)	-	-	(2)	(1)	-	(1)	-	(2)	(6.4)
Extension/ Roads	0	0	1	0	1	0	3	0	1	4	0	0	0	0	0	0	0	0	1	1	6
(percent)	-	-	(.41)	-	(.41)	-	(1.2)	-	(.41)	(1.6)	-	-	-	-	-	-	-	-	(1)	(1)	(1.7)
Fertilizer/ Seed	4	3	5	0	12	5	1	1	2	9	1	0	0	1	2	1	0	0	0	1	24
(percent)	(1.6)	(1.2)	(2.1)	-	(4.9)	(2.1)	(.41)	(.41)	(.82)	(3.7)	(1)	-	-	(1)	(2)	(1)	-	-	-	(1)	(7.0)
Insecticide	2	1	2	0	5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	6
(percent)	(.82)	(.41)	(.82)	-	(2.1)	-	-	-	-	-	-	-	-	-	-		-	-	-	( )	(1.7)
Capital/ Credit	0	2	0	0	2	1	0	1	0	2	2	0	0	0	2	0	0	0	0	0	6
(percent)	-	(.82)	-	-	(.82)	(.41)	-	(.41)	-	(.82)	(2)	-	-	-	(2)	-	-	-	-	-	(1.7)
Labor Shortage	0	0	0	0	0	2	0	0	0	2	1	0	0	0	1	0	0	0	0	0	3
(percent)	-	-	-	-	-	(.82)	-	-	-	(.82)	(1)	-	-	-	(1)	-	-	-	-	-	(.9)
Lack of Land	3	1	1	1	6	1	2	0	0	3	0	0	2	0	2	0	0	0	0	0	11
(percent)	(1.2)	(.41)	(.41)	(.41)	(2.5)	(.41)	(.82)	-	-	(1.2)	-	-	(2)	-	(2)	-	-	-	-	-	(3.2)
No Major Problem	0	0	0	1	1	1	2	0	0	3	1	0	2	0	3	0	0	0	0	0	7
(percent)	-	-	-	(.41)	(.41)	(.41)	(.82)	-	-	(1.2)	(1)	-	(2)	-	(3)	-	-	-	-	-	(2.0)
Column Total	48	38	44	2	133	33	29	34	15	111	21	11	16	5	53	15	8	17	7	47	
(percent)	(20.1)	(15.6)	(18.0)	(.82)	(54.5)	(13.5)	(11.9)	(13.9)	(6.1)	(45.5)	(21)	(11)	(16)	(5)	(53)	(15)	(8)	(17)	(7)	(47)	

PERENNIAL N = 244

NONPERENNIAL N = 100

TOTAL N = 344

Ratio of Water Problems to all Other Problems Combined: 3.4:1 | 3.4:1 | 8.4:1

and no tubewell supplementation--it can be observed that the latter are much more likely to perceive their major farm problem to be associated with water (see Table 3). As Table 3 indicates, sample farmers on perennial watercourses supplemented by public tubewells are more likely to identify nonwater problems as their major problem. Yet, the majority of farmers experiencing the relatively favorable water supply conditions still specify water problems to be their major constraint to improved agricultural production.

An examination of perceptions of farm problems by size of farmer landholdings reveals that respondents in all size categories select water problems as those most important (see Table 4). Looking down the columns of Table 4, the tendency to perceive water problems as the most important holds up by wide margins across all size categories. In no category is the relationship reversed. Whereas water problems outweigh all other nonwater problems in the perceptions of farmers of all four categories, the ratios of water to nonwater problems jump in a major way among farmers on nonperennial canals with no tubewell supplementation.

If water problems are viewed to be central, a further question is in order. What specific water problems do sample farmers tend to perceive as being most important? Figure 3 displays the overall pattern of sample farmer perceptions. Approximately 47 percent more farmers report their major problem to be insufficient mogha (outlet) discharge into the watercourse than all other water problems combined. Only one in eight farmers perceives the major water problem to be associated with watercourse losses, and about one in ten sees the major problem to be dead storage losses in poorly constructed watercourses. Sample

Table 3. Sample farmer perceptions of major farm problems by watercourse position comparing farmers with perennial supplies and public tubewells to farmers with nonperennial supplies and no tubewells.

	Perennial Public Tubewell Only				Nonperennial No Tubewell				
	Head	Middle	Tail	Multiple Positions	Head	Middle	Tail	Multiple Positions	Total
Water Problems	6	4	5	0	12	8	16	6	57
(percent)	(7.9)	(5.3)	(6.6)	(0)	(15.8)	(10.5)	(21.1)	(7.9)	(75.0)
Nonwater Problems Combined	6	5	3	0	3	0	1	1	19
(percent)	(7.9)	(6.6)	(3.9)	(0)	(3.9)	(0)	(1.3)	(1.3)	(25.0)
	12	9	8	0	15	8	17	7	76

Table 4. Sample farmer perceptions of major farm problems by size and land holdings (acres) controlling for canal type and tubewell supplementation of canal water.

Major Farm Problem	Nonperennial												Perennial											
	With Tubewells						Without Tubewells						With Tubewells						Without Tubewells					
	< 2.4	2.5 7.4	7.5 12.4	12.5 24	25 +	Total	< 2.4	2.5 7.4	7.5 12.4	12.5 24	25 +	Total	< 2.4	2.5 7.4	7.5 12.4	12.5 24	25 +	Total	< 2.4	2.5 7.4	7.5 12.4	12.5 24	25 +	Total
Water	12	11	8	9	1	41	19	7	8	8	0	42	6	26	27	17	14	90	18	25	22	19	2	86
(percent)	(12)	(11)	(8)	(9)	(1)	(41)	(19)	(7)	(8)	(8)	(0)	(42)	(2.49)	(10.8)	(11.2)	(7.1)	(5.8)	(37.5)	(7.5)	(10.4)	(9.1)	(7.9)	(.81)	(35.7)
Machinery/ Parts	2	0	0	0	0	2	0	1	1	0	0	2	1	3	3	1	8	16	0	1	0	1	0	2
(percent)	(2)	-	-	-	-	(2)	(0)	(1)	(1)	(0)	(0)	(2)	(.41)	(1.2)	(1.2)	(.41)	(3.3)	(6.6)	-	(.41)	-	(.41)	-	(0.8)
Extension/ Roads	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	3	1	0	4
(percent)	-	-	-	-	-	-	-	-	-	(1)	-	(1)	-	-	-	(.41)	-	(0.4)	-	-	(1.2)	(.41)	-	(1.7)
Fertilizer/ Seed	0	0	0	2	0	2	0	1	0	0	0	1	0	3	3	4	2	12	1	5	2	1	0	9
(percent)	-	-	-	(2)	-	(2)	-	(1)	-	-	-	(1)	-	(1.2)	(1.2)	(1.7)	(0.8)	(5.0)	(.41)	(2.1)	(.81)	(.41)	-	(3.7)
Insecticides	0	0	0	0	0	0	1	0	0	0	0	1	0	2	0	0	1	3	0	0	0	0	0	0
(percent)	-	-	-	-	-	-	(1)	-	-	-	-	(1)	-	(.81)	-	-	(.41)	(1.3)	-	-	-	-	-	-
Lack Land	0	0	2	0	0	2	0	0	0	0	0	0	2	0	2	0	1	5	2	0	0	1	0	3
(percent)	-	-	(2)	-	-	(2)	-	-	-	-	-	-	(.81)	-	(.81)	-	(.41)	(2.1)	(.81)	-	-	(.41)	-	(1.2)
Capital/ Credit	1	0	0	1	0	2	0	0	0	0	0	0	0	0	0	1	1	2	0	1	1	0	0	2
(percent)	(1)	-	-	(1)	-	(2)	-	-	-	-	-	-	-	-	-	(.41)	(.41)	(0.8)	-	(.41)	(.41)	-	-	(0.8)
Lack Labor	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
(percent)	-	-	-	(1)	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(.81)	(0.8)
No Problem	1	1	0	1	0	3	0	0	0	0	0	0	0	0	0	1	0	1	0	2	1	0	0	3
(percent)	(1)	(1)	-	(1)	-	(3)	-	-	-	-	-	-	-	-	-	(.41)	-	(0.4)	-	(.81)	(.41)	-	-	(1.2)
Column Total	16	12	10	14	1	53	20	9	9	9	0	47	9	34	35	25	27	120	21	34	29	23	4	111
(Percents)	(16)	(12)	(10)	(14)	(1)	(53)	(20)	(9)	(9)	(9)	-	(47)	(3.7)	(14.1)	(14.5)	(10.4)	(11.2)	(53.9)	(8.7)	(14.1)	(12.0)	(9.5)	(1.7)	(46.1)
	NONPERENNIAL N = 100												TOTAL N = 341						PERENNIAL N = 241					
Ratio of Water Problems vs. All Other Problems Combined			3.4:1						8.4:1						2.3:1						3.4:1			

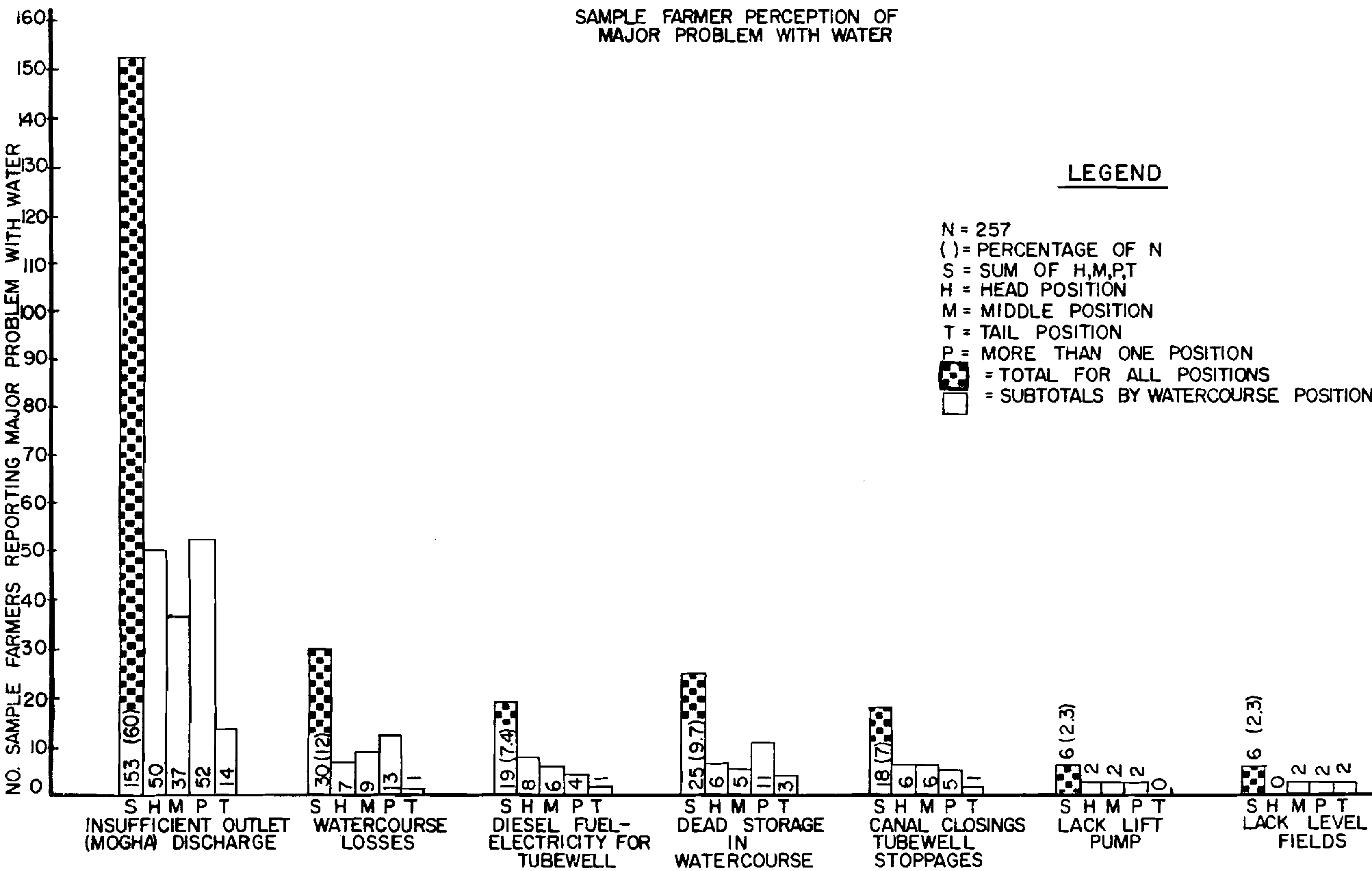

FIGURE 3. FARMERS REPORTING SPECIFIC WATER PROBLEM.

farmer perceptions tend to emphasize the problem of mogha supply and to be directed away from watercourse channel losses. Programs for watercourse reconstruction and improvement will need to overcome this bias in perception.

The strong tendency to see the problem of water to be inadequate mogha discharge holds up even when the data are examined by the type of canal (perennial/nonperennial), presence of tubewells, and watercourse position as revealed by Table 5. Looking down each of the columns, one can determine that "insufficient mogha discharge" receives a greater frequency of endorsement than all other water related problems combined. Ratios, expressing the relative proportions of farmers selecting "insufficient mogha discharge" as their major water problem vs. those selecting all other water problems, are found at the bottom of each of the four column categories in Table 5. It is clear, as might be expected, that farmers on nonperennial canal commands and who are not served by tubewells of any type, are more prone to express their major water problem in terms of insufficient discharge, but the difference is not statistically significant. Across all categories of farm position, farmers share a high propensity to see their problem as insufficient supply as opposed to better management of existing supplies. This is true of farmers at the "head" just as much as those who are located "downstream."

An interesting question suggests itself. Since farmers tend to be water quantity oriented in their perceptions, do those who experience the lowest delivery efficiencies tend to view water problems as having greater priority than do beneficiaries of higher delivery efficiencies? To answer this question, those farmers experiencing low farm delivery

Table 5. Sample farmer perceptions of which water problems most constrain increased agricultural production by watercourse position controlling for canal type and presence of tubewells.

If Major Farm Problem is Water Related, it is Specifically:	Watercourse Attribute: Nonperennial, With Tubewells					Nonperennial, Without Tubewells					Perennial, With Tubewells					Perennial, Without Tubewells					Row Total
	Head	Middle	Tail	Multiple Position	Total	Head	Middle	Tail	Multiple Position	Total	Head	Middle	Tail	Multiple Position	Total	Head	Middle	Tail	Multiple Position	Total	
Insufficient Mogha Discharge	8	4	8	3	23	10	7	13	2	32	21	15	18	1	55	11	11	13	8	43	153
(percent)	(9.8)	(4.9)	(9.8)	(3.7)	(28.1)	(12.2)	(8.5)	(15.9)	(2.4)	(39.0)	(12.1)	(8.6)	(10.3)	(0.6)	(31.6)	(6.3)	(6.3)	(7.5)	(4.6)	(24.7)	(59.8)
Diesel Fuel Electricity	4	0	1	0	5	1	0	0	0	1	3	6	2	1	12	0	0	1	1	2	20
(percent)	(4.9)	-	(1.2)	-	(6.1)	(1.2)	-	-	-	(1.2)	(1.7)	(3.5)	(1.2)	(0.6)	(6.9)	-	-	(0.6)	(0.6)	(1.2)	(7.8)
Watercourse Losses	3	2	1	0	6	0	0	1	1	2	3	6	6	0	15	1	1	5	0	7	30
(percent)	(3.7)	(2.4)	(1.2)	-	(7.3)	-	-	(1.2)	(1.2)	(2.4)	(1.7)	(3.5)	(3.5)	-	(8.6)	(0.6)	(0.6)	(2.9)	-	(4.0)	(11.7)
Unleveled Fields	0	0	0	1	1	0	1	0	0	1	0	1	2	0	3	0	0	0	1	1	6
(percent)	-	-	-	(1.2)	(1.2)	-	(1.2)	-	-	(1.2)	-	(0.6)	(1.2)	-	(1.7)	-	-	-	(0.6)	(0.6)	(2.3)
Lack Lift Pump	0	0	0	0	0	0	0	0	0	0	2	1	2	0	5	0	1	0	0	1	6
(percent)	-	-	-	-	-	-	-	-	-	-	(1.2)	(0.6)	(1.2)	-	(2.9)	-	(0.6)	-	-	(0.6)	(2.3)
Watercourse Dead Storage	0	1	1	0	2	1	0	0	2	3	0	0	0	0	0	5	4	10	1	20	25
(percent)	-	(1.2)	(1.2)	-	(2.4)	(1.2)	-	-	(2.4)	(3.7)	-	-	-	-	-	(2.9)	(2.3)	(5.7)	(0.6)	(11.5)	(9.8)
Canal Closings/ Tubewell shutdowns	1	1	1	0	3	0	0	2	1	3	0	1	0	0	1	4	3	2	0	9	16
(percent)	(1.2)	(1.2)	(1.2)	-	(3.7)	-	-	(2.4)	(1.2)	(3.7)	-	(0.6)	-	-	(0.6)	(2.3)	(1.7)	(1.2)	-	(5.2)	(6.3)
Column Total	16	8	12	4	40	12	8	16	6	42	29	30	30	2	91	21	20	31	11	83	
(Percent)	(19.5)	(9.8)	(14.6)	(4.9)	(48.8)	(14.6)	(9.8)	(19.5)	(7.3)	(51.2)	(16.7)	(17.2)	(17.2)	(1.1)	(52.3)	(12.1)	(11.5)	(17.8)	(6.3)	(47.7)	

Nonperennial N = 82 Total N = 256 Perennial N = 174

	Nonperennial With Tubewells	Nonperennial Without Tubewells	Perennial With Tubewells	Perennial Without Tubewells
Ratio of Insufficient Discharge Problem To All Other Problems Combined	1.4:1	3.2:1	1.5:1	1.1:1

efficiencies--defined as one half of a standard deviation below the sample mean or lower--were compared to farmers having farm delivery efficiencies one half of a standard deviation or more above the sample mean of all delivery efficiencies. The results of this comparison are displayed in Table 6. Inspection of Table 5 reveals a slight tendency for farmers suffering from "low" delivery efficiencies to give higher priority to water problems; yet, the difference is not statistically significant.

In sum, then, of all farm problems, water looms overwhelmingly as the perceived constraint to increased production. Water problems outdistance those associated with machinery and machinery parts, fertilizer, seeds, insecticides, lack of land and labor, and shortages of capital and credit. When investigators probed specific problems farmers claim to have with regard to water, sample farmers reveal a consistent tendency to view their problem as insufficient supply. Investigators may be impressed with the substantial losses from watercourses and over-irrigation, but farmers' perceptions are focused on obtaining greater supplies at the mogha. Problems associated with poor watercourse conditions, and consequent losses of water, take a subordinate position in the eyes of farmers across all watercourse positions, types of canal commands, and tubewell water availability categories. The obvious implication is that if farmers are to be effectively mobilized to undertake the arduous tasks of watercourse reconstruction and maintenance so as to improve relatively poor delivery efficiencies identified in foregoing volumes, farmers must be made aware of the significance of their losses in poorly constructed watercourses and in their fields.

Table 6. Sample farmer perception of major farm problem by farm delivery efficiency.

Farm Delivery Efficiency	Major Perceived Farm Problems							
	No Problem	Water	Capital/ Credit	Machinery/ Parts	Extension/ Roads	Fertilizer/ Seed	Insecticides	Labor
Low 1-34% 1/2 s.d. below sample mean	1 (.9)	46 (40.0)	1 (.9)	4 (3.5)	3 (2.6)	7 (6.1)	2 (1.7)	1 (.9)
High 76+% 1/2 s.d. above sample mean	3 (2.6)	34 (29.6)	1 (.9)	2 (1.7)	0 (0)	9 (7.8)	0 (0)	1 (.9)

N = 115
( ) = %

CHAPTER TWO

PHYSICAL CONSTRAINTS

Given the importance farmers place on water as a constraint to crop productivity, Chapter Two examines physical factors affecting water management. Central variables of interest here include: farm location, water availability, uncertainty of water delivery, levelness of fields, water adequacy and waterlogging.

I. PHYSICAL FARM LOCATION AND YIELDS

The location of a command area on a minor canal or distributary, and the location of farms on a given command, importantly affect water supplies. For example, site 104, with three command areas, has only one private tubewell. This site is also at the distributary tail. Average per acre yields for wheat, paddy rice, and cotton respectively are only 14, 15, and 3 maunds, due to canal water shortages. Even during kharif season, farmers were making cuts directly in the distributary to increase water supplies. Of 25 irrigation evaluations at this site, 18 were underirrigations resulting in a weighted mean field application efficiency of 91 percent. When examined in terms of the amount of water supplied relative to the soil moisture depletion, farmers applied 67 percent of the required water.

Crop yields on a given command area are related to the location of the farm. Since losses of irrigation water are a function of distance, farms at the tails of commands with high total losses often experience lower per acre yields than farms located at the heads of command areas. Table 7 provides information about effect of farm location on crop yields.

Table 7. Crop yields and location of farm on watercourse command reach.

Location of Farm on Command Area	Irrigation Efficiency (Ed x Ea) Mean	Median	Number of Farms	Wheat Md/Acre	Number of Farms	Rice Md/Acre	Number of Farms	Cotton Md/Acre
Head	47%	50%	111	20	25	20	55	11
Middle	41	43	94	19	43	20	39	10
Tail	32	35	37	22	11	13	22	6

Table 8. Control over water supplies and yields/acre of wheat and cotton.

Command Area Site and No. of Commands	Control over Supplemental water supplies (Tw=Tubewell)	Private Tubewell Density (Acres) CCA/TW	Wheat Yields Md/Acre	Cotton Yields Md/Acre
107-3wc	Very good (26 Tw)	79	30	13
102-1wc	Good (6 Tw)	87	24	11
114-4wc	Poor (2 Tw)	450	15	7

II. WATER AVAILABILITY AND CROP YIELDS

Chapter Four of Volume Three includes data showing the importance of the water supply situation for crop yields. At this point those findings are summarized. First, weighted average wheat yield per acre for 228 perennial command farms is 22 maunds as compared with only 17 maunds for the 94 farms on nonperennial commands. Likewise, rice yields are about 1 maund less on nonperennial commands and cotton yields are 3 maunds less for farms on nonperennial commands as compared with perennial commands. There is very little cultivation of rice or cotton on nonperennial commands except where there are public or private tubewells. Secondly, given the importance of water control for irrigating in accordance with crop needs, private tubewell owners have average wheat yields four maunds greater per acre than farmers who use public tubewells, and six maunds greater than farmers who use no tubewell water. In terms of rice yields, private tubewell farms have a weighted mean yield of 23 maunds/acre as compared to 19 maunds for farmers where there are public tubewell supplies and 14 maunds where there are no tubewells. Owners of tubewells have cotton yields of 13 maunds/acre as compared with 8 maunds for farmers with public tubewell supplies. Farmers with improved water supplies tend to utilize more fertilizer than other farmers. Tubewell owners, on the average, utilize about 20 to 25 percent more nitrogen than farmers with no tubewell supplies.

III. UNCERTAINTY OF DELIVERY

The uncertainty of delivery is greatest for farmers on nonperennial commands with no tubewell supplements to canal supplies. Sites 114 and 115 have such sample farms. The weighted average yield of wheat per acre is about 15 to 16 maunds as compared to an average of

22 maunds/acre for the 228 perennial farmers. Yet, uncertainty of water supplies on perennial commands is also substantial because farmers do not receive reliable information about canal openings or closures. The upper Indus Basin watercourse survey (Gibb, 1966: Vol. 10, p. 110) provides data about the frequency and pattern of canal closures. For 7 nonperennial commands, the average days the canal was open were 180, but the standard deviation is 40 days with a range of 124 to 228 days. The same type of variability is found on 13 perennial commands where the canals are opened for an average of 300 days a year with a wide range of 241 to 336 days. Yearly changes are substantial and the uncertainty of water delivery is great.

Closures for annual maintenance on perennial commands usually take place in December and January. Though not a bad time in respect to crop needs, the dates are not adequately announced nor are strict schedules maintained. Closures after heavy rains or during a flood are often necessary in July, August and September, but, farmers, of course, have no forewarning. Closures at other times for emergency repairs or shortages of water are unavoidable. When these take place in March, April, October and November at land preparation time, the impact is substantial on cropping decisions and crop yields. At one particular watercourse in another survey during a period of canal closure in rabi, 1974 (Lowdermilk, Clyma, Early), one of the authors received from the canal department a copy of the rationing schedule for farmers. The published schedule, however, was not followed.

As a means of overcoming uncertainty of delivery, farmers, who can, have installed private tubewells where groundwater quality permits. As an example of the importance of private tubewells, we cite the case of village 107 where there are 26 private tubewells, of which about 75 percent are owned jointly by small farmers. Except for one case, all these tubewells belong to the members of the same kinship group. The tubewell density on the three watercourse commands is one well per about 75 acres. Given the control over irrigation supplies, the weighted average yield per acre of wheat is 30 maunds for 52 farmers, and the average yield of cotton is 13 maunds per acre. No rice is cultivated by sample farmers at this site due to the lack of medium to fine loam and clay loam soils. These yields, with good water control, compared with average yields for perennial commands, are five maunds/acre higher for wheat and three maunds per acre higher for cotton (see Table 8). In Table 8 the crop yields of site 107, with good water control, are compared with two other command areas in the same agro-climatic zone with similar soils. The climatic region has an estimated annual atmospheric evaporative deficit of 60 inches. Site 102 is a cotton dominated command area in Multan District, as is site 107. The only difference between the sites is density of private tubewells. Site 114 is also a cotton dominant command area in the same climatic region located at Bahawalpar. It is a nonperennial area with a very low density of private tubewells.

In the comparison of these three types of commands the differences in yields are striking. These data show the importance of certainty of supplies of irrigation water. This not only influences yields per acre, but, as discussed earlier, also greatly influences cropping intensities. As one group of analysts states (World Bank, 1976: Vol. III, p. 1):

> Given these difficulties, it is not surprising that individual farmers are reluctant to invest in other material agricultural inputs necessary for acceptable yields because the basic input, water, is unreliable.

IV. UNLEVEL FIELDS AND CROP YIELDS

A major research need in Pakistan is related to benefits and costs of percision land leveling. It is surprising that little empirical data exist about the influence of land leveling on crop yields. Though we discuss the need for more level basins of irrigation, we have no primary data from this survey about yields of crops and precision land leveling. We, however, present available data to document the importance of the relationship of land leveling and crop yields.

One study (Wahla and Reuss, 1976) of measured field levelness, cotton stands, and yields, found that cotton yields were reduced by 50 percent or more by unlevel fields. The study revealed water applied to low elevation areas in fields was 4.65 acre inches more than the high elevation spot and 2.54 inches more than the middle elevation spot. The mean number of cotton stalks per 400 square feet was 124 at high elevations, 130 at middle elevations and 80 at low elevations. Likewise, yields in maunds per acre were 7.5 at high elevations, 8.1 at middle elevations and 3.8 at low elevations. Mean elevations between the high and low spots for this study were 4.65 inches with a range of 3.0 to 10.6 inches.

Though field levelness was estimated by sight in the Lower Indus Basin watercourse study in 1963-64 (MacDonald, 1966: Vol. I), the investigators found a relationship between crop yields for several crops and the leveling standard of fields. Their estimates are presented below in Table 9.

Table 9. Relationship between levelness and crop yields (maunds/acre).

Crop	Estimated leveling standard Poor	Fair	Good
Rice	7	13	32
Cotton	6	7	11
Wheat	6	14	14
Sugarcane	300	530	460

Though we are not sure what "poor," "fair" and "good" leveling is in actual inches of elevation difference, it is widely accepted that precision land leveling is related to improved crop yields. The Lower Indus study, using these crude estimates, reports that of 3850 acres observed, 32 percent were "poorly leveled," 60 percent were "fairly leveled" and only 8 percent were "well leveled." It can be argued that one can gain an approximation of field levelness by observing the patterns of water movement across fields, but this method is not always accurate.

Evaluations of fields after precision land leveling in Multan District, Mian Channu, the Shadab Project near Lahore and in Sargodha District have shown that there is a savings of from one-third to one-half the water on precision leveled fields as compared to traditional unlevel fields (Ali, Clyma, Ashraf, 1975: p. 27). Several studies have indirectly examined the influence of land leveling on yields but have not isolated its effect separate from other improved practices. For example, in a demonstration program near Lahore in 1974-75 rabi wheat season, several trials were conducted with a package of traditional practices versus a package of improved practices. The traditional practices were sowing with pora, low fertility of 50 lbs. of nitrogen and traditional irrigation practices. The improved package of practices was seeding with drill, high fertility (150 lbs. of N and 37 to 75 lbs. of $P_{20}S$) and irrigation applications according to soil moisture depletion. The various replications were on a farmer's field that had just been precision leveled before sowing within the tolerance of 0.1 foot from high to low elevation. The types of treatments and results are shown in Table 10 for Chenab 70 high yielding wheat variety sown on November 17 with a seed rate of 40 lbs. of seed to the acre.

Table 10. Mean yields of grain and amount of irrigation water used by wheat at Mohlinaal village (Lahore District) (rabi 1974-75).*

Treatment No.	Type Treatment	Acre inches irrigation water	Yield maunds/ acre	Maunds/ acre inch
1	Pora sowing low fertility (50 lbs N and 0.0 $P_{20}S$) traditional irrigation.	24.5	24.1	.98
2	Pora-low fertility-improved irrigation.	14.5	26.9	1.86
3	Broadcast, high fertility 155 lb N-split application 75 lbs $P_{20}S$ improved irrigation	14.5	46.2	3.19
4	Pora-high fertility-traditional irrigation	24.5	49.6	2.02
5	Pora-high fertility improved irrigation	14.5	53.2	3.67

*Department of Agriculture, Punjab, On-Farm Management Studies, Series No. 1, Lahore, Pakistan, November 1976. (Note the acre inches of irrigation water, do not include about three inches of rainfall.)

Actually only three factors were tested in this experiment. These were irrigation, fertility and sowing method. All plants were on a level field. We should note, however, the increase in yields due to fertilizer. Irrigation practices at treatment 5 provided 3.7 mds per acre inch of water applied compared with only 2 mds per acre inch for treatment 4 which differs only in irrigation practices.

Probably the most significant finding from these experiments is the savings in water between the traditional and the improved irrigations. Water as an input should be related to yield per acre in order to gain a realistic value of water. For example, if we estimate the cost of water at the farmer's field at Rs. 50 per acre foot the average savings in water between treatments 1 and 2 as well as 3 and 4 is Rs. 41.65 per acre (10" ÷ 12" = .83 x Rs. 50). Another lesson to gain from these trials is that land leveling alone is insufficient. Once fields are leveled farmers still must learn new management practices. It is also suggested from these data that farmers tend to overirrigate wheat.

While these data do not isolate the impact of land leveling on yields, they do indicate its importance. Research is sorely needed about the actual benefits in order to motivate farmers to adopt the practice. Experience indicates that land leveling can influence yields by producing increased uniformity of stands, greater uniformity of growth, and reduced fertilizer losses. Extra acres brought into production due to water savings also add to production. There must be some way to help farmers become more water conscious over time. Maunds of production per unit of water should become a standard method of discussing yields. If one can express yields in terms of nitrogen, one can also express yields in terms of units of water utilized.

V. WATER ADEQUACY AND YIELDS

The water adequacy measure has several limitations. A major weakness is that it does not reflect irrigation adequately throughout a given season. It only tells us how much the farmer may have irrigated at a given point in time. We will use this measure, however, where the weighted mean water adequacy values are 150 percent or more, and compare them to yields for three crops (see Table 11). All sites except sites 101 and 110 (Table 11) are public tubewell supplemented commands. Site 110 has a very high private tubewell density (27 TW for 1384 acres).

Sites where substantial overirrigation took place are compared with underirrigated sites as shown in Table 11. The major difference in yields/acre between the two groups is for the rice crop.

Table 11. Adequacy of irrigation and yields per acre.

Sites	No. Farms	Adequacy of irrigation	Wheat yields mds/acre	Rice yields mds/acre	Cotton yields mds/acre
101 - 1wc	5	153	27	13	7
109 - 2wc	12	234	16	15	7
116 - 4wc	21	276	9	13	-
105 - 1wc	5	321	25	15	5
110 - 2wc	27	167	15	23	-
Weighted Totals	71	220	15	17	2
All Other Commands Weighted	251	74	21	11	9

VI. WATERLOGGING AND YIELDS

Two sites, both perennial, where substantial waterlogging is evident are sites 113 and 116. At site 113, the four commands have serious waterlogging problems at the tail reaches. At site 116 waterlogging is a problem throughout the four command areas because the farmers have excess irrigation supplies throughout the year and excessive distributary elevation relative to fields leads to visibly evident seepage. In addition, the drainage system is not adequate. Yield data in Table 12 are only indicative since there are few head and tail cases, we cannot draw strong conclusions. In all cases, where we have data, with the exception of rice at site 116, the difference in head and tail yields are obvious. This suggests that waterlogging is usually greater at the tails of affected command areas than at the heads. More data, however, are required to ascertain the magnitude of waterlogging differences.

Table 12. Yields of head and tail farms on heavily waterlogged command areas.

Command sites	No. farms	Wheat yield mds/acre	No. farms	Rice yields mds/acre	No. farms	Cotton yields mds/acre
113 - 4 wc						
Head Farms	3	33.7	1	27.0	2	7.0
Tail Farms	7	28.0	1	13.0	3	2.1
116 - 4 wc						
Head Farms	2	10.0	6	10.7	0	-
Tail Farms	4	9.7	11	12.5	0	-

CHAPTER THREE

AGRONOMIC AND ECONOMIC CONSTRAINTS

Physical water supply constraint represent only one major set of problems confronting farmers in Pakistan.

Irrigation water management includes not only the more efficient conveyance and utilization of water, but also includes insuring the availability and proper utilization of crop inputs, extension services, and farm technology required for higher crop yields. Some of these inputs farmers can provide themselves, but most depend upon positive government policies and well organized services which reach effectively to the farm level. The agrarian structure, including tenure patterns and farm size, often influences the ability of farmers to obtain what services and inputs are available. Often, many of these factors are not included in an examination of irrigation systems, but they determine the success or failure of these systems at the farm level.

This chapter, therefore, presents a description of the magnitude of agronomic and economic constraints which presently confront sample farmers.

I. AVAILABILITY OF SELECTED INPUTS

The reports by sample farmers on availability of two crucial inputs, tubewell water and fertilizer, are presented graphically in Figure 4 by farm size category. This information and data displayed in Table 13 show a significant relationship between availability of both fertilizer and tubewell water and farm size (see Figure 4 and Table 13). The larger the farm size the more easily available is supplemental tubewell water--the same general relationship holds for fertilizer. Of the 24 farmers with 25 acres or more of land, 67 percent report tubewell water as easily available as compared to only

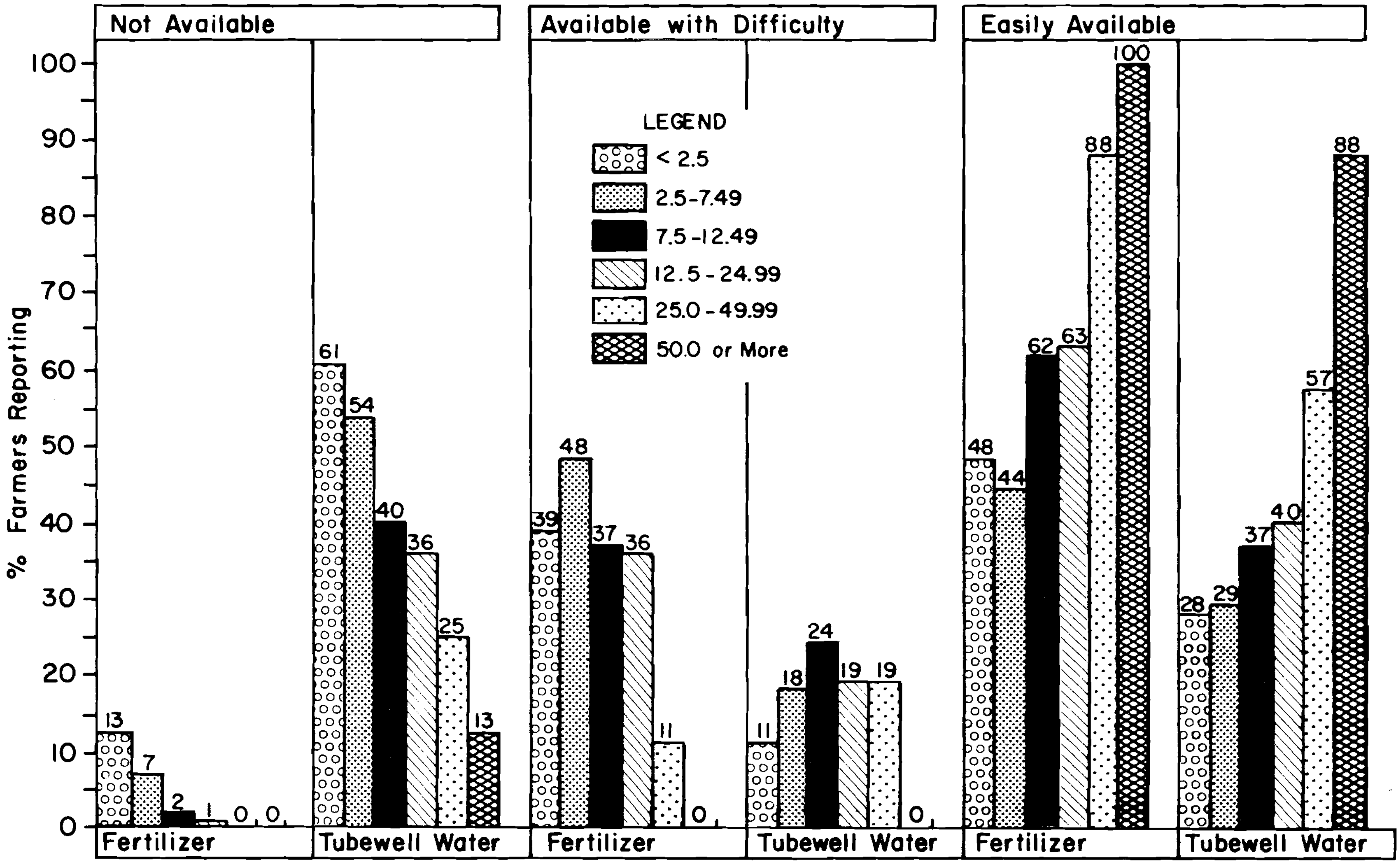

FIGURE 4. PERCENTAGE OF SAMPLE FARMERS REPORTING AVAILABILITY OF FERTILIZER AND TUBEWELL WATER

Table 13. Percentage of sample farmers reporting availability of fertilizer and tubewell water.

Farm Characteristics	Fertilizer				Tubewell Water			
	# of Farms	Not Available	With Difficulty	Easily Available	# of Farms	Not Available	With Difficulty	Easily Available
<u>Farm Size Class (Acres)</u>								
Under 2.5	72	12.5	38.9	48.6	62	61.3	11.3	27.4
2.5-7.49	97	7.2	48.5	44.3	91	53.8	17.6	28.6
7.5-12.49	100	2.0	36.0	62.0	95	40.0	24.2	35.8
12.5-24.99	87	1.1	35.6	63.2	80	36.2	18.8	45.0
25.0-49.99	17	-	11.8	88.2	16	25.0	18.8	56.3
50 or More	8	-	-	100.0	8	12.5	-	87.5
	(X^2=34.0)** d.f. = 10				(X^2=27.3)* d.f. = 10			
<u>Tenure</u>								
Owners	254	5.9	38.6	55.5	239	48.6	16.7	34.7
Owner-Tenants	56	3.6	35.7	60.7	52	36.5	25.0	38.5
Tenants & Contractors	71	2.9	36.6	60.1	61	40.7	18.6	42.6
<u>Weighted Totals</u>	381	5.0	37.8	57.2	352	45.2	18.2	36.6

* Denotes significance between .05 and .001
**Denotes significance at the .001 level or higher

about 30 percent of the farmers with under 12.5 acres of cultivated holdings. Figure 4 shows a small percentage of farmers who report that fertilizer is not available. While fertilizer is available somewhere at some price, these farmers report that due to a lack of capital and/or availability at the nearest agency, fertilizer is essentially unavailable to them at the time required.

Table 13 also shows availability of fertilizer and tubewell water by tenure groups. Little difference is shown in the availability of fertilizer and tubewell water by tenure groups. However, of the total 381 farmers reporting only 57 percent report fertilizer as "easily available." Reasons given for lack of fertilizer availability include its high cost and lack of credit, distance to agency and its frequent nonavailability at agencies when required. For the total sample, 45 percent of the farmers do not have tubewell water available and 18 percent report that it is available but with difficulty. Reasons given are lack of credit, heavy demand on private tubewells, topographical problems and distance from the tubewells to their farm plots.

Farmers were questioned about the availability of improved seed and pesticides. Seed availability refers primarily to high yielding wheat varieties and cotton seed of proven quality. Farmers frequently use their own seed or those available from other farmers; therefore, there is little difference as shown in Table 14 between farm size and land tenure classes in the availability of seed. Farmers tend to perceive that their own farm-produced seeds are of good quality. Seed quality, and services to improve the availability of improved seed, has been a problem in Pakistan over the years. Several studies have examined this problem in detail and have recommended action for improved seed production, standards, and distribution (Johnson, Douglas, 1970: Report 13).

Farmers consistently report that pesticides and insecticides are not available in the market (see Table 14). Sixty-three percent of the 339 reporting farmers state that insecticides are not available even if one has the capital to purchase them. Only about 54 percent of the larger farmers with 25 or more acres report that these inputs are easily available. Other studies (Mendivil, 1966) report that the availability and proper use of insecticides are a major problem, especially for rice and cotton farmers. Our purpose here is to present farmer's reports of availability and suggest that a problem exists.

II. AVAILABILITY OF CREDIT FOR SELECTED CROP INPUTS

Figure 5 and Table 15 present information about the availability of credit or capital for fertilizer, seed and pesticides by farm size classes. As expected, smaller farmers with under 12.5 acres of cultivated holdings, consistently face greater problems with credit for all inputs. However, farmers with 25 acres or more also face credit constraints. For example, of these larger farmers 68 percent report credit easily available for fertilizer. For seed and pesticide, there is no institutional credit available, so reports of availability refer to personal sources. As mentioned above, farmers do not perceive seed as a major problem since they use farm-produced seed. The capital or credit required for seed is usually very small in comparison with other inputs. However, for the total sample, only 32 percent of the sample farmers report that they have capital or can obtain credit from some source for the purchase of improved seed.

Table 14. Percentage of sample farmers reporting availability of improved seed and pesticide.

Farm Characteristics	Seed				Pesticides			
	# of Farms	Not Available	With Difficulty	Easily Available	# of Farms	Not Available	With Difficulty	Easily Available
Farm Size Class (Acres)								
Under 2.5	74	6.8	16.2	77.0	58	72.4	12.1	14.8
2.5-7.49	96	8.3	14.6	77.1	85	75.3	15.3	9.4
7.5-12.49	99	4.0	16.2	79.8	89	64.0	22.5	13.5
12.5-24.99	87	5.7	12.6	81.6	83	54.2	22.9	22.9
25.0-49.99	17	-	-	100.0	16	25.0	31.3	43.8
50 or More	8	-	-	100.0	8	12.5	12.5	75.0
					(X^2=41.6,10df)*			
Tenure								
Owners	255	6.7	14.1	79.2	227	60.8	19.8	19.4
Owner-Tenants	56	7.1	14.3	78.6	51	68.6	19.6	11.8
Tenants and Contractors	70	1.5	13.2	85.7	61	65.6	16.9	18.6
Weighted Totals	381	5.8	13.9	80.3	339	62.8	19.2	18.0

*Denotes significance at the .001 level or higher

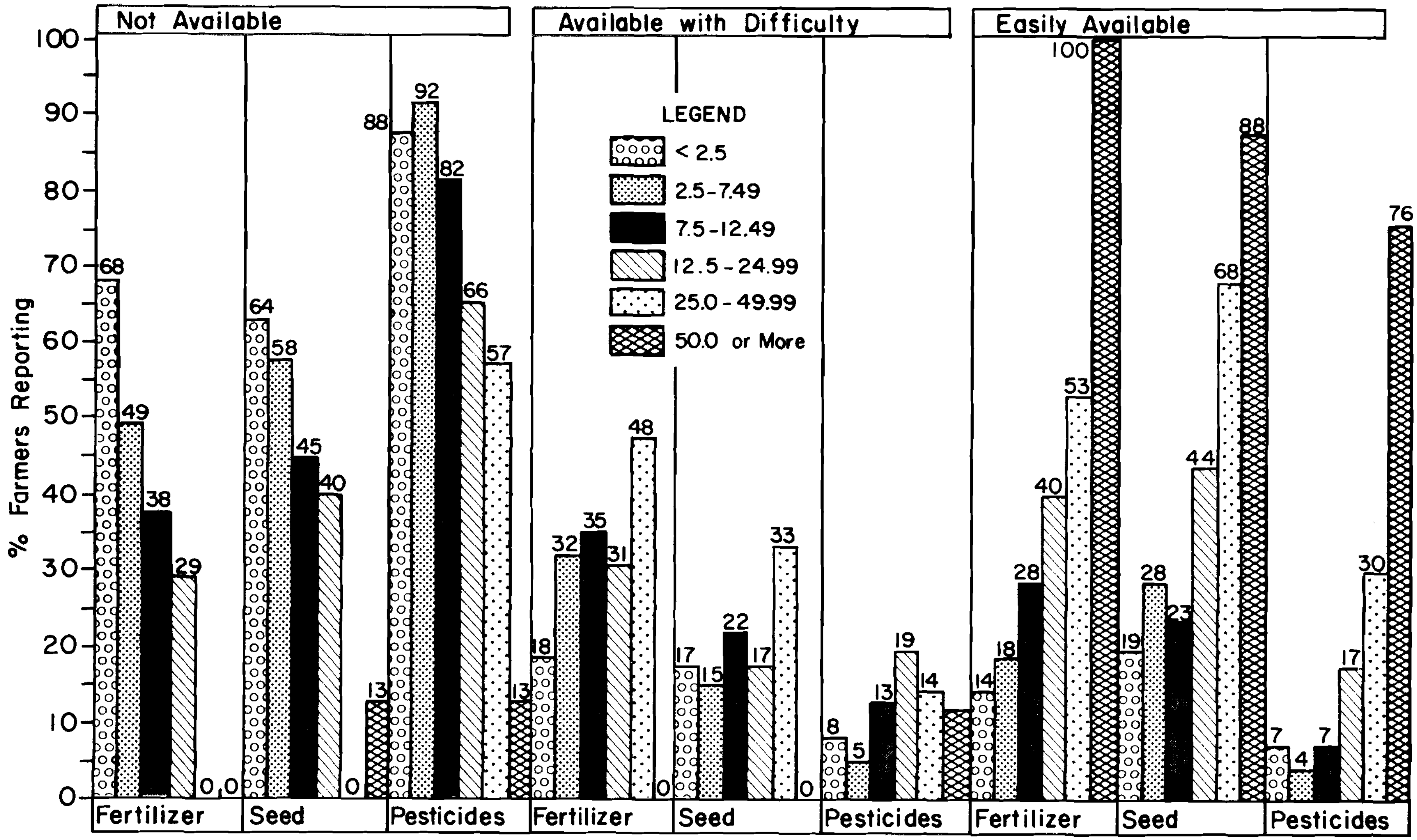

FIGURE 5. PERCENTAGE OF SAMPLE FARMERS REPORTING AVAILABILITY OF CREDIT FOR FERTILIZER, SEED AND PESTICIDES

Table 15. Percentage of sample farmers reporting availability of credit or capital for fertilizer, seed and pesticides.

Farm Characteristics	Fertilizer				Seed				Pesticides			
	# of Farms	Not Available	With Difficulty	Easily Available	# of Farms	Not Available	With Difficulty	Easily Available	# of Farms	Not Available	With Difficulty	Easily Available
Farm Size Class, Acres												
Under 2.5	71	67.6	18.3	14.1	66	63.6	16.7	19.7	67	86.6	7.5	6.0
2.5-7.49	93	49.5	32.3	18.3	88	56.8	14.8	28.4	86	90.7	4.7	4.7
7.5-12.49	95	37.9	33.7	28.4	85	54.1	22.4	23.5	90	80.8	13.3	6.7
12.5-24.99	82	29.3	30.5	40.2	78	39.7	16.7	43.6	75	65.3	18.7	16.7
25.0-49.99	17	-	47.1	52.9	15	-	33.3	66.7	14	57.1	14.3	28.6
50 or More	8	-	-	100.0	8	12.5	-	87.5	8	12.5	12.5	75.0
						$(X^2=41.8)$** d.f. = 10				$(X^2=60.7)$** d.f. = 10		
Tenure												
Owners	249	40.2	29.3	30.5	232	49.1	15.1	35.8	230	77.8	9.1	13.0
Owner-Tenants	52	38.5	44.2	17.3	48	43.8	33.3	22.9	53	81.1	15.1	3.8
Tenants & Contractors	65	54.0	18.5	30.2	60	58.3	16.7	25.9	57	77.2	16.4	7.3
						$(X^2=11.9)$* d.f. = 4						
Weighted Totals	366	42.1	29.5	28.5	340	50.0	17.9	32.1	340	78.2	11.2	10.6

* Denotes significance between .05 and .001

**Denotes significance of .001 or higher

As expected, there is a significant relationship between capital or credit availability for pesticides when needed and farm size.

Sample farmers were questioned about the availability of capital or credit for tractor hire and household use. Household use is included; because, especially for small farmers, it is difficult to segregate productive and consumptive uses of credit. Table 16 shows that the larger the farm size, the more easily available is credit or capital for tractor hire. With the tractor owners excluded, about 58 percent of farmers with 25 or more acres report "easily available" while only 11 percent of farms with less than 25 acres in cultivated holdings give this report. For smaller farmers and tenants, capital or credit for tractor hire is only minimally available. Tractor hire rates have increased rapidly over the last few years due to general inflation, import costs, and the energy crisis.

Table 16 also contains reported information on availability of credit for household uses which include sickness, weddings, travel, and home improvements. Whatever the source of the capital or credit, it is much more difficult for small farmers. About 25 percent of the farmers with under 7.5 acres report that it is easily available (usually from relatives or friends). In contrast about 80 percent of farmers with 25 or more acres report easily available.

III. MAJOR SOURCES OF CREDIT

The major sources of credit are noninstitutional, which, in order of importance, are family, friends, money lenders, and commission agents. Table 17 and Figure 6 show the percentages of farmers reporting major sources of credit. About 72 percent of the farmers reporting give "family or friends" as major credit sources. Only 9 percent report

Table 16. Percentage of sample farmers reporting availability of capital or credit for tractor hire and household use.

Farm Characteristics	Tractor Hire				Household Use			
	# of Farms	Not Available	With Difficulty	Easily Available	# of Farms	Not Available	With Difficulty	Easily Available
Farm Size Class (Acres)								
Under 2.5	66	83.3	9.1	7.6	67	59.7	17.9	22.4
2.5-7.49	82	81.7	13.4	4.9	87	43.7	26.4	29.9
7.5-12.49	85	78.8	12.9	8.2	89	42.7	23.6	33.7
12.5-24.99	76	59.2	17.1	23.7	70	35.7	15.7	48.6
25.0-49.99	16	18.8	31.3	50.0	14	14.3	14.3	71.4
50 or More	8	12.5	12.5	75.0	8	12.5	-	87.5
	(X^2=68.5,10df)*				(X^2=32.5,10df)*			
Tenure								
Owners	228	68.9	13.6	17.5	225	41.3	19.6	39.1
Owner-Tenants	52	76.9	17.3	5.8	50	40.0	26.0	34.0
Tenants & Contractors	53	77.3	13.7	9.8	60	53.4	20.7	28.3
	(X^2=6.8,6df)*				(X^2=8.3,6df)*			
Weighted Totals	333	71.5	14.1	14.4	335	43.0	20.6	36.4

*Denotes significance at the .001 level or higher

Table 17. Percentage of sample farmers reporting major sources of credit by farm size and tenancy.

Farm characteristics	No. of farms	Bank or other institution	Lender, landlord or commission agent	Family or friends*
Farm size class (acres)				
Under 2.5	25	8.0	8.0	56.0
2.5 - 7.49	51	9.8	5.9	72.5
7.5 - 12.49	55	14.5	12.7	70.9
12.5 - 24.99	51	27.5	9.8	58.8
25.0 - 49.99	15	26.7	-	73.3
50 or more	7	71.4	-	28.6
	(X^2=45.7,20df)**			
Tenure				
Owners	143	25.2	2.1	66.4
Owner-tenants	29	6.9	6.9	79.3
Tenants & contractors	32	-	37.5	46.9
	(X^2=65.3,12df)**			
Weighted Totals	204	18.6	8.3	65.2

*Denotes 6.9 percent of the farmers who also report "self."
**Denotes significance at the .001 level or higher.

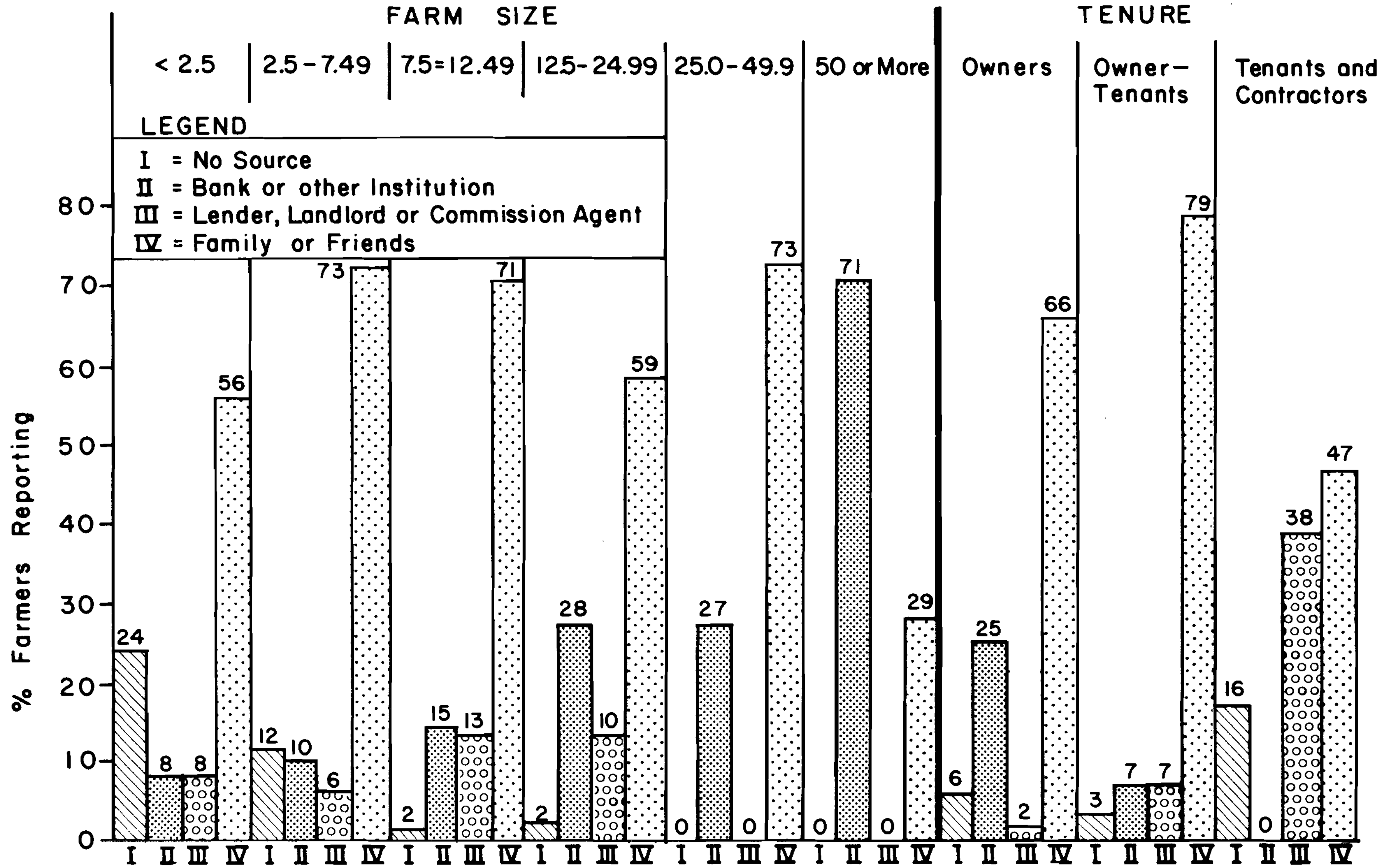

FIGURE 6. PERCENTAGE OF SAMPLE FARMERS REPORTING MAJOR SOURCES OF CREDIT BY FARM SIZE AND TENANCY.

sources including the landlord, money lender, or commission agent. The commission agents, in the markets or mandis, often advance cash to farmers against particular farm products such as wheat, cotton, or rice, which are pledged to them for marketing after harvest. While no farmer with 25 acres or more reports use of the money lender, commission agent, or landlord, about 41 percent report institutional sources. None of the reporting tenants and only 7 percent of the owner-cum-tenants report use of institutional sources. However, 25 percent of the owners report using some institutional sources. Tenants make much use of credit advanced by landlords.

Sample wheat farmers were questioned about their actual use of institutional credit for fertilizer to be used for wheat. Table 18 shows the distribution of 54 farmers who made use of institutional credit by farm size category. Given such a small number of farmers receiving institutional credit for fertilizer purchases, it is difficult to make generalizations. However, on the basis of these data (Table 18), we note that the weighted average of farmers, with under 12.5 acres who received credit, is 11 percent and for farmers with over 12.5 acres 37 percent. Though there are only 8 farmers with 50 acres or more, it is important to note that about 63 percent of these used institutional credit. The new credit program, operated through a developing network of rural banks, has made much progress in the last few years, but the perennial problem exists of making more credit available to small operators and tenants. Though not shown in tabular form, of 232 owners, 46 (19.8%) used institutional credit for fertilizer in the 1975-76 season; of 52 owner-cum-tenants, 5 or about 10 percent used credit. Of 57 tenants only three employed institutional credit.

Table 18. Percentage of farmers who utilized institutional credit for fertilizer (wheat crop, 1975-76).

Farm size class (acres)	Farmers reporting No.	Percentage of farmers	
		Some use	No use
Under 2.5	66	4.5	95.5
2.5-7.49	88	11.4	88.6
7.5-12.49	89	14.6	85.4
12.5-24.99	78	24.4	75.6
25.0-49.99	17	23.5	76.5
50.0 and above	8	62.5	37.5
Weighted Totals	346	15.6	84.4

X^2 = 26.1 with 5 degrees of freedom, significant at .001 level.

IV. UTILIZATION OF INORGANIC FERTILIZER

Table 19 provides an overview of the percentages of sample farmers utilizing various levels of both nitrogen and phosphatic fertilizer, by farm size and tenure classes for wheat which is cultivated by all but 20 of the 369 sample farmers, for the 1975-76 season.

Nineteen percent of the sample wheat farmers report using no inorganic nitrogen; roughly 60 percent of the farmers report using from 26 to 51 nutrient pounds of nitrogen per acre which is equivalent to one-half to one bag of nitrogen in the form of urea. Only 13 percent report using the equivalent of one to two bags of urea. Since only about 8 percent of the sample wheat farmers cultivate local varieties, the level of nitrogen use is very low. Depending on the previous crop, soil fertility, type of soil, and manure applied, the recommended levels of nitrogen in nutrient lbs/acre range from about the equivalent of 101 lbs. of N to 150 lbs. Only a small percentage of the sample farmers report using over 102 lbs. of nitrogen. There is a significant relationship between farm size, land tenure classes and the quantity of fertilizer used (see Table 19).

The situation for phosphorus is more critical in that fully 76 percent of sample farmers report using none. Generally, the recommended amount of phosphorus per acre is about 51 nutrient pounds, the equivalent of one bag of DAP or triple super phosphate. Only 22 percent report using from one-half to one bag of phosphatic fertilizer, and only 8 farmers report utilizing over one 51 nutrient pounds per acre. The simple correlation coefficient between yields of wheat/acre and both nitrogen and phosphorus are .43 and .48 which indicates the importance of these fertilizers for increased yields. Tenant farmers hardly use

Table 19. Fertilizer use for wheat with farm size (area cultivated) and tenure classes.

Farm size and tenure classes	No. of farms	Percentage of farmers using nutrient lbs. of nitrogen					Percentage of farmers using nutrient lbs. of phosphorus				
		None	1-25 lbs.	25-51 lbs.	52-101 lbs.	102 & above	None	1-25 lbs.	26-51 lbs.	52-101 lbs.	102 & above
Farm size classes (acres)											
< 2.5	69	38	-	52	6	4	96	-	4	-	-
2.5-7.49	93	24	-	55	14	7	75	-	24	1	-
7.5-12.49	96	18	-	61	13	8	71	-	28	1	-
12.5-24.99	86	6	-	62	17	15	77	-	20	3	-
25.0-49.99	17	6	-	65	18	12	53	-	41	6	-
50.0 & above	8	-	-	50	13	37	37	-	50	13	-
		(X^2=50.1,21df, Sign=.001)					(X^2=47.9,14df, Sign=.0001)				
Tenure classes											
Owners	247	21	-	55	12	12	72	-	26	2	-
Owner-cum-tenants	55	9	-	62	24	5	78	-	22	-	-
Tenants	67	23	-	67	6	5	91	-	7	1	-
		(X^2=23.4,9df, Sign=.005)					(X^2=12.8,6df, Sign=.04)				
Weighted Totals	369	19	-	58	13	10	76	-	22	2	-

phosphatic fertilizers, as 91 percent or 60 of 67 farmers report no use. Twenty-eight percent of the tenants report ever using phosphatic fertilizer and only 16 percent report having adopted it on a regular basis. Both trial and adoption of phosphatic fertilizers, as would be expected, are significantly related both to farm size and tenure status.

A. Fertilizer Use and Farm Type

Table 20 provides information on the average nutrient pounds of nitrogen utilized by farmers on different farm size and tenure categories for five major crops -- wheat, cotton, rice, berseem fodder and sugarcane. Ranges in recommended levels of nitrogen per acre for the crops are: wheat - 75 to 150 lbs; cotton - 50 to 75 lbs; rice - 75 to 150 lbs; berseem - 50 to 75 lbs; and sugarcane 100 to 200 lbs per acre. In comparison to the minimum values, levels of nitrogen for all crops are low. Overall, sample farmers utilize about 60 percent of the minimum recommended level for wheat, 68 percent for cotton; 47 percent for rice; 34 percent for berseem, and 54 percent for sugarcane. Farmers do utilize farm yard manure--especially for berseem, sugarcane, and rice. However, there is seldom sufficient farmyard manure to provide adequate nitrogen (Lowdermilk, 1972: 397-399).

Little variation is observed between farm size classes and levels of nitrogen used except between those farms over 12.5 acres in size and those smaller. Farms with over 12.5 acres utilize about 10-15 more lbs. of nitrogen for wheat but very little more for cotton. Rice farms which are over 12.5 acres use a weighted average of 44 lbs. of N/acre as compared with 31 lbs. for smaller farmers. Almost no differences are detectable between farm size classes and the amounts of nitrogen applied for the berseem crop. This probably results from the fact that

Table 20. Average nutrient pounds of inorganic nitrogen/acre for selected crops by farm size and tenure categories.

Farm characteristics	Average nutrient lbs. of inorganic nitrogen applied/acre									
	Farms Reporting	Wheat	No. farms	Cotton	No. farms	Rice	No. farms	Berseem	No. farms	Sugar-cane
Farm size category										
< 2.5	69	35	25	35	26	37	54	16	15	33
2.5-7.49	93	43	50	34	42	27	90	11	54	57
7.5-12.49	96	47	55	29	47	32	90	18	67	44
12.5-24.99	86	60	62	38	41	40	76	20	66	56
25.0-49.99	17	61	12	26	8	41	15	32	17	70
50 and above	8	83	8	58	5	80	7	14	8	89
Tenure category										
Owner operators	247	49	141	35	108	38	224	18	147	56
Owner-cum-tenants	55	49	34	38	21	38	50	15	39	55
Tenants	67	43	37	27	40	27	58	12	41	42
Weighted totals	369	48	212	34	169	35	332	17	227	53

all sample farmers use relatively high levels of farm manure for this crop. For sugarcane, the amount of nitrogen reported is for one season only and not for the total two seasons required for this crop. Larger farmers with 25 or more acres average 25 to 45 lbs. more nitrogen per acre per season than smaller farmers.

In terms of tenure categories, tenants consistently apply less nitrogen to all the crops, except wheat, than owners or owners-cum-tenants. However, the differences in levels applied range from only about 6 to 15 lbs. for all the crops.

Table 21 presents the same data broken down in categories of nitrogen use by farm size groups. This gives a clearer picture of the percentages of farmers of each farm size class who utilize no nitrogen and various levels. As one examines the column labled "none", it is obvious that, except for the berseem crop, the differences are explained primarily by farm size.

Table 22 presents data on levels of nitrogen use for the five crops by tenure categories. Under "no use" it is important to note that when tenants are compared with owner operators who report "no use" of nitrogen, important differences exist for cotton and berseem crops. Thirty-two percent of owner operators report using no nitrogen for cotton as compared to 46 percent for the tenant farmers. Sixty-one percent of the owners use no purchased nitrogen inputs for berseem as compared with 72 percent for tenants. A larger percentage of owner operators use 52 nutrient pounds or more per acre than tenant farmers. However, for the three tenure classes the differences in levels of nitrogen used for wheat and berseem are the only ones which are statistically significant.

Table 21. Percentages of farmers using various levels of nutrient lbs. of nitrogen/acre for selected crops by farm size classes.

Farm size category by crop	Percentages of farmers using various levels of nitrogen/acre					
	Farms No.	None	Under 25 lbs	25-51 lbs	52-101 lbs	102 & more lbs
Under 2.5 Acres						
Wheat	69	37.7	5.8	46.4	5.8	4.3
Rice	26	34.6	3.8	50.0	-	11.5
Cotton	25	40.0	4.0	44.0	4.0	8.0
Sugarcane	15	53.3	6.7	20.0	6.7	13.3
Berseem	54	61.1	13.0	25.9	-	-
2.5-7.49 Acres						
Wheat	93	23.7	9.7	45.2	14.0	7.5
Rice	42	50.0	9.5	33.3	2.4	4.8
Cotton	50	30.0	10.0	50.0	10.0	-
Sugarcane	54	20.4	1.9	42.6	18.5	16.7
Berseem	90	73.3	4.4	18.9	3.3	-
7.5-12.49 Acres						
Wheat	96	17.7	6.3	55.2	12.5	8.3
Rice	47	42.6	4.3	44.7	2.1	6.4
Cotton	55	34.5	10.9	45.5	7.3	1.8
Sugarcane	67	28.4	1.5	46.3	14.9	9.0
Berseem	90	60.0	5.6	30.0	3.3	1.1
12.5-24.99 Acres						
Wheat	86	5.8	3.5	58.1	17.4	15.1
Rice	41	22.0	7.3	63.4	4.9	2.4
Cotton	62	32.3	8.1	45.2	9.7	4.8
Sugarcane	66	15.2	6.1	50.0	16.7	12.1
Berseem	76	60.5	9.2	25.0	2.6	2.6
25.0-49.0 Acres						
Wheat	17	5.9	-	64.7	17.6	11.8
Rice	8	12.5	12.5	75.0	-	-
Cotton	12	41.7	8.3	50.0	-	-
Sugarcane	17	5.9	-	47.1	41.2	5.9
Berseem	15	40.0	-	53.3	6.7	-
50.0 and Over						
Wheat	8	-	-	50.1	12.5	37.5
Rice	5	20.0	-	20.0	-	60.0
Cotton	8	12.5	-	62.5	12.5	12.5
Sugarcane	8	-	-	37.5	25.0	37.5
Berseem	7	71.4	-	28.6	-	-
Weighted Totals						
*Wheat	369	19.3	6.0	52.0	13.0	9.7
*Rice	169	36.1	6.5	47.9	2.4	7.1
Cotton	212	33.0	8.5	47.2	8.0	3.3
*Sugarcane	227	21.6	3.1	44.5	18.1	12.8
*Berseem	332	63.2	6.9	26.2	2.7	.9

* Denotes significance between farm size classes of .03 or greater using X^2 and 20 df.

Table 22. Percentages of farmers utilizing various levels of nutrient lbs. of nitrogen per acre for selected crops by tenure categories.

Tenure Categories	Percentage of Farmers Using Various Levels of Nitrogen					
	# Farms	None/ Acre	Under 25 Lbs/ Acre	26-51 Lbs/ Acre	52-101 Lbs/ Acre	102 & Over Lbs/ Acre
Owner-Operators						
Wheat	247	20.6	4.5	50.6	12.1	12.1
Rice	108	35.2	4.6	48.1	2.8	9.3
Cotton	141	31.9	7.8	49.6	7.8	2.8
Sugarcane	147	20.4	2.7	43.5	19.7	13.6
Berseem	224	60.7	7.1	28.1	2.7	1.3
Owner-Tenants						
Wheat	55	9.1	10.9	50.9	23.6	5.5
Rice	21	33.3	4.8	52.4	-	9.5
Cotton	34	23.5	8.8	47.1	14.7	5.9
Sugarcane	39	12.8	2.6	56.4	15.4	12.8
Berseem	50	64.0	6.0	28.0	2.0	-
Tenants						
Wheat	67	22.3	7.5	58.2	7.5	4.5
Rice	40	40.0	12.5	45.0	2.5	-
Cotton	37	45.9	10.8	37.8	2.7	2.7
Sugarcane	41	34.1	4.9	36.6	14.6	9.8
Berseem	58	72.4	6.9	17.2	3.4	-
Weighted Totals						
*Wheat	369	19.2	6.0	52.0	13.0	9.7
Rice	169	36.1	6.5	47.9	2.4	7.1
Cotton	212	33.0	8.5	47.1	8.0	3.3
Sugarcane	227	21.6	3.1	44.5	18.1	12.8
*Berseem	332	63.2	6.9	26.2	2.7	.9

* Denotes significance at .01 level between tenure categories (X^2 = 26.2 for wheat; d. f. = 12) and for berseem (X^2 = 24.2; d. f.= 12).

B. Selected Institutional Variables and Use of Fertilizer

Farmers face considerable constraints in availability of fertilizer and credit for fertilizer purchases. Table 23 presents information to show the levels of use of nitrogen by availability of fertilizer, miles to the nearest fertilizer agency, availability of credit or capital for fertilizer, and the use of institutional credit. There is no consistent pattern which shows the farmers who report "easy availability of fertilizer" utilize more nitrogen/acre than farmers who report experiencing problems in acquiring it.

Since a major factor influencing fertilizer use is availability of credit, Table 23 provides information about reported use of fertilizer for wheat and availability of credit

One influence on levels of fertilizer use is distance to the nearest fertilizer agency. Farmers often require fertilizer at a place, time and price where they can make use of it. Studies in Pakistan (Lowdermilk, 1972: 400) show that small farmers especially do not make purchases until very shortly before they apply fertilizer. One of the reasons for this is unreliability of irrigation supplies. The information in Table 23 shows no clear relationship between nitrogen use and distance to the nearest agency except for the one village site which has a fertilizer agency located in it. The 12 sample farmers in this village do report utilizing slightly higher levels per acre than farmers who are not as close to agencies. One explanation for the overall lack of relationship between distance and fertilizer use is that farmers are able to transport fertilizer rather long distances by camels, donkeys, buses, and cycles.

Table 23. Percentages of farmers using various levels of nutrient lbs. of nitrogen/acre for wheat by reports of availability of fertilizer and credit and miles from fertilizer agency and utilization of institutional credit for fertilizer

Availability of Fertilizer, Credit & Use of Credit	# Farms	Percentage of Farmers Utilizing Various Levels of Nitrogen				
		None	Under 25 Lbs	26-51 Lbs	52-101 Lbs	102 or More Lbs
*1. Availability of Fertilizer						
Not Availabile	18	77.8	5.6	11.1	-	5.6
W/Difficulty	132	16.7	5.3	49.2	17.4	11.4
Easily	219	14.2	6.6	58.0	11.8	9.4
2. Miles to Fertilizer Agency						
Located in Village	12	8.3	-	58.3	8.3	25.0
Under 2 Miles	69	29.0	7.2	47.8	7.2	8.7
2.0-4.99	151	20.5	7.3	51.7	11.3	9.3
5.0-7.49	128	13.3	4.7	52.9	18.8	9.4
10.0% & Above	9	22.2	-	55.6	11.1	11.1
*3. Availability of Credit for Fertilizer						
Not Available	140	30.7	7.9	46.4	7.1	7.9
W/Difficulty	104	17.3	3.8	54.8	16.3	7.7
Easily	102	6.9	3.9	60.8	16.7	11.8
*4. Utilization of Institutional Credit						
No Use	275	22.9	6.5	51.6	12.0	6.9
Some Use	53	3.8	1.9	54.7	22.6	17.0

*Respectively 1,3,4 above have chi square values of 49.9, 29.3, & 18.9 which are significant at the .001 level.

There is a relationship between availability of credit or capital and use of nitrogen for wheat which is statistically significant. However, the difference does not appear to be very great or extremely important except for farmers who use no nitrogen. This finding suggests that increased credit facilities would be helpful for increasing fertilizer use. This view is strengthened when farmers are grouped in relationship with actual use of institutional credit for fertilizer (Table 24). Though only 53 of the 328 farmers for whom we have data reported using credit from the new rural credit program operated by the National Bank of Pakistan, it is evident that those who receive credit utilize higher levels of fertilizer for wheat. The differences in Table 24 are deflated because included in the "no use of institutional credit" are large landlords who did not require credit services.

C. Fertilizer Use and Water Supply

A major factor influencing fertilizer use is the water supply situation, especially reliability. Table 25 provides a breakdown of nitrogen use by five crops and by perennial versus nonperennial watercourse commands. Wheat is the only crop that shows a significant difference in fertilizer use/acre between farmers of the two types of command areas. Farmers on perennial commands tend to apply higher levels of nitrogen to wheat as compared to farmers on nonperennial commands. For other crops the differences are not important. For example, of those farms using 52 lbs. or more per acre the following percentages for farmers on the two types of commands are given in Table 25a. The major differences between perennial and nonperennial farmers are for this level of nitrogen. None of these differences are significant between levels of use except for the wheat crop.

Table 24. Utilization of institutional credit for fertilizer for wheat crop and levels of use in nutrient lbs./acre. (1975-76 rabi season.)

Lbs. of Nutrient Lbs. of Fertilizer Applies	Utilized No Institutional Credit for Fertilizer (n=275)	Utilized Some Institutional Credit for Fertilizer (n=53)
Nitrogen		
None	22.9	3.8
Under 51 Lbs.	58.2	56.6
52-101 Lbs.	12.0	22.6
102 and Over Lbs.	6.9	17.0
Total	100.0	100.0
Phosphorus		
None	80.5	54.7
Under 51 Lbs.	18.4	37.7
52-101 Lbs.	1.1	7.5
102 and Over Lbs.	-	-
Total	100.0	100.0

Table 25. Percentages of farmers using various levels of nutrient lbs. of nitrogen/acre for selected crops by perennial and nonperennial commands.

Water Supply Situation & Selected Crops	# of Farms	Percentage of Farmers Applying Amounts of Nitrogen/Acre				
		None	Under 25 Lbs	25-51 Lbs	52-101 Lbs	102 & More
TYPE COMMAND						
Perennial						
*Wheat	256	11.7	4.7	56.3	15.6	11.7
Rice	126	35.7	5.6	49.2	3.2	6.3
Cotton	151	29.8	7.3	49.7	9.9	3.3
Sugarcane	191	19.9	3.7	42.9	19.4	14.1
Berseem	243	60.1	78.3	28.0	3.7	.8
Nonperennial						
Wheat	101	33.7	9.9	44.6	6.9	5.0
Rice	31	48.4	12.9	29.0	-	9.7
Cotton	61	41.0	11.5	41.0	3.3	3.3
Sugarcane	34	32.4	-	52.9	11.8	2.9
Berseem	79	72.2	6.3	20.3	-	1.3

*Denotes X^2 32.1 with 4 dif., and significant at .001 level for wheat only

Table 25a. Percentage of sample farmers using 52 lbs or more nitrogen/acre.

Crop	(1) Perennial commands	(2) Nonperennial	Difference in 1 and 2
Wheat	27	12	15
Rice	10	10	0
Cotton	13	7	6
Sugarcane	33	14	19

Table 26 provides summary information on the average nutrient pounds of nitrogen used per acre for five crops under several water supply situations.

There is little difference among tubewell categories in the mean levels of nitrogen applied for wheat except for sample farms on public tubewell supplemented commands (see Table 26). This relationship is reversed for the average nutrient pounds of nitrogen applied for cotton because the farmers on public tubewell watercourses cultivate primarily the low yielding "desi" or local varieties which do not respond as well to nitrogen as do upland varieties. Cotton, on these commands, is cultivated almost entirely for home use. Nitrogen levels for rice on public tubwell supplemented commands are about 13-15 lbs/acre higher than for commands with some private tubewells.

Under item 5, (see Table 26) "actual number of private tubewells," the commands with both public and private tubewells are excluded. In relationship to density of tubewells, there is little difference in applications of nitrogen for wheat, but farmers on commands with three or more tubewells apply significantly higher levels of phosphorus/acre.

When farmers' reports of tubewell water availability (see item 3, Table 26) are compared with their reports of nutrient pounds of fertilizer

Table 26. Summary of average nutrient lbs. of nitrogen and phosphorus/acre for wheat, cotton and rice crops by water supply situation.

Water supply situation	Wheat Nutrient lbs/acre			Cotton Nutrient lbs/acre			Rice Nutrient lbs/acre		
	Farms No.	N lbs	P lbs	Farms No.	N lbs	P lbs	Farms No.	N lbs	P lbs
1. Type of command									
Perennial	256	54	16	151	37	9	126	36	1
Nonperennial	101	35	4	61	27	0	31	48	1
2. Tubewell supplements									
None	162	45	9	78	36	4	71	33	1
Private TW	154	49	17	92	38	9	55	35	0
Public	33	55	12	24	20	6	27	48	5
Private & public	20	50	5	18	24	0	16	25	3
3. Farmers' reports of tubewell availability									
Not	146	43	7	65	31	3	75	31	1
W/difficulty	64	53	18	50	36	9	22	25	0
Easily	126	53	16	83	34	9	57	44	3
4. Farmers' reports of use of TW									
No use	193	45	8	90	36	4	94	32	0
Buys TW water	123	49	15	83	29	6	58	39	3
Owns TW	44	57	26	34	42	16	13	40	0
5. Actual No. of private TW*									
Under 3	63	48	8	26	27	0	26	28	0
3 - 6	33	59	28	27	45	7	9	40	0
7 or more	57	48	21	39	43	19	20	41	0

*Commands with public and private tubewells excluded.

applied for the three crops one notes that the more easily available the tubewell water, the higher the levels of both nitrogen and phosphorus fertilizer use. However, there is little difference noted for cotton farmers who tend to apply about the same amounts of fertilizer regardless of the supplemental water supply situation.

Item 4 (Table 26) compares farmers' reports of tubewell use to level of fertilizer application. In comparing farmers who report "no use" of tubewells with farmers who own tubewells it is evident that the latter apply about 12 lbs. more nitrogen for wheat; 6 lbs. more for cotton; and 8 lbs. more for rice. The same pattern holds for phosphorus except for rice crops.

In summary, data in Table 26 reveal that the water supply situation is significantly related to fertilizer use for most crops.

D. Levels of Nitrogen and Location of Farm on Watercourse Command Area

Given the greater average total losses of canal water for farms located at the tail reaches of command areas, it is expected that farmers at tail command areas will utilize less fertilizer than head farmers. However, there are several major factors which may reduce the impact of watercourse location. First, sample farmers generally utilize relatively low levels of fertilizer for all crops for which we have data. In general, they are currently applying less than half the recommended levels of nitrogen for major crops and almost no phosphorus. Secondly, the differences between head and tail farms are masked due to the location of private tubewells and Persian wells. Thirdly, credit and fertilizer availability affect fertilizer use.

Utilization of nitrogen fertilizer in nutrient lbs/acre for five crops is presented in Table 27 by head and tail farm location. Farms located at the middle command reaches and those with holdings at more than one location on the watercourse are excluded. Two location criteria are employed. The first is the position estimated by the researcher, and the second is the measured position adjusted for all watercourse commands at village sites. The information provided with each measure for the five crops suggest that there is actually very little difference in fertilizer use for head and tail farms. Therefore, Table 28 provides data on the actual number of tubewells at each location and the utilization of fertilizer.

Table 28. Average nutrient pounds of nitrogen applied for wheat, rice and cotton/acre by private tubewell equivalents for position of water on watercourse command.

Watercourse position and number of tubewell equivalents*	Average nutrient pounds of nitrogen/acre					
	No. of farms	Wheat	No. of farms	Rice	No. of farms	Cotton
Head Position						
No. of tubewells						
None	57	52	26	37	29	44
1-2	63	62	40	44	29	35
3 or More	12	56	-	-	12	49
Weighted Totals	132	57	66	41	70	41
Tail Position						
No. of tubewells						
None	69	57	37	38	42	30
1-2	27	59	6	34	20	38
3 or More	16	69	2	38	15	56
Weighted Totals	112	59	45	37	77	37

*Private tubewell equivalents combine public tubewells at head position and private tubewells. One public tubewell serving one command area is counted as 3 private tubewells; one public tubewell serving 2 command areas is counted as 2 private tubewells.

Table 27. Differences in nutrient lbs. of inorganic nitrogen fertilizer per acre for selected crops by head and tail farms on watercourse command area reaches.

Watercourse position variables	No. farms	Head lbs. N	No. farms	Tail lbs. N
Watercourse position				
Wheat	133	49	112	48
Cotton	72	36	77	31
Rice	67	39	45	36
Berseem	122	16	108	18
Sugarcane	79	55	73	55
*Adjusted watercourse position				
Wheat	108	44	58	56
Cotton	66	37	33	39
Rice	45	43	27	34
Berseem	95	19	51	15
Sugarcane	55	47	44	55

*Denotes the adjusted position of the farm in relationship to the longest watercourse in the village.

The information in Table 28 shows no clear pattern of nitrogen use between head and tail farms. Only slightly more nitrogen is used for the three crops by head farmers versus tail farmers. Where no tubewells are available for head or tail farms, it is not evident that head farmers use more nitrogen except for cotton crops. Almost no difference exists between head and tail farms with up to two tubewells and where there are three or more tubewells, tail farmers appear to use more fertilizer than head farmers. On the basis of this data we must conclude that there is little difference between head and tail farms in the use of nitrogen fertilizer. The large number of private tubewells and Persian wells on watercourse commands reduces the impact of watercourse position.

E. Use of Nitrogen and Major Physical Soil Textural Types

Another factor which may influence nitrogen use is the difference in textural soil types. The physical soil types listed in Table 29 are textural classes ranging from light medium sandy loam to fine clay loams. The most consistent pattern observed in these data is the slightly higher levels of nitrogen used for farms with more sandy soils. When all other textural types are grouped, those farmers with more sandy soils report slightly higher levels of nitrogen used for wheat, cotton, rice, and berseem than farms which have soils that are predominately of other textures. Though these differences are not great, this suggests that farmers with more sandy soils have learned from experience that higher levels of nitrogen are required due to increased leaching of nitrates in sandy soils. The actual differences in levels of nitrogen between farms with light-medium sandy loam when all others are grouped and weighted are only 6 lbs. for wheat, 11 lbs. for cotton; 5 lbs. for rice; and 14 lbs. for berseem. For sugarcane farmers with more sandy soils, there is a lower reported use of nitrogen than for other farms.

Table 29. Average nutrient pounds of inorganic nitrogen/acre for selected crops by general physical soil texture classes.

Physical Soil Texture Types	# of Farms	Wheat	# of Farms	Cotton	# of Farms	Rice	# of Farms	Berseem	# of Farms	Sugarcane
Light Medium Sandy Loam	26	53	7	43	11	40	23	30	17	48
Medium Loam	28	45	16	20	14	31	22	10	20	53
Medium Fine Loam	49	48	16	19	36	29	50	21	26	65
Fine Loam-Clay Loam	96	47	30	32	71	39	87	9	44	45
Multi-Storied	170	48	143	38	37	34	150	19	120	55
Weighted Totals	369	48	212	35	169	35	332	17	227	54

F. Varieties of Wheat and Levels of Fertilizer

Of the 349 sample farmers growing wheat, only 22 cultivate only local varieties and 7 grow both local and high yielding varieties (see Table 30). Farmers who cultivate HY wheat report using much higher levels of both nitrogen and phosphorus than farmers growing only local varieties. For example, growers of HYV's have a weighted average of 28 lbs. more nitrogen and 6 lbs. more phosphorus than growers of local varieties (see Table 30). There is also some difference between the levels of nitrogen used for different HY varieties. Of the 55 farmers growing the late variety SA 42, 4 farmers with the Blue Silver variety, and the 14 farmers with other varieties tend to use more fertilizer than other HYV wheat growers. Farmers who cultivate the late variety SA 42 tend to apply more fertilizer because SA 42 is often used following the cotton crop because it fits better with this cropping pattern than either Mexi-Pak 65 or the early variety, Chenab 70. The 4 farmers who grow Blue Silver have holdings of 25 acres or more; therefore, they may have more capital for fertilizer.

Table 30 data do show that farmers apply more fertilizer for the HYV of wheat than for local varieties. However, most of the HYV farmers are still using less than one-half the recommended levels of fertilizer for high yields.

V. OWNERSHIP AND UTILIZATION OF SELECTED FARM TECHNOLOGIES

The technologies examined include those which range from small low cost technologies, such as improved plows, to the more costly ones such as tractors and threshing machines. Both ownership and use are examined in relationship to farm size and land tenure classes to ascertain the relative access sample farmers have to such technologies. Figure 7

Table 30. Average nutrient pounds of inorganic fertilizer applied per acre for various varieties of wheat.

Wheat Variety	Nutrient lbs. of Nitrogen and Phosporus/Acre For Various Wheat Varieties					
	No. of Farms	Nitrogen	No. of Farms	Phosphorus	No. of Farms	Nitrogen Plus Phosphorus
<u>High Yielding Varieties</u>	310	51	311	11	310	64
Mexi-Pak 65	104	44	104	8	104	52
Chenab 70	133	49	134	10	133	59
SA 42	55	61	55	27	55	88
Blue Silver	4	99	4	50	4	149
Other HYV	14	58	14	25	14	83
<u>Local Varieties</u>						
AC 591	22	23	22	5	22	28
AC 273+HYV	7	41	7	0	7	41
Weighted Totals	339	48	340	12	339	60

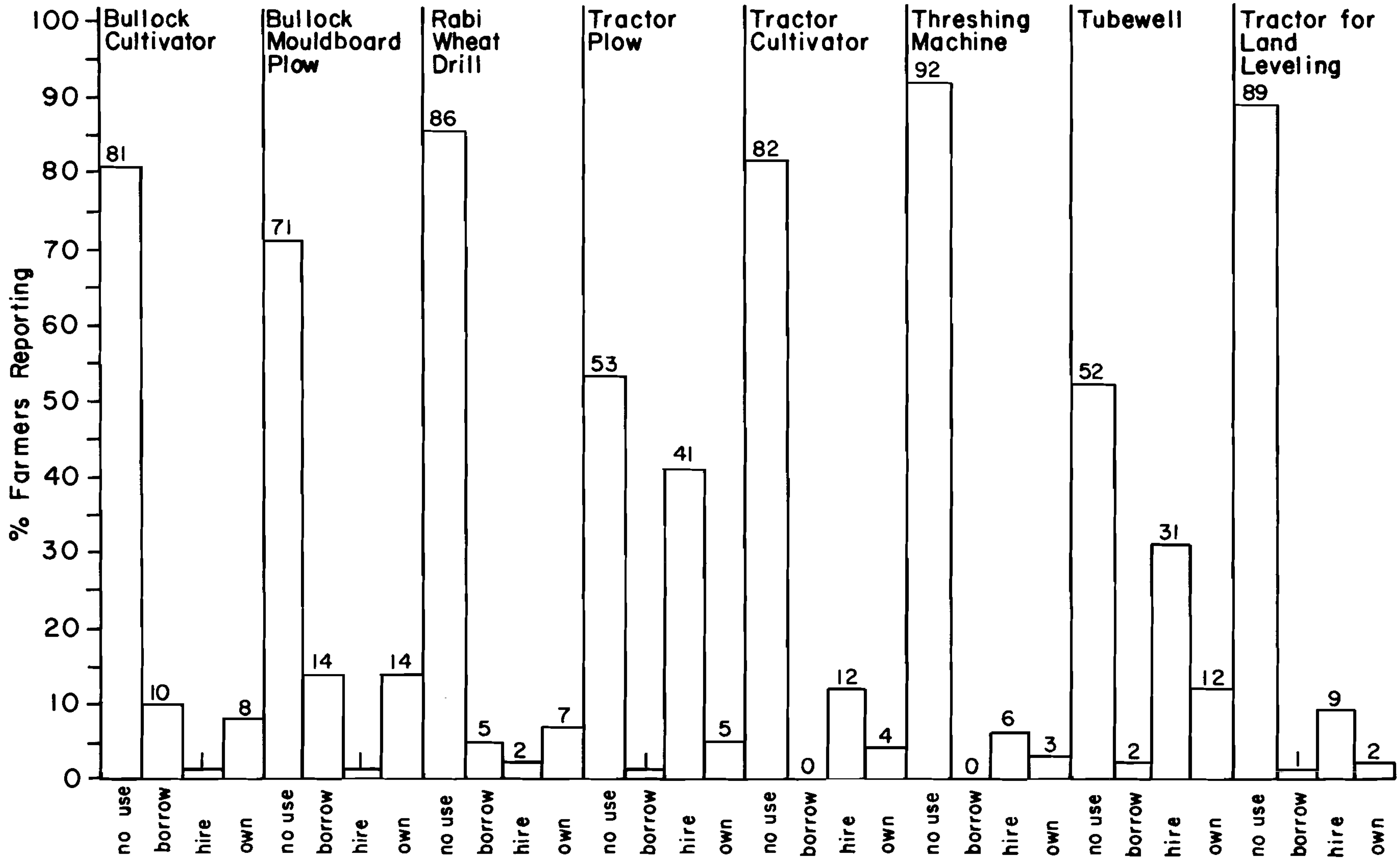

FIGURE 7. UTILIZATION OF IMPROVED FARM TECHNOLOGY

provides a graphic presentation of the ownership and use of these technologies for the 389 sample farmers. In terms of ownership and use, the following percentages of sample farmers own the types of farm equipment listed below:

Farm equipment item	Percentages (rounded) Owners	Use
Bullock cultivator	9	20
Bullock mouldboard plow	14	29
Bullock rabi wheat drill	8	15
Tractor	5	47
Threshing machine	3	9
Tubewell	12	44
Tractor with backblade for land leveling	2	12

Implements such as the bullock cultivator, mouldboard plow and the rabi wheat drill, relatively low in cost, have been recommended by the Agriculture Department since the early 1900's. However, unlike the fodder chopper, which was introduced about the same time and is owned by about 75 percent of the sample farmers, these other improved implements have not widely diffused among farmers. For example, the improved bullock powered cultivator and mouldboard plow cost about Rs. 100 each and both are an improvement over the local plow, which has no inversion action and consists of a single crude tine with a sole and a steel share. While the improved mouldboard plow has been proven to do a better job of plowing deeper and turning under of organic matter, still only about 29 percent of the farmers report using this implement, and only 20 percent report using the 3 to 4 tine cultivator, which is especially good for weeding and row crop cultivation. Farmers report several factors which help explain the lack of acceptance of these implements. First, they often complain that the draft required for the mouldboard plow is greater than that for the local plow. Available data confirm this reasoning of the farmer as an earlier study (Roberts, 1951: p 77) shows that the local plow which makes a furrow of about 4.5 x 9 inches requires only 130 lbs. of total draft as compared with the common raja mouldboard plow which makes a furrow of 6 x 9 inches and requires a total draft of 170 lbs. One must also consider the fact that bullocks often do not receive adequate nutrition and vary a great deal in their strength. Farmers report that the usual 6-8 hours to plow an acre of land with a traditional plane is increased by about 20-25 percent when a mouldboard plow is used since the bullocks must be rested more often. Farmers also report that the turning action of the improved plow creates deeper and wider furrows which leave the fields in a more unlevel condition than the more shallow plowing with the desi plow. While these reasons appear valid, the major factor is probably related to repairs and spare parts which are often difficult or impossible to obtain from village blacksmiths. Village blacksmiths are usually unable to cast spare parts, such as the mouldboard, shares and tips. Usually major repairs and spare parts are only obtainable in the shops of small towns. Both the village blacksmith and carpenter are paid a fixed amount of crop produce on an annual basis for repair of local farm implements; therefore no cash is needed by the farmer at the time he needs the part. The local implements, unlike improved ones, can be made and repaired in the village by local artisans. Until village blacksmithy technology is improved and the spare parts problems solved, it is understandable why these implements are not widely accepted.

Tables 31, 32 and 33 provide information about the ownership and use of these technologies in relationship to both farm size and land tenure classes. It is evident from Table 31 that there is a significant

Table 31. Percentage of sample farmers reporting use of bullock cultivator, mouldboard plow and rabi drill (bullock).

Farm Characteristics	Bullock Cultivator				Mouldboard Plow				Bullock Rabi Drill			
	# of Farms	No Use	Rents or Borrows	Owns	# of Farms	No Use	Rents or Borrows	Owns	# of Farms	No Use	Rents or Borrows	Owns
Farm Category Size (Acres)												
Under 2.5	74	95.9	4.1	0	77	83.1	9.1	7.8	76	93.4	1.3	5.3
2.5-7.49	95	83.2	11.6	5.3	97	75.3	16.5	8.2	97	91.8	4.2	4.1
7.5-12.49	97	78.4	8.2	13.4	99	73.7	17.2	9.1	99	82.8	11.1	6.1
12.5-24.99	85	75.3	16.5	8.2	87	59.8	13.8	26.4	87	81.6	5.7	12.6
25.0-49.99	17	52.9	29.4	17.6	17	47.1	29.4	23.5	17	58.8	23.5	17.6
50 or More	8	25.0	12.5	62.5	8	50.0	0	50.5	8	50.0	37.5	12.5
		X^2= 56.7(10df)**				X^2= 35.5(10df)**				X^2= 35.2(10df)**		
Tenure												
Owners	251	76.5	13.5	10.0	257	68.1	14.8	17.1	256	84.8	7.6	7.6
Owner-Tenants	54	79.6	7.4	13.0	56	66.1	25.0	8.9	56	85.3	9.0	5.7
Tenants & Contractors	71	92.9	5.7	1.4	72	86.1	7.1	7.1	72	85.8	7.1	7.1
						X^2= 15.1(4df)*						
Weighted totals	376	80.1	11.2	8.8	385	71.2	14.8	14.0	384	85.2	7.5	7.4

* Denotes significance between .05 and .001
**Denotes significance at .001 level or higher

Table 32. Percentage of sample farmers reporting use of tractor plow, tractor trolley and tractor with blade for land leveling.

	Tractor Plow				Tractor Trolley				Tractor With Blade			
Farm Character-istics	# of Farms	No Use	Rents	Owns	# of Farms	No Use	Rents	Owns	# of Farms	No Use	Rents	Owns
Farm Size Cate. (Acres)												
Under 2.5	75	82.7	16.0	1.3	76	97.4	1.3	1.3	76	98.7	1.3	0
2.5-7.49	98	53.1	44.9	2.0	98	85.7	13.3	1.0	94	92.6	7.4	0
7.5-12.49	99	51.5	45.4	3.0	99	84.8	12.1	3.0	98	88.8	11.2	0
12.5-24.99	86	39.5	52.4	8.1	87	75.9	18.3	5.7	86	81.4	13.9	4.7
25.0-49.99	17	11.8	76.5	11.8	17	41.2	47.1	11.8	17	58.8	29.4	11.8
50 or More	8	12.5	25.0	62.5	8	25.0	12.5	62.5	8	62.5	12.4	25.0
		X^2=102.3(15df)**				X^2=105.5(15df)**				X^2=60.3(15df)		
Tenure												
Owners	256	47.7	45.3	7.0	257	79.4	14.8	5.8	253	85.0	11.9	3.2
Owner-Tenants	56	46.4	51.8	1.8	56	85.7	12.5	1.8	54	90.7	9.3	0
Tenants & Contractors	71	76.0	23.1	1.4	72	90.3	7.1	1.4	72	97.2	2.8	0
		X^2=24.3(9df)*										
Weighted totals	383	52.7	42.1	5.2	385	82.3	13.1	4.4	379	88.1	9.7	2.1

* Denotes significance between .05 and .001
**Denotes significance at the .001 level or above

Table 33. Reported median rates of hiring tractors for land preparation, cartage, land leveling and hiring threshers at selected village sites.

Village sites	Median hire price in rupees for selected technologies and/or in share of crop					
	Tractor Land preparation		Tractor trolley		Land leveling	Thresher
	per acre	per hour	per trip	per maund	per hour	seers*
			(miles in round trip=m)			
101	17	-	(m=10) 15	58	25	5 seer
102	23	-	(m=12) 17	-	24	6 seer
103	-	-	-	-	-	-
104	15	15	-	-	-	30Rs/hr
105	-	20	-	-	21	5 seer
106	-	19	-	-	-	
107	13	-	(m=11) 15	Rs.5/hr	25	Rs.20/hr
108	20	-	-	-	-	-
109	18	-	-	-	-	-
110	27	-	-	Rs.10/hr	-	-
111	35	-	-	-	-	
112	35	-	-	-	35	6 seer
116	35	-	-	-	35	-

*One seer equals approximately 2.2 pounds.

relationship between farm size and the ownership and use of the improved cultivator, mouldboard plow and the rabi drill. For respondents with farms under 7.5 acres, 89 percent report not using the cultivator; 79 percent do not use the mouldboard plow; and 92 percent do not make use of the rabi wheat drill. Both trial and adoption are significantly related to farm size. It does appear that capital does enter into the use of even these low cost implements. However, about the same percentages of the sample farmers rent or borrow these implements as own them for all size groups except the larger farmers. Very few actually rent these implements; borrowing from neighbors is the rule.

In regard to ownership and use by tenure categories, the only significant relationship is for use and ownership of the mouldboard plow where owner operators both rent and own the improved plow more than tenants.

As expected, the ownership and use of tractors for several purposes are each highly related to farm size. Table 32 provides information to show the use of tractors for plowing (primarily seedbed preparation), the cartage of goods to and from market, and for land leveling. It is important to note the fairly high use of the tractor for all purposes by all but the smallest farmers with under 2.5 acres. Small farmers with 7.5 acres or more utilize tractors more than one would expect. Given liberal import policies, especially in the late 1960's, the number of tractors in the Punjab Province alone rose at a phenomenal rate. While only 5.2 percent of the sample farmers own tractors, nearly half of the farmers report using them from time to time for cultivation; about 18 percent utilize tractor trolleys, and about 12 percent use them for rough land leveling.

The cost of hiring tractors has increased rapidly in the last few years due to general inflation and the high cost of spare parts and fuel. The rates charged for different operations as reported by sample farmers are shown in Table 33. These rates vary in relationship to the demand in certain village areas and the type of work required. At all village sites there were insufficient tractors in the area to meet the demand of farmers for land preparation, especially in the period between rabi and kharif when the time constraint is great in getting in the next crop. At village 101 there were four wheat threshers working full time in May-June of 1975 and many farmers complained that they could not utilize these due to demand and high cost.

Tractor rates for land preparation also vary in relationship to the actual job required. Farmers usually pay by the acre and the tractor operator typically plows the field twice with a cultivator. It usually requires about one hour for this double operation which would require 12-16 hours for a bullock team. Farmers who engage in intensive operations always face a considerable time constraint at rabi wheat threshing when fields must be prepared for the kharif cotton crop. Tractor plowing is also in demand for the first plowing after a sugarcane crop due to the heavy crop residues and roots that have to be removed or turned under for the next crop.

Table 34 provides information by farm size and land tenure categories for use of tubewells (including public tubewells under hire) and threshers. There is less difference for use of tubewells in relationship to farm size than might be expected since about 45 percent of the sample farmers have access to public or private tubewells. However, it is evident that farmers of 12.5 acres or more have more access to tubewells

TABLE 34. Percentage of farmers reporting use of tubewell and thresher.

Farm Characteristics	Tubewell				Thresher			
	# of Farms	No Use	Rents	Owns	# of Farms	No Use	Rents	Owns
Farm Size (Acres)								
Under 2.5	76	73.7	22.4	3.9	76	98.7	1.3	0
2.5-7.49	96	61.5	32.3	6.3	97	93.8	5.2	1.0
7.5-12.49	98	55.1	30.6	14.3	99	93.9	6.1	0
12.5-24.99	86	46.5	39.5	14.0	87	89.7	6.9	3.4
25.0-49.5	17	17.6	52.9	29.4	17	64.7	23.5	11.8
50 or More	7	0	42.9	57.1	8	37.5	12.5	50.0
	(X^2=45.2,10df)**				(X^2=97.0.10df)**			
Tenure								
Owners	254	57.1	27.2	15.7	256	88.7	7.8	3.5
Owner-Tenants	54	57.4	35.2	7.4	56	92.9	5.4	1.8
Tenants & Contractors	72	51.4	50.0	0	72	100.0	0	0
	(X^2=22.3.4df)**							
Weighted Totals	380	55.9	32.7	11.6	384	91.4	6.0	2.6

* Denotes significance between .05 and .001
**Denotes significance at the .001 level or higher

than smaller farmers. Use of threshers is primarily for farms with 25 or more acres in cultivated holdings. No tenants reported using threshers and only about 9 percent of the other farmers report using threshers. No tenants, of course, own tubewells but only 50 percent report using them as compared to 57 percent of the owners and owner-cum-tenant sample farms. This is influenced greatly by the large percentage of tenants in the Sargodha District public tubewell SCARP area, where in five command areas, 48 percent of the sample farmers were tenants. Only about nineteen percent of the sample farmers on the other watercourse commands were tenants.[2/]

Tubewell rental rates vary greatly for the sample watercourses. On public tubewell supplemented commands, farmers pay the tubewell cost with their canal water rates known as abania. The two rates are combined and paid seasonally. Private tubewell water rates vary in relationship to the estimated discharge, the demand situation, and the particular type of tubewell--diesel or electric.

For example, on one command at village 101 two private tubewell owners with diesel powered wells charged Rs. 8 to 11 per hour. At village site 102 with six private tubewell owners, rates ranged from 6 to 11 rupees per hour. However, at site 104 with 2 electrified tubewells rates were rupees 4 per hour. Village 107 with 26 diesel powered private tubewells for 3 command areas with a total cultivated area of over 2000 acres, rates ranged from 8 to 9 rupees with an average of rupees 8.6 per hour. At village site 110, consisting of 3 command areas (total cultivated area equalling 896 acres) with 26 diesel powered tubewells, hourly rates were about 10-12 rupees per hour. However, a custom prevalent at this

2/It must be remembered that one of the criteria for selection of sample commands included those with a predominance of small operators.

site was the charge of one-third of the harvest. Given an average of 20 maunds of wheat per acre this would amount to about Rs. 270 for irrigation water. One of the three commands receives no canal water, therefore the rental rates for tubewells are high.

A. Ownership of Miscellaneous Farm Technologies

Table 35 provides information about the ownership of such technologies as the bar harrow, fodder choppers and rubber-tired bullock carts by farm size classes. Probably the most wide-spread improved farm machine in Pakistan is the fodder cutter which has knives mounted on a large wheel about four feet in diameter and a simple feed box and gear device for feeding the fodder into the machine. In the early 1940's there were an estimated 100,000 of these in the Punjab Province alone and today in Pakistan the number is probably over a million (Roberts, 1951: p 100). The characteristics related to the spread of this innovation are its efficiency and saving of labor. It also helps to economize on fodder which is better prepared than the fine chopped fodder using the slow hand toka similar to a butcher's meat cleaver. About three-quarters of the sample farmers own these hand operated machines and there is little difference between farm size groups except for the smallest farmers with under 2.5 acres. The demand for these fodder cutters is great and they are produced at rather low cost throughout the Provinces of Punjab and Sind. A variation of this machine is one powered by bullocks using a system similar to that of the Persian well or waterlift. These machines powered by camels or bullocks have an hourly production of 20 to 40 maunds of green fodder per hour as compared to 6-8 maunds/hour for the hand operated fodder choppers. Only 13 percent of the sample farmers own these machines; about 38 percent of larger farmers report

Table 35. Selected farm technologies by farm size classes.

Farm size classes (acres)	No. of farms	Percentage of sample farmers owning			
		Bar harrow	Hand fodder chopper	Bullock powered fodder chopper	Rubber tired bullock cart
Under 2.5	77	0	53.4	5.2	0
2.5 - 7.49	99	2.0	70.2	6.1	4.0
7.5 - 12.49	100	5.0	81.7	10.1	3.0
12.5 - 24.99	87	4.6	76.8	14.9	8.0
25.0 - 49.99	17	17.6	94.1	11.8	23.5
50.0 and over	8	25.0	100.0	37.5	12.5
Weighted Totals	388	4.1	73.0	9.8	4.9
X^2 if significant and 5 degrees of freedom		21.3**	25.6**	13.0*	20.4**

*Denotes significance between .05 and .001 level.
**Denotes significance at the .001 level or higher.

owning them as compared to only 10 to 15 percent of the farmers owning 7.5 to 50 acres. This machine, when operated by diesel engines or electricity, often at tubewell locations, can produce anywhere from 30 to 150 maunds of fresh fodder per hour.

The light bar harrow introduced in the Punjab about 1918 consists of a wooden or iron triangular frame with 17 to 20 iron points or tines. The tines are slanted slightly backwards on improved models to reduce the uprooting of plants. With a width of about 4 feet, a farmer can cover about 4 to 5 acres in about 8 hours. This implement is used primarily for harrowing wheat, cotton, and sugarcane in the early stages and is very useful when highly pulvarized soils develop crustation after a rain shower. The problem of crustation is serious in some areas where soils have little organic matter and tend to seal over, greatly reducing plant germination and emergence. Twenty-one percent of the sample farmers report owning harrows, but, as seen in Table 35, they are in greater use by farmers with 25 or more acres in cultivated holdings.

All except the very small farmers own a traditional bullock cart because transport by camels is about twice as costly. Since the weight of this cart is about 1200 lbs. and has no wheel bearings the average load is about 1600 to 2000 lbs. for dirt roads which requires fairly tall and large bullocks. Larger farmers, with much cartage, increasingly are using wheel bearings and improved pneumatic tires on bullock carts. Tests made in the early 1900's found that such improved bullock carts could carry 4500 lbs. of sugarcane as compared to 2000 lbs. for conventional carts at a speed that was 15-20 percent faster (Roberts, 1951: 109-110). Twenty percent of the sample farmers own these improved carts. However, again we note that the larger farmers tend to use them more. Given the introduction of the tractor, the large farmers are increasingly using tractor trolleys. All the sample tractor farmers, for example, also own trolleys. As seen in Table 32, many tractor owners also develop a profitable side business of transporting goods to and from market.

VI. TRIAL AND ADOPTION OF SELECTED HYV CROP VARIETIES AND PRACTICES

Farmers were asked if they had "ever tried" several crop varieties and improved practices. In addition, they were asked if they were making regular use of these innovations or not. Adoption is usually defined as the incorporation of a new crop variety, technology, or innovation into the farm operation on a regular basis. A summary of eight practices is given in Table 36 by farm size in order to determine the difference in trial and adoption for various varieties or practices.

High yielding wheat--Chenab 70 and S.A. 42--are early and late varieties respectively. Though these are not as popular as some other HYV varieties with farmers, such as Mexipak 69 and the older Mexipak 65 variety, they have become widely used for early and late sowings. While 65.9 percent of the sample farmers have tried Chenab 70, 57 percent (or 81 percent of those who tried it) have adopted this variety. However, the late variety sown in the Punjab between November 25 to December 15 has been tried by only 42 percent of the sample farmers and adopted by 36 percent--about 86 percent of those who tried it. S.A. 42 is a more specialized variety used primarily after cotton and rice in very intensive farming. Larger farmers have tried and adopted both of these varieties in greater numbers than smaller operators as seen from the reports of sample farmers (see Table 36). Though not shown in Table 36, owner operators have put both of the HYV's to trial and have

Table 36. Percentage of farmers trying and adopting selected agricultural crop varieties and innovations by farm size.

Farm size and land tenure classes	Trial and adoption of selected crop varieties and practices													
	HYV wheat Chenab 70		HYV wheat SA 42		HYV rice		Line planting rice seedlings		Insect control measures rice		Insect control measures cotton		Phosphate fertilizers	
	trial	adopt	trial	adopt	trial	adopt	trial	adopt	trial	adopt	trial	adopt	trial	adopt
	(n=381)	(n=381)	(n=378)	(n=378)	(n=293)	(n=293)	(n=290)	(n=290)	(n=290)	(n=292)	(n=368)	(n=368)	(n=377)	(n=377)
Farm size classes (acres)														
Under 2.5	50.0	44.4	21.1	19.7	15.6	9.4	4.8	1.6	11.1	4.8	11.3	5.6	11.3	5.6
2.5 - 7.49	60.6	48.5	42.3	35.1	39.0	18.2	21.1	11.8	10.4	6.5	16.0	7.4	37.5	28.1
7.5 - 12.49	67.7	57.6	46.5	38.4	33.0	16.0	21.3	5.3	20.0	10.7	19.8	6.3	48.5	31.3
12.5 - 24.99	75.6	69.8	44.2	37.2	40.7	35.6	16.9	11.9	16.9	16.9	22.6	17.9	55.8	44.2
25.0 - 49.99	94.1	88.2	76.5	70.6	41.7	41.6	25.0	16.7	58.3	41.7	53.3	33.3	88.2	70.6
50.0 & over	87.5	75.0	75.0	62.5	83.3	66.7	50.0	0.0	33.3	0.0	37.5	25.0	100.0	62.5
X^2 value with 5df	20.7**	21.1**	27.4**	18.4*	18.5*	24.8**	13.1*	8.7	20.3**	19.1*	16.9*	19.4*	62.0**	44.9**
All classes	65.9	57.2	41.8	36.0	33.8	21.2	17.6	7.9	16.8	10.6	19.6	10.6	43.2	31.0

The levels of significance indicated by * and ** in previous tables is omitted in this one.

adopted them in greater numbers than tenant farmers. Only 45 percent of the sample tenants adopted Chenab 70 and only 21 percent have adopted S.A. 42 as compared to 62 and 42 percent of the owner operators in the sample.

Of the 293 rice farmers, which includes those who produce rice for home consumption as well as for the market, 34 percent report they have tried the HYV of rice but only 21 percent report they have adopted this variety. The variety of rice which has the greatest domestic as well as foreign demand is the aromatic "basmati" variety which has qualities in great demand in the Middle East, but is not a high yielding variety. The fact that only 21 percent of the farmers adopted the HYV indicates that it is not preferred despite its higher yield potentials. Most of the HYV of rice, such as Irri-PAK, were found in Sind Province where, for some yet undetermined reason, the popular basmati varieties lose their aromatic qualities. As seen from Table 36 there is a significant relationship between farm size and both trial and adoption of the new rice varieties. The most plausible explanation for this is that the majority of the sample farmers cultivate rice for home consumption and prefer to use either basmati or other local varieties due to taste and cooking qualities.

Line planting of rice seedlings, often referred to as the Japanese or Philippine method, is usually thought to add substantially to yields due to more uniform plant populations and greater efficiency in weeding and application of both fertilizer and insecticides. However, of the reporting rice growers, only 18 percent stated that they had tried this practice and only 8 percent reported using it on a regular basis. While larger farmers reported having tried this more than smaller farmers, the difference is not great except for farms over 25 acres as compared with the very small farms. The major constraint in using this practice is the skilled labor requirement. Most of the rice is transplanted but some is still broadcast although transplanted rice usually is thought to yield 4 to 5 maunds/acre more (Gibb, 1966: 156-159). An earlier study shows that transplanting an acre of rice requires about 34 man hours by skilled labor. Transplanting the seedlings in rows requires much supervision to see that the depth of seedling placement and the spacing is proper. The cost today for transplanting rice is probably about 16 to 20 rupees/acre. Only farmers at sites 110 and 116 produced rice primarily for the market on a large scale; other sample farmers used either casual labor or their own labor for transplanting.

A major factor explaining low crop yields, especially of rice and cotton, are poor plant protection measures. The lack of easily available insecticides and pesticides, low cost sprayers and dusters, and knowledge, result in few farmers using insecticides. For example, of 292 rice farmers only 17 percent reported using insecticides and only 11 percent had adopted them on a regular basis. Of 368 farmers who grow cotton only 20 percent reported having tried plant protection measures and only 11 percent had adopted them.

Probably the only viable solution is to make materials and cheap machines available to farmers and teach them how to effectively control their pest and insect problems. Also systemic materials, not requiring sophisticated equipment, are needed which farmers can apply at the time of transplanting seedlings.

The problem of plant protection is just as serious with cotton (especially upland varieties) as with rice. Given the large cotton acreage in the Punjab and Sind it is surprising that only 11 percent of the sample farmers reported having adopted regular insect and pest control measures. Studies (Gibb, 1966: 148) have shown that good plant protection measures can almost double yields given other improved practices. Major insects that create damage to cotton are jassids, mites, and boll worms. Efforts are made in cotton regions, such as Multan, to conduct special campaigns using both aerial sprayings and ground crews by the Department of Agriculture. Though these efforts are helpful, the Department alone, with limited funds and staff, cannot expect to service the plant protection needs of farmers. Here again farmers themselves can best do the job provided they have the materials and the training. No amount of propoganda will do the job until farmers have more easily available materials and equipment. In all survey sites where farmers grow cotton a common complaint was the lack of insecticide availability.

Another factor creating low crop yields is the low level of use of phosphatic fertilizers (see Table 36). Earlier in the examination of factors related to differences in wheat, cotton, and rice yields it was found that level of use of phosphorus was major. The simple correlation between use of this fertilizer and yields of wheat, cotton, and rice gave coefficients respectively of .48, .28 and .22. Of the 377 sample farmers reporting, only 43 percent reported that they have ever tried phosphatic fertilizer and only 31 percent reported using it on a regular basis. As expected both the trial and adoption of this fertilizer is highly correlated with farm size. Whereas, of the largest farmers, 100 percent report "trial" and 62 percent report "adoption," but of the smallest farmers, only 11 percent report ever trying phosphorus for any crops and only about 6 percent report using it on a regular basis.

Several conclusions can be drawn from this discussion of trial and adoption of these seven important innovations. First, in all cases, except the adoption of line planting of rice seedlings there is a strong relationship between both trial and adoption of the selected technologies--high percentages of those who give the innovation a trial, adopt it. Second, for HYV of rice, line planting of rice seedlings, plant protection measures for rice and cotton, and use of phosphatic fertilizers, both the trial and adoption rates as reported by sample farmers are seriously low. Third, since all of these practices are essential for improved yields, new approaches are necessary to assure they will become accepted by farmers. This will require nothing less than a transformation of the conventional organizations which have the responsibility to serve farmers. Programs must be restructured and staff upgraded to work intensively in training farmers. Though farmers can be supplied more water, this alone will do little to increase present low crop yields. Any program for improving the on-farm irrigation system must have a strong input of effective farm level advisors to demonstrate to farmers what is possible using a comprehensive management approach to crop production.

VII. UTILIZATION OF RECOMMENDED PRACTICES FOR HIGH YIELDING WHEAT VARIETIES

Perhaps the most effective work of the Agriculture Department and its special farm radio programs has been the propagation of information about improved practices for the HYV of wheat. Since 1965, extension workers, supported by radio programs and fertilizer distributors, have also probably established more demonstration plots for the high yielding wheat varieties than for all other crop varieties. More than ten years of outstanding research on the high yielding varieties has been conducted by the research institutes and agricultural universities by staff trained at CYMITT in Mexico. In choosing to examine the utilization of recommended practices of the HYV of wheat, it must be realized that wheat production is less complex than crops such as rice, cotton, or sugarcane and HYV have been promoted intensively for over 10 years in Pakistan. Yields are still low (see Volume III, Chapter Six). Many factors result in the low average yields. In recent years, yields have reached a plateau and some observers report a slight decrease in yields. Earlier (Volume III, Chapter Six) we have seen that both water supply and levels of fertilization explain about 26 percent of the variation in yields. Other factors include sowing dates, proper seedbed preparation, seed depth, seed rates, seed placement, interactions between nitrogen-phosphorus fertilizers and various levels of irrigation, split applications of nitrogen with different soils, levelness of fields and leaching of nitrates by excessive water application.

The information presented in Table 37 is descriptive in the sense that is compares what sample farmers report their practices are in relationship to recommended practices. Recommended practices are all taken from the annual reports and special publications of the Punjab Agricultural Research Institute (PARI) formerly known as the Ayub Research Institute. The latest written recommendations available at the time of the survey were those for 1974-75. Special reference is made to each recommendation and its source in the presentation of data. Many controlled plot experiments have been conducted in both Pakistan and India for most of the recommendations examined and, where appropriate, these will be cited.

Table 37. Summary table of farmers' utilization of recommended management practices for high yielding wheat varieties.

Management practices (Recommended practice shown by asterisk)	No. of farms reporting		Percentage using
1. Proper range for date of sowing			
a. Does not use	148		43.0
b. Within ± 4 days	86		25.0*
c. Uses correct range	110		32.0*
	344		
2. Seedbed preparation			
a. Local plow	271		73.0
b. Mouldboard plow	51	+(1970 28.1)	13.7*
c. Tractor plow	49		13.2*
	371		
3. Seed Depth			
a. Off by more than .5"	104		30.4
b. Within ± .5"	117		34.2*
c. Correct range	121		35.4*
	342		
4. Seeding method			
a. Broadcast	139		37.5
b. Kera	90		24.3
c. Pora	125	+(1970 5.2)	33.7*
d. Drill	17		4.6*
	371		
5. Level of N (nutrient lbs.)			
a. None	69		18.6
b. < 75	241	+(1970 87)	65.0
c. 75-99	8		2.0
d. 100-114	29		7.8*
e. 115+	24		6.5*
	371		
6. Level of P (nutrient lbs/acre)			
a. None	269	+(1970 93)	71.7
b. < 25	6		1.6
c. 25-49	6		1.6
d. 50 or more	94		25.1*
	375		
7. Splits fertilizer application			
a. No	232		63.7
b. Yes	132	+(1970 41)	36.3*
	364		
8. Seed rate (seer/acre)*			
a. < 36	64		34.2
b. 36-39	16		8.6
c. 40 or more	107	+(1970 39)	57.2*
	187		

+ denotes percentages using selected practices for HYV wheat in 1970. See Lowdermilk, Diffusion of Dwarf Wheat Production Technology in Pakistans' Punjab, 1972, op. cit. pp. 310-312.

A. Sowing Dates

The recommended sowing dates (Joint Recommendations, 1974) for the varieties used by sample farmers for both Punjab and Sind Provinces are given below:

Variety and Province	Recommended Sowing dates
1. Punjab	
Chenab 70	Oct. 25 - Nov. 20
Lyallpur 73	Nov. 1 - Nov. 20
Mexi-Pak 69	Nov. 10 - Nov. 25
Sandal	Nov. 20 - Dec. 10
S.A. 42	Nov. 25 - Dec. 15
Blue Silver	Nov. 25 - Dec. 15
2. Sind	
Pak 70	Oct. 20 - Nov. 20
Chenab 70	Oct. 20 - Nov. 20
Mexi-Pak 70	Nov. 1 - Nov. 20

Farmers were asked to provide the range of sowing dates used for the particular variety they cultivated for the 1975-76 season. These dates were then compared with the recommended range of sowing dates for the variety used by the farmer (see Table 37). A major constraint on meeting the recommended sowing dates is the lack of reliability of canal irrigation supplies for farmers who do not have easy access to tubewell irrigation supplies. For example, in 1974 the monsoon rains terminated early and there was little rainfall from August 6 to December 1. Rivers were at their lowest levels in about 90 years. Added to this problem, engineering problems at the famous Tarbella Dam, which was almost completed, necessitated the early release and loss of all waters in storage. Canal rationing had to be enforced, and farmers without supplemental supplies were unable to sow their wheat on time. Even when canal supplies are regular, farmers seldom can sow all their wheat crop at the same time. Therefore delays inevitably take place.

B. Seedbed Preparation

Improved methods of seedbed preparation have been recommended since 1965 for the HYV and though there are little available data to isolate the importance of deep plowing using a mouldboard plow, it is usually recommended. Farmers can prepare a good seedbed with the local desi plow, but it does not run deep and usually 6 to 8 plowings and plankings are necessary to control weeds. Field observations indicate that often the local plow leaves unplowed gaps, due to the lack of soil inversion. Local plows running at a shallow depth also result in excessive plowings which breakdown the soil structure, thereby establishing a condition that creates soil crustation when rainfall occurs. Excessive final plowings also result in much moisture depletion. Of the 371 sample farmers, only 27 percent report using the mouldboard plow and tractor plowing for seedbed preparation. In an intensive field study in 1970 (Lowdermilk, 1972: 371-72) it was found that only 28 percent of the 350 sample farmers in the Multan District used these improved methods of seedbed preparation. However, the major constraints of farmers to using the improved plow are spare parts and lack of repair facilities in villages. Also, for the smaller farmers, cost may be an obstacle.

C. Seeding Depth and Seeding Method

Studies have shown that due to the shorter and weaker coleoptile of HYV of wheat as compared to local varieties such as AC 273 and AC 591 the depth of seeding is critical for good seed emergence. Several studies have investigated the importance of this factor (Lowdermilk, 1972: 371-72). Singh (Singh, 1969: 136) found that depths of 5.0 to 7.5 (2" to 2.9") gave the best results when other factors were controlled. Also, research results and recommendations in Pakistan have stressed the importance of uniform seeding depths of 2 to 2.5 inches.

Farmers in Pakistan through long years of trial and error have found that local varieties can be seeded at a depth up to 4 inches or more using the kera and pora methods. About 30 percent of the sample farmers report that they still use depths of seeding that are 3 to 4 inches. Some report 5 to 6 inches. About 34 percent (see Table 37) report depths from plus or minus about .5 inches of the recommended depth of 2.5 to 3.0 inches and about the same percentage report sowing at the recommended depth. More research is needed to isolate the importance of this factor on plant emergence and yields. Even very shallow depths of seeding often reduce yields from the lack of moisture in the top one to two inches of the seedbed due to excessive plowings.

Related to seed depth is the method required for adequate depth and uniformity in seed placement. Sowing is usually done by broadcasting, the use of kera, which is dibbling the seed in furrows, the use of pora, which is a pipe with a small funnel secured behind a small local furrow plow, or the use of an automatic rabi wheat drill. The pora and the drill are recommended because "they give the best results in all provinces as they insure uniform stands and also save seed" (Joint Recommendations, 1974: 71).

When seed is broadcast usually an extra plowing and planking are used to cover the seed. This broadcast method, while requiring only about 0.3 of a man hour/acre as compared with about 10 hours/acre using the pora method, leaves many seeds uncovered which birds eat or in the top levels of the soil profile where moisture is rapidly depleted (Gibb, 1966: p. 94). Recommendations suggest (Joint Recommendations, 1975: 7) that both with the broadcast and kera methods at least 30 percent more seed are required to assure better plant populations. The pora and kera methods usually leave the seed at a depth of 3 to 5 inches, which is too deep for good emergence of the HYV. However, if we include pora as an improved seeding method with the drill, about 38 percent of the sample farmers can be said to use improved sowing methods. The automatic bullock powered seed drill is a simple device, without a fertilizer attachment, which has a seed box mounted on wheels with 4 to 5 tubes and coulters which can be crudely set for the seed rate required. The coulters can be set in slots for the depth required. While these locally made machines are crude, they are a great improvement over other methods; they provide more uniform seed depth and placement at a greater speed than that of the kera or pora method.

D. Levels of Fertilizer Use and Methods of Application

Levels of phosphorus/acre for the HYV of wheat average only 11 nutrient lbs for sample farmers (see Table 37). Seventy-two percent of the sample farmers report they use none at all. Because only 25 percent use the recommended levels one is not surprised at low yields. The simple correlation coefficient for phosphorus and yields is .48 which suggests its importance for yields. The 1974-75 recommendations (Joint Recommendations, 1974-5: p. 7-10) state the following:

> "Last year's reports indicate that the overall ratio of nitrogen to phosphorus was close to 6:1. This year we aim for 4:1 if not to the ideal of 2:1. However, on account of extensive use of nitrogenous fertilizer over the last 8 to 9 years a great depletion in phosphorus availability has occurred. Some of the best yields have been obtained using a 1:1 ratio...wheat is extremely sensitive to phosphorus deficiency and the effects on yield when this element is insufficient are spectacular."

It is interesting that the ratio of nitrogen to phosphorus by sample farmers was 4.6:1 (51 lbs. of N and 11 lbs. of P) for the season 1975-76.

The amount of phosphorus is important, but its placement is crucial (Qureshi and Khan, 1970: 91). Drilling or banding this fertilizer at a proper depth is important for its improved availability to the plant. The method of broadcasting phosphatic fertilizer followed by plowings and planking leaves amounts at variable depths and often much remains on the soil surface or only a few centimeters from the surface. Since phosphorus does not move in the soil and is not lost through leaching, the high Ph of many soils in Pakistan, especially as salts move upward, also affect its availability to plants. The problem of low levels of use of phosphorus have been evident since the late 1960's for HYV of wheat. In 1970, (Lowdermilk, 1972: p. 256-298) a sample survey in Multan District reported that 93 percent of 350 HY wheat growers used no phosphorus at all.

Equally important to the use of fertilizer is proper timing of application. All recommendations call for splitting the nitrogen and, of course, all the phosphatic fertilizers are to be applied at time of sowing or a few days before. Since the vast majority of our sample farmers apply only one bag of nitrogen, they do not split the applications but apply all at the time of sowing (see Table 37). At a minimum, when more than one bag is applied, about half should be applied at the first or second irrigation given typical soil conditions. When farmers utilize a bag of fertilizer in one application and irrigate basins by flooding, a considerable amount of the nitrates are leached through the root zones. This loss is greatly accelerated on the more sandy soils. Kemper (Kemper, 1975e: 458-465) and others have investigated this phenomenon and find that a substantial percentage of the costly nitrates are unavailable to plants due to leaching depending on the soil type and condition, infiltration rates, and volume of water applied.

Almost all fertilizers are broadcast and most are applied in one application at seeding. The generally recommended levels of fertilizer required are next to impossible to ascertain due to the differences in natural soil fertility, soil type, the nutrient utilization of preceding crop, the amount of farm yard manure used, the irrigation water supply situation, the amounts of phosphorus especially applied to previous crops and the method of applying fertilizer. Earlier, general recommendations were given for the provinces with little consideration for these factors. In recent years more usable recommendations are given which include the general soil fertility type including very high, high, average, and depleted fertility categories. The average, after a summer crop, is 100 nutrient lbs. of N and 50 lbs. of P with no potash (Joint Recommendation, 1974: pp. 7-12). If we assume, for our sample of wheat farmers, average fertility after a summer crop as a comparison, we note that about 20 percent of the farmers used no purchased inputs of nitrogen; 65 percent used less than 75 nutrient lbs., 2 percent used from 75-99 lbs. and only 14 percent used the recommended rate of 100 lbs. or more (see Table 37). These are low levels, indeed, and, constitute a major reason for low yields. Earlier, in the examination of factors related to variation in yields, we found that nitrogen and phosphorus used alone, with other factors controlled, explained about 21 percent of the variation. The simple correlation coefficient for nitrogen and wheat yields was .43. The simple correlation coefficient for split applications and yields was .43. However, since only farmers using higher levels of N split their application, level of the use of nitrogen and split applications are also correlated at .51.

E. Seed Rates

Proper seed rates are related to many factors such as the date of sowing, the method of sowing, and the soil type. For example, recommendations (Joint Recommendations, 1974) call for 25 to 30 seer for farmers who use the pora method or automatic seed drills and 40 seer for the broadcast method. Late sowing recommendations for the varieties used by sample farmers are 35-40 seer for pora and drill methods and 45-50 seer for broadcasting. Since the majority of sample farmers use broadcast and kera methods, and 43 percent are not able to meet the recommended sowing date, let us assume that 40 seer is a minimum amount required. We note in Table 37 that about 43 percent of the sample farmers use less than 40 seer. The use of generally low seed rates are probably related to tradition because the cost of a few lbs. of extra seed is very little (about Rs. 1/seer), and seed of the HYV are easily available from farmers' own seed supplies or from neighbors. The Punjabi farmer speaks of traditional seed rates of 32 seer and 36 seer, and farmers explain that, with the kera and pora method, they can sow almost the exact amount of 32 to 36 seer evenly over an acre of land. Many factors are related to the actual plant population achieved. However, given the high pH of arid soils, salinity problems, and the traditional methods of seeding, it appears that higher seed rates would result in off-setting some of these problems and result in higher yields. Recommendations are often established from the best management conditions of research stations and do not take into full consideration the actual conditions and practices at the farm level. In an earlier study (Lowdermilk, 1972: pp 441-446) seed rate of wheat HYV was significantly related to yields/acre.

Until the water supply situation is improved there is little that the farmer can do to sow or plant crops on time. Likewise, increased cost of fertilizers have probably resulted in lower levels of use. To offset this problem improved facilities for institutional credit will be necessary, especially for small farmers and tenants. However, even if these constraints are removed, farmers in general need more help in improving their farm management practices. Farmers are rational and are doing the best they can given their constraints. The problem is the lack of farm level services and information to assure that farmers have improved production possibilities. It has been assumed that given more water and more fertilizers farmers would automatically increase their levels of crop production without considerable inputs of other institutional services. This is a questionable assumption. One doubts that water and fertilizer constraints alone explain the present low plateau of wheat yields in Pakistan. Some (Borlaug and Morales, 1969: 8-10) have stressed the multiple factors which result in low wheat (HYV) yields--farmers unaware of the proper dates of sowing, depth of seeding, amounts and timing of fertilizer inputs, poor quality of seed used, seed rates too low and broadcasting seeding methods, inadequate depth of plowing for seedbed preparation, lack of phosphatic and nitrogen fertilizers.

F. Farm Size Classes and Utilization of Recommended Practices for HYV of Wheat

Table 38 shows the differences in use of the recommended practices by sample farmers distributed among six different farm size categories. Some of the practices require inputs of capital and equipment not easily available to small farmers such as the improved plow for seedbed preparation and recommended levels of nitrogen; others, such as seeding depth, seeding method, split applications of fertilizer and seed rates do not require significant additional capital.

As seen from Table 38, seeding date was not found to be significantly related to size of farm. However, note that about 50 percent of the farmers with holdings of 25 or more acres actually used the recommended seeding date.

Table 38. Percentage of farmers using recommended management practices for HYV of wheat by farm size classes.

Farm size classes (acres)	Range of sowing dates (a) (n=344)	Seedbed preparation (b) (n=371)	Seeding depth (c) (n=342)	Seeding method (d) (n=371)	Nitrogen rates (e) (n=371)	Phosphorus rates (f) (n=375)	Split application of nitrogen(g) (n=364)	Seed rates (h) (n=187)
Under 2.5	27.9	12.5	23.7	48.6	4.2	5.5	15.3	82.4
2.5 - 7.49	32.6	15.9	35.3	36.2	10.6	26.3	35.6	57.1
7.5 - 12.49	27.3	29.4	33.3	34.7	16.9	27.1	39.8	56.6
12.5 - 24.99	33.3	37.6	41.0	32.9	18.8	26.7	42.9	56.9
25.0 - 49.99	52.9	58.8	35.3	35.3	23.5	70.6	64.7	41.2
50.0 and above	50.0	75.0	87.5	75.0	50.0	54.0	62.5	42.9
All sizes	32.0	26.9	35.4	38.3	14.3	25.1	36.3	57.2
Chi square values	X^2=13.6	X^2=61.4	X^2=19.4	X^2=26.9	X^2=72.2	X^2=52.2	X^2=24.2	X^2=13.1
Degrees of freedom	10	15	15	15	20	15	5	10
Significance level (i)	NS	.001	NS	.03	.001	.001	.001	NS

a. The recommended range of sowing dates for HYV used by farmer.
b. Use of bullock powered mouldboard plow or tractor for deep plowing.
c. Use of 1.5 to 2.5 inch depths.
d. Use of pora or drill methods.
e. Use of 100 nutrient lbs. of nitrogen or more.
f. Use of 50 or more nutrient lbs. of phosphatic fertilizers.
g. Splits nitrogen applications.
h. Uses 40 seer or more seed.
i. Note that the degrees of freedom include several categories as shown in Table 38, therefore the larger number of degrees of freedom than "yes" "no" categories would give.

This may suggest the fact that large farmers having tubewells have more control over irrigation supplies. Seedbed preparation which requires an improved raja mouldboard plow or tractor plow is found to be related to farm size because as found earlier larger farmers own more improved plows and make greater use of tractors for seedbed preparation. Seeding depth and seed rate are not significantly related to farm size, though larger farmers use more drills than smaller farmers. However, the small farmer could easily use the pora method at no extra cost. The levels of nitrogen and phosphatic fertilizers used are highly related to farm size as expected because larger farmers control the means of obtaining increasingly costly inputs of fertilizer. Also the split application of nitrogen depends on the amounts used and earlier we found that the simple correlation between nitrogen used for wheat and split applications equals .51.

In conclusion, we find that farm size explains much of the difference in utilization of recommended practices for HYV of wheat. Larger farmers not only are able to finance the improved practices which require increased capital but also they are able to receive more benefits from extension and other services than smaller farmers.

G. Summary Regression Analysis of Adoption of Improved Farm Technologies

After examining the types and levels of technologies utilized by sample farmers, a summary regression analysis is presented to search out factors which help explain the differences in adoption levels. However, first a note of warning should be given about grouping a number of innovations into an index. Agricultural innovations usually have unique individual characteristics in relationship to such factors as divisibility, complexity, cost-benefits, congruence with old practices, and visibility.

Therefore, often it is important to study each innovation separately rather than in an index. With this reservation, the adoption index[3/] which is described in Volume VI, Appendix I-B, is used as the dependent variable to ascertain those independent variables which may have some influence on farmers' adoption behaviors. The adoption index has a total possible score of 29. The mean, median and ranges of scores obtained by sample farmers are respectively 5.7, 5.0 and 0-16. Use of an innovation by hire, etc., is scored the same as for ownership.

The variables with the highest intercorrelations are between mass media exposure and the farm management knowledge index (r = .38), and mass media - education (r = .44). Other variables show much less intercorrelation.

The regression model used is:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 \ldots b_8x_8$$

where a and b are the parameters to be estimated:

x_1 is the farm management knowledge index

x_2 is level of education (years of formal education completed)

x_3 farm size (acres owned)

x_4 type of command (dummy variable - 1 = perennial; 0 = nonperennial)

x_5 age of farmer in years

x_6 tenure status (dummy variable) owner = 1, owner-cum-tenant = 2, and tenant = 3

x_7 mass media use index

x_8 use of tubewell (dummy variable, no use = 0, hire = 2, ownership = 3)

The three most important factors which help to explain about 58 percent of the difference in adoption rates are: farm management knowledge, level of education, and farm size. One would expect high intercorrelations

3/The index has not been tested for scalibility at this point.

of the first two factors and farm size but the correlation coefficients obtained between farm management knowledge and adoption (r = .16) and adoption (r = .33) are relatively low. It will be recalled that the farm management knowledge index (see Volume VI, Appendix B) is composed of eight recommended or improved production practices for HYV of wheat. It is used here as a proxy for a farmer's general knowledge about agricultural innovations and as noted from Table 39 this variable explains about 46 percent of the variation in adoption rates.

Level of education of the farmer respondent and farm size combined also explain jointly about 11 percent of the variation in adoption. Education is important in that it is correlated to management knowledge and mass media exposure respectively with coefficients of .28 and .44. This rather high intercorrelation with mass media exposure reduces the contribution of mass media at step 7 in the regression.

Table 39. Summary of step-wise multiple regression analysis, selected independent variables and relationships with adoption index.

Steps	Variables	Beta	S.E.of* Beta	t ratio	Multiple R	Multiple R^2	Final F* ratio
1	Farm management knowledge index	.286	.0364	7.86**	.680	.463	61.49***
2	Level of education	.713	.2643	2.69*	.7396	.547	7.28***
3	Farm size (owned)	.010	.0080	1.25	.7591	.576	1.61**
4	Type of watercourse command (perennial vs. nonperennial)	1.051	.6392	1.64	.774	.598	2.70**
5	Age of farmer	.040	.0172	2.33	.781	.609	5.29[a]
6	Tenure status	.507	.3363	1.51	.786	.618	2.27
7	Mass media index	.049	.0894	.55	.793	.629	.30
8	Use of tubewell	.077	.2390	.32	.796	.634	.103

*Note that the t ratio = Beta or regression coefficient ÷ S.E. of Beta.
F values or variance ratios required are 2.36 and 3.50 for one and seven degrees of freedom for the .05 and .01 levels of significance.
***Significant at .001 level.
**Significant at .01 level.
[a]Significant at .07 level

CHAPTER FOUR

KNOWLEDGE AND INFORMATION CONSTRAINTS

In addition to physical and economic constraints are a number of other production constraints having to do with knowledge and information problems. The modernization of any agricultural sector requires a set of institutions providing farmers with adequate extension services, agra-business services and information systems which provide a steady stream of innovations, ideas, and new knowledge. As modernization proceeds, demands for adequate services and information increase because the margins for risk reduce as agriculture itself becomes more complex. Farmers in Pakistan sorely require improved informational services which presently are poor in quality and in short supply--especially for small operators.

The purpose of this chapter is to identify factors which make it difficult for farmers to make rational cropping decisions. The problem lies not so much with the farmer himself, who responds positively to incentive programs, but with the lack of appropriate services for many farmers in Pakistan. Especially with regard to irrigation practices, the farmer, through trial and error, is more expert than the presently poorly trained field workers assigned to assist him.

I. FARMERS' REPORTS OF MAJOR FACTOR IN DECISION MAKING TO CULTIVATE SELECTED CROPS

Farmers' perceptions of major factors involved in their decisions to cultivate certain crops, are presented in graphic form for all village sites (see Figures 8 and 9). Multiple factors are usually influential in making cropping decisions. However, to gain an overview of farmers' perceptions, farmers were asked to report the most important factor involved

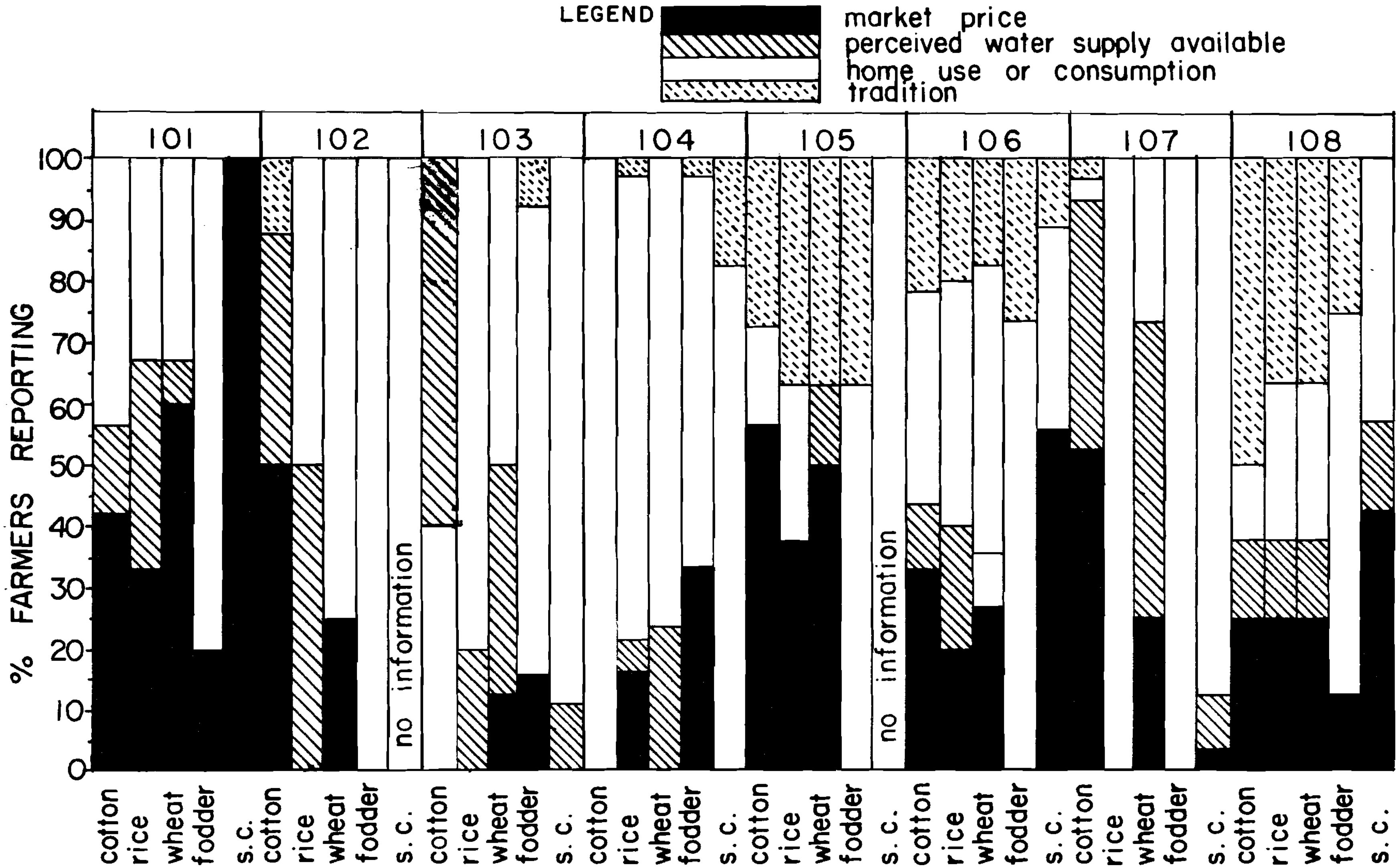

FIGURE 8. FARMERS' REPORTS OF MAJOR FACTOR IN DECISION MAKING TO CULTIVATE SELECTED CROPS

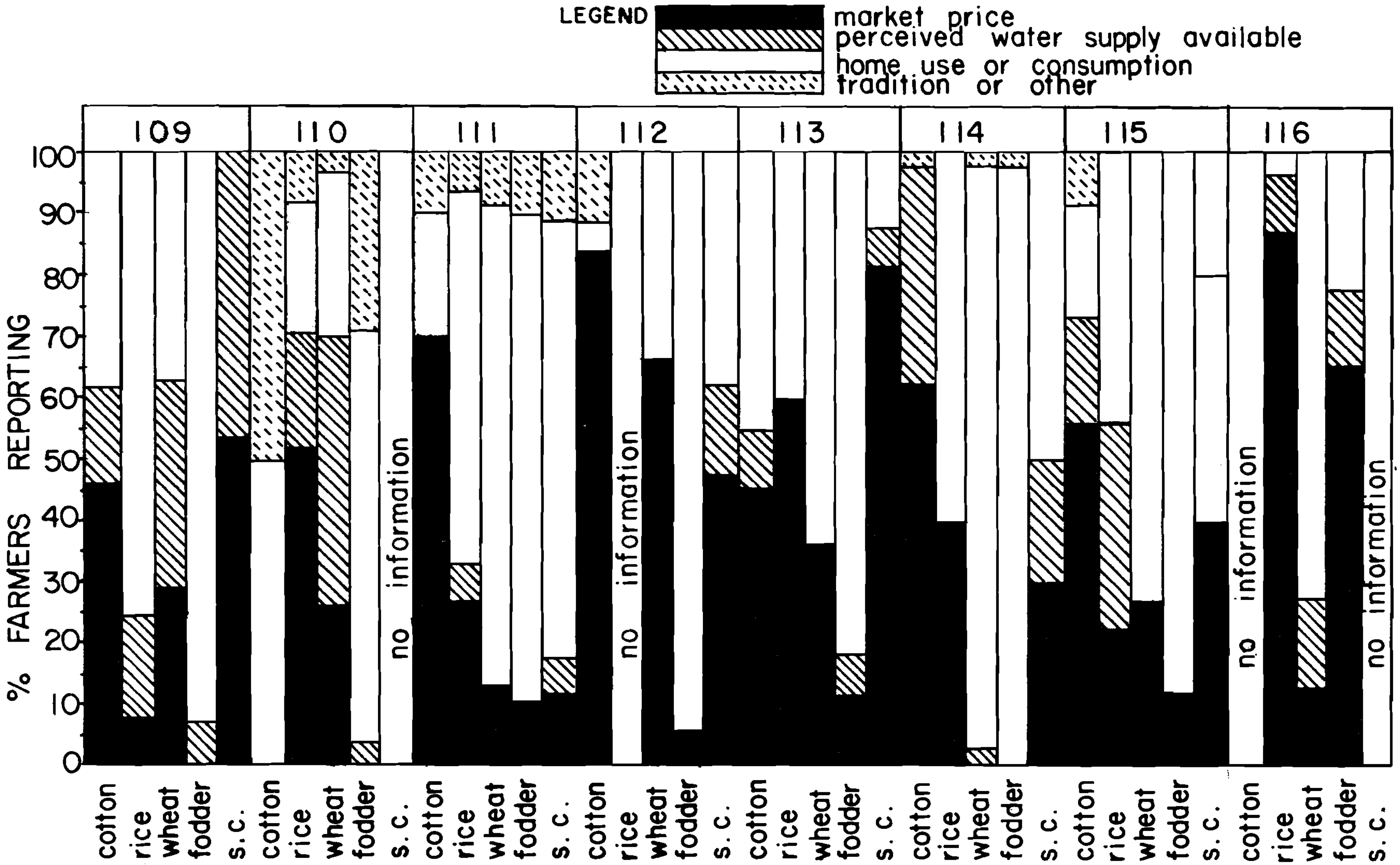

FIGURE 9. FARMERS' REPORTS OF MAJOR FACTOR IN DECISION MAKING TO CULTIVATE SELECTED CROPS

in their decisions to cultivate cotton, rice, wheat, fodder, and sugarcane crops. Each of the village sites are examined separately.

It is evident that the major factors for farmers in village 101, with perennial irrigation supplies, two private tubewells, and a high water table at the lower command reach, that market price and home consumption are the major factors reported. However, for cotton and rice "perceived water supply available" becomes important for rice growers especially. Note that 100 percent of the 15 sample farmers report market price as the single most important factor for the decision to cultivate sugarcane. This is one of the village sites near a sugar mill and all sample farmers cultivate large areas of sugarcane. Near the tail of the command areas the high water table also provides much moisture for crops.

Village 102 is predominatly wheat-cotton perennial command area with six private tubewells for a cultivated area of 369 acres. Here, due to the high water demands for cotton, over 37 percent of the farmers report perceived water supply available as the major factor in cultivating cotton and about 50 percent give the same report for rice. Market price plays the dominant role in the decision to cultivate cotton and fodder is all cultivated for home use. No sample farmers cultivate sugarcane on this watercourse command where sugarcane is a minor crop.

Village 103 is on a perennial command and has one private tubewell. All canal water is lifted from the watercourse by jhallar waterlifts which provide a variable discharge of from .2 to .4 cusecs depending on the speed of the animals. The water factor becomes important here for cotton and wheat with respectively 60 and 37 percent of the farmers reporting "perceived canal water supply" as the most important factor. While market price is reported for fodder, the price near Lahore City is usually good due to a strong demand, and much fodder is used for milch cows whose products are marketed in the city.

Likewise, farmers on three perennial commands at site 104 market much fodder and also milk products in Lahore markets; therefore, price and home use become important for decisions to cultivate fodder. Price plays a role in rice cultivation and the water supply situation for the wheat crop. The small acreages of rice are primarily for home use as is the sugarcane crop.

Site 105 is a nonperennial command with one public tubewell with a discharge of 1.8 cusecs. Market price is instrumental for all crops but fodder, and farmers' perceived water supplies are not influential in cropping decisions due to the fairly good tubewell supply which provides substantial reliability and control of irrigation supplies.

Site 106 is both a perennial command and one that has the extra reliability and supplies of water from a public tubewell with a measured discharge of 1.3 cusecs as the time of the survey. Market price plays a role in deciding to cultivate cotton, rice, wheat, and sugarcane. There is a sugar mill about 10-15 miles from this command area and sample farmers cultivate this crop. Again, given the public tubewell supplies and relatively good water control, the perceived water supply situation is only slightly important for cotton and rice cultivation.

Village 107 with three perennial command areas and 26 diesel powered private tubewells grows rice and fodder only for home use. Small acreages of sugarcane are cultivated, and a few sample farmers sell some cane and country sugar to village shops for local consumption. Due to the high density of tubewells, sixteen of which are jointly owned, the intensity of cropping is very high. The village is completely made up of refugees from former Indian Provinces near Amritsar. About 40 and 47 percent of the farmers respectively report "perceived canal supplies" as important in decision making for cotton and wheat cultivation. Market price is the dominate factor in cotton production for the 55 farmers at this site located in Multan District at the heart of the cotton belt. Market price is also the most important consideration for about 25 percent of the wheat farmers.

Respondents at site 108, a nonperennial command with two private tubewells and a public tubewell, report that traditional practices play a most important role in their decisions for wheat, rice, and cotton. Market price is more important for sugarcane, as 7 of the 8 sample farmers grow cane for a local sugar mill. Price is also fairly important in decision making for all other crops except fodder, as about 25 percent of the farmers report this as an important factor. Figure 9 provides data for sites 109 to 116.

In summary, several observations can be made about farmers' perceptions about major factors in their decisions to cultivate certain crops. First, for fodder, the primary factor involved is home consumption. Secondly, where wheat, rice, cotton and sugarcane are marketed and where there is a relatively fair to good water supply situation, farmers' reports show that market prices are of greatest concern to most respondents -- especially sugarcane and cotton. Thirdly, the water supply situation represents a major factor for some farmers at all sites for one or more crops. Fourthly, each site has its own particular water supply situation which influences farmers' responses. The presence of supplemental sources of irrigation water is important--tubewells and Persian wells--providing more control and reliability of irrigation supplies.

II. WATER APPLICATION--TIMING, METHODS AND QUANTITY

The application of irrigation water as well as its distribution among farmers is as much a human problem as a physical one. The primary focus of this section is to learn from sample farmers what their attitudes and levels of knowledge are about certain irrigation practices and soil-water-plant relationships. This will provide some idea of "where they are" and what might be required to help them improve their knowledge and consequently their irrigation behaviors. Where possible, we will make some rough comparisons of information presented by farmers with actual measurements of amounts of water applied and size of irrigation basins. This will provide a comparison between what they report they do and what they actually do.

As discussed in the previous chapters, improvements in the distribution and application of irrigation water greatly depends on the farmer himself. We cannot assume that physical improvements of watercourses and land leveling services alone will make much impact on farmers' per acre yields or levels of living without changes in farmers' knowledge levels.

A. When to irrigate?

Farmers were asked how they make decisions to irrigate crops. Their responses are summarized in Figure 10 and are grouped under various water supply situations. While farmers were asked to rank the three most important factors, only the most important consideration is displayed in Figure 10. The first impression gained from Figure 10 is that there is little difference in responses of the 376 sample farmers regardless of the water supply situation.

For the total sample, about 60 percent of the farmers rank as the most important method in making decisions when to irrigate the visual

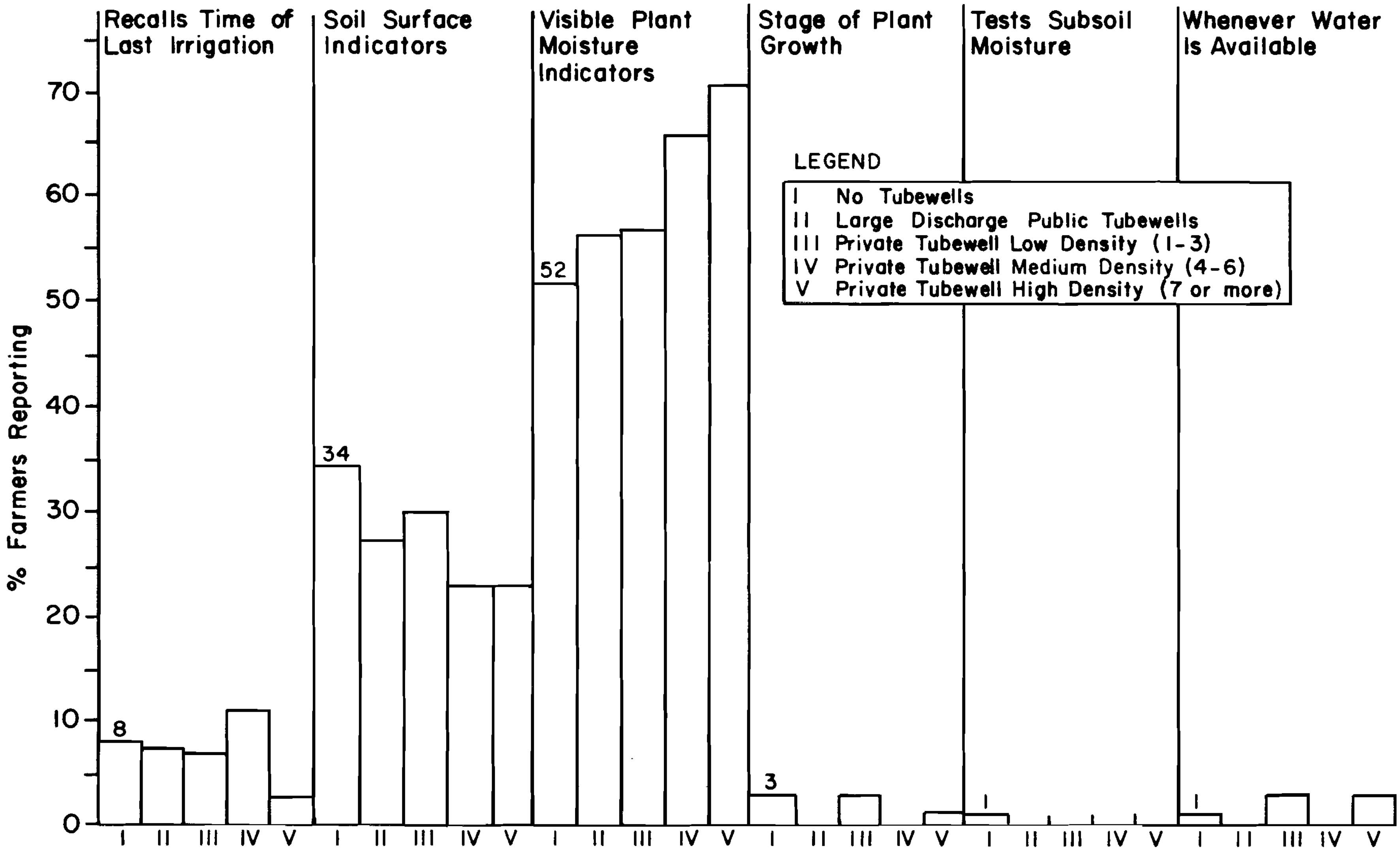

FIGURE 10. FARMERS' REPORTS OF MAJOR METHODS OF DECISION MAKING TO IRRIGATE CROPS BY TUBEWELL SUPPLEMENTED AND NONSUPPLEMENTED WATERCOURSES

observation of crop plants. The second most important method reported is "when the soil surface appears dry." The third most important method reported is farmers' remembrance of the time of last irrigation. These three types of decision making were also reported more often by farmers as first and second most important methods used. It is significant, that of the 376 farmers reporting, only 11 reported testing the subsoil moisture by digging with a cussie (spade) and "feeling" the soil.

Some crop plants, such as maize and cotton, do indicate to a degree soil moisture requirements while other plants are near the wilting point before stress signs are visible. Also, soil surface observations alone gives little indication of moisture stored in the root zones.

Farmers appear to have no adequate methods of deciding when to irrigate. This is to be expected given the absence of on-farm water management extension or advisory services in Pakistan, and when it is remembered that farmers have relatively little control over the timing of water. We do not know, but we suspect that much of the over and under-irrigation observed in this survey resulted from the limited knowledge of farmers as well as other constraints, such as limited control over timing of canal water supplies. As reported earlier, during the survey we observed farmers irrigating during substantial rainfalls. We recorded data on several farms where farmers applied water when there was zero soil moisture depletion. Farmers were also observed opening field inlets and going away allowing the water to completely fill the basin and over-flow into the next field.

B. When to stop an irrigation?

Farmers were asked how they decide when to stop an irrigation for a particular basin. About 47 percent reported "when water reaches the far border," 33 percent reported "when water covers all the high spots," and 10 percent of the 378 reporting farmers stated "when a certain depth of water is applied to the basin."[4/] Another 10 percent indicated "just before the irrigation water reaches the far border." The bar graph displayed in Figure 11 provides farmer reports for five different water supply situations on the 40 sample commands. Farmers on public tubewell supplemented commands, usually with more available water, and commands with medium density of private tubewells, prefer to completely fill the basins. The major concern of farmers on nonsupplemental commands is to cover the high spots. Unlevel fields present many problems to farmers. With high and low spots in a field, some areas receive excess water while others receive too little. By the time many farmers have applied amounts of water to completely cover basin high spots, soil moisture requirements have been exceeded. Where nitrogen fertilizer has been applied, it is expected that much of the nitrate is leached out and lost. Actually, overirrigation of crops can be viewed as a triple menace because it creates waterlogging and salinity problems, leaches expensive nitrates, and reduces the quality of groundwater by mixing with salts--all resulting in the reduction of crop yields. It is significant that only on commands with public tubewells, and commands with a medium to high density of private tubewells, do 10 to 20 percent of the farmers report that they stop irrigations before water reaches the far border of the basin. This probably results from the greater volume of water for irrigations which farmers

4/However, in comparison to farmers' reports, actual observations of 291 farmers while irrigating showed that the following percentages of farmers stopped irrigations when: water completely filled basin (70%); when irrigation time over (11%); when few marks left (6%); when high spots covered (3%); other (10%). (Other includes those who appeared at field to open the nakkas for irrigation and never returned. Eighteen of these 26 farmers were from public tubewell or excess water commands.)

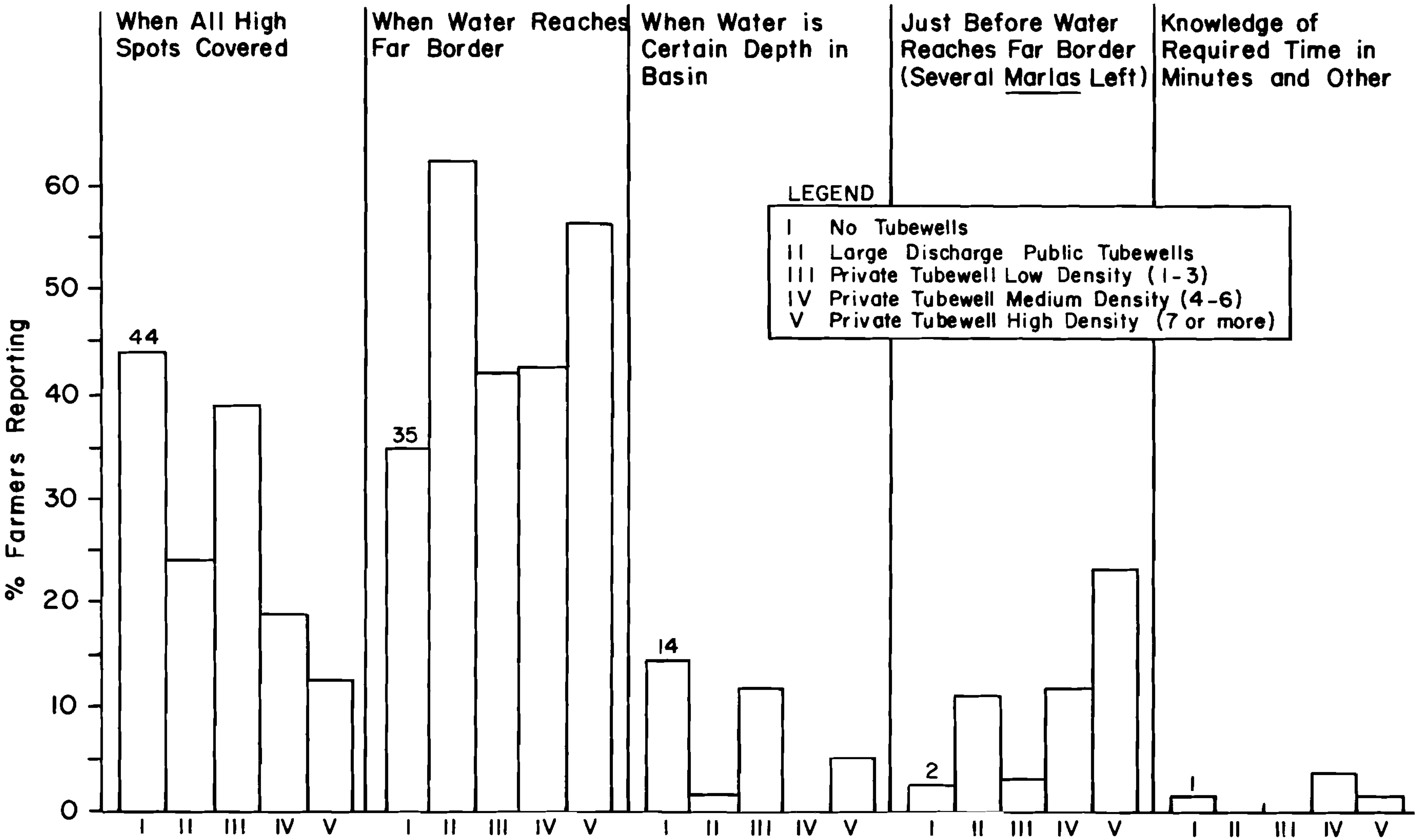

FIGURE 11. SUMMARY OF FARMERS' REPORTS OF METHOD USED TO STOP AN IRRIGATION BY TUBEWELL SUPPLEMENTED AND NONSUPPLEMENTED WATERCOURSES

know will cover the field completely. It is also interesting that only about 2 percent of the farmers report a knowledge of the required time it takes to irrigate their basins. Farmers need improved technology for land leveling and extension advice on how, how much and when to irrigate.

C. Farmers' Reports of Water Applied for a Typical Irrigation

Each farmer was asked what he would consider a good irrigation for his soils in terms of "inches of water applied." It must be realized that farmers have no way of knowing how much water they apply in acre inches because they have no accurate method of measuring water. The farmers' concept is the amount of water or delta ponded in the basin when an irrigation is completed. This method does not include infiltration rates during an irrigation. Figure 12 shows farmers' reports of inches of delta applied to their basins for what they consider to be a typical irrigation. Farmers were asked in each case to indicate on their hand and fingers the depth of water they usually pond on their fields. These estimates, though only crude approximations, were then made by the interviewers and reported in intervals. However crude the estimate, fully 75 percent of the sample farmers reported 2.0 inches or more. By the time water has been ponded at this depth, depending on the size of the basin, the soil moisture deficiency, the roughness of the soil surface, the infiltration rate into the soil profile, and the slope or level of the field, it is likely to be more than double the required amount of water for the particular crop. Figure 12 shows the modal number of estimated water depths farmers report they pond on their basins. This information is presented by the four estimated atmospheric evaporative regions or zones. The median depths in the low deficit zone is from 2.0 to under 3.0 inches. However, for the low to medium deficit zone the median is 3.5 to under

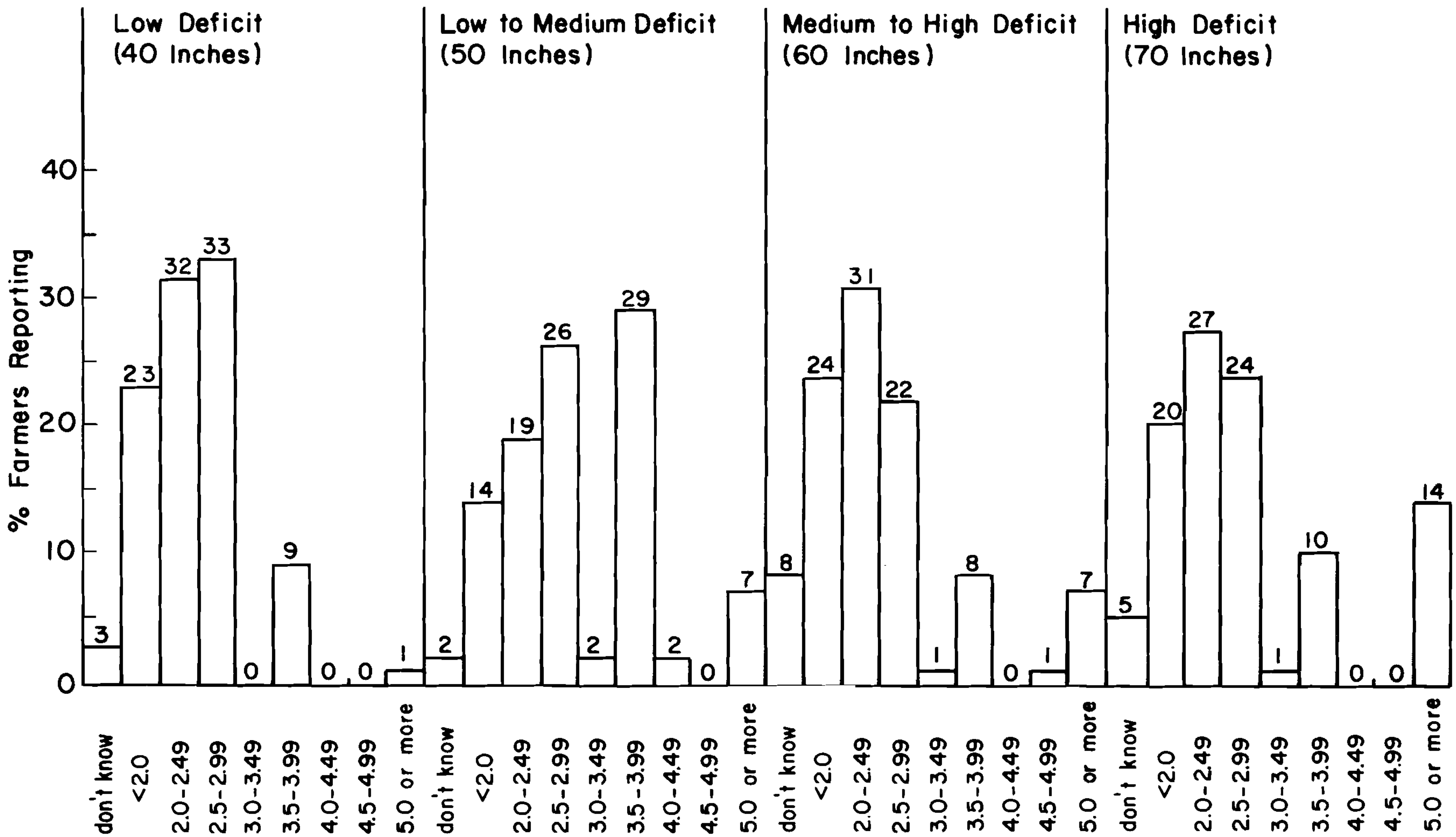

FIGURE 12. FARMERS' ESTIMATES OF DELTA OF WATER APPLIED FOR A TYPICAL IRRIGATION AFTER PRE-IRRIGATION BY ANNUAL ATMOSPHERIC EVAPORATIVE MOISTURE DEFICIT

4.0 inches. This is the region with five commands supplemented by public tubewells. The median interval for farmers in the medium to high zone is 2.0 to under 3.0 inches as is the case for the high atmospheric evaporative zone. However, in this zone about 15 percent of the farmers report applying 5 inches or more.

Table 40 provides a clearer picture of respondent estimates of water depth applied as it compares farmers' reports to the watercourse supplemental supply. Table 40 shows farmers' reports of inches of delta ponded in their basins for what they consider to be a "good" or typical irrigation. We note that about 74 percent of the farmers report ponding up to about 2.5 to 3.0 inches per irrigation.

D. Number of Irrigations: Another Crude Measure Used by Pakistani Farmers

Determining the number of irrigations represents a very inadequate way of estimating irrigation adequacy--there being no accurate information about how much water is actually applied--it is the farmers' measure. Even research institutes in Pakistan often use this as a measure of crop requirements (Joint Recommendation for Wheat Production, 1974: 2-13). To examine the differences between reports of what farmers usually apply and what they perceive the optimum number of irrigations to be, farmers were questioned about wheat--a crop cultivated in all regions. Their reports are presented in Table 41. Table 41 indicates that farmers in each region differ greatly as to usual and optimum numbers of irrigations. For example, at site 107 with 26 private tubewells for 3 command areas in the Multan Region, there is wide variation between farmers as to both optimum and usual number of irrigations.

Table 40. Cumulative percentages of estimated inches of water farmers report they pond in basins for a "good" irrigation by time of command and site.

Type of command and sites	No. farms report-ing	Cumulative percentages of estimated inches of water farmers report they pond in basins for a good irrigation								
		<2	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.0+	Don't know
Perennial										
101	15	33.3	53.3	86.6	86.6	93.3	93.3	93.3	93.3	100.0
102**	9	44.4	77.7	88.8	88.8	88.8	88.8	88.8	100.0	-
103	16	25.0	75.0	100.0	-	-	-	-	-	-
104	36	30.6	55.6	83.4	83.4	94.5	94.5	94.5	97.3	100.0
106*	12	0	8.3	33.3	33.3	83.3	83.3	83.3	100.0	-
107**	55	35.8	64.3	86.9	86.9	88.8	88.8	90.7	90.7	100.0
109*	14	7.1	35.7	50.0	57.1	92.9	92.9	92.9	100.0	-
110**	27	11.1	40.7	85.2	85.2	96.3	96.3	96.3	96.3	100.0
112	34	4.0	40.0	64.0	64.0	68.0	68.0	68.0	80.0	100.0
113	26	26.9	69.2	84.6	84.6	100.0	-	-	-	-
116	26	31.9	50.0	68.2	68.2	72.7	72.7	72.7	95.4	100.0
Nonperennial										
105*	8	12.5	25.0	37.5	37.5	87.5	100.0	-	-	-
108*	9	11.1	33.3	77.8	77.8	88.9	88.9	88.9	100.0	-
111*	24	0	45.0	75.0	80.0	100.0	-	-	-	-
114	39	15.8	42.1	50.5	50.5	71.0	71.0	71.0	89.4	100.0
115	39	18.4	34.2	65.8	68.4	81.6	81.6	81.6	100.0	-
Weighted totals	389	20.4	48.9	74.2	75.0	87.0	87.3	87.3	90.9	100.0

*Denotes public tubewell supplemented commands
**Denotes commands supplemented by 6 or more private tubewells only.

Table 41. Number of optimum and usual irrigations reported by farmers for high yielding varieties of wheat by village site.

Type of command and village site	No. farms reporting	Optimum and usual	Estimated number of irrigations excluding preirrigations					
			< 3 %	4-5 %	6-7 %	8-9 %	10-11 %	12+ %
Perennial								
101	15	optimum	6.7	20.0	40.0	26.7	6.7	-
		usual	26.7	40.0	20.0	-	-	13.4
102**	8	optimum	-	12.5	37.5	37.5	-	12.5
		usual	-	33.3	33.3	22.2	-	11.1
103	16	optimum	-	-	62.5	25.0	6.3	6.3
		usual	6.3	56.3	25.0	12.5	-	-
104	36	optimum	-	71.4	20.0	-	2.9	5.7
		usual	57.1	37.1	-	2.9	-	2.9
106*	9	optimum	-	22.2	56.6	11.1	11.1	-
		usual	-	44.4	33.3	22.2	-	-
107**	50	optimum	-	2.0	10.0	22.0	22.0	44.0
		usual	-	4.1	18.4	38.8	20.4	18.3
109*	14	optimum	-	21.4	64.3	14.3	-	-
		usual	14.3	71.4	14.3	-	-	-
110**	16	optimum	6.2	25.0	37.5	31.2	-	-
		usual	28.6	28.6	35.7	7.1	-	-
112	34	optimum	-	43.5	43.5	8.7	4.3	-
		usual	26.3	52.6	5.3	15.8	-	-
113	24	optimum	8.3	29.2	29.2	12.5	8.3	12.5
		usual	20.0	40.0	25.0	5.0	-	10.0
Nonperennial								
105*	8	optimum	-	75.0	25.0	-	-	-
		usual	25.0	62.5	12.5	-	-	-
108*	9	optimum	-	44.4	44.4	-	11.1	-
		usual	44.4	44.4	-	-	11.1	-
111*	21	optimum	4.8	38.1	47.6	4.8	-	4.8
		usual	35.0	45.0	15.0	-	-	5.0
114	39	optimum	5.8	76.4	11.8	5.9	-	-
		usual	52.9	44.1	2.9	-	-	-
115	39	optimum	11.1	44.4	27.8	16.7	-	-
		usual	33.3	38.9	25.0	-	-	2.8
Weighted totals	338	optimum	3.4	36.2	30.6	13.7	5.6	9.7
		usual	27.4	37.7	15.5	10.1	3.6	5.5

* = Public tubewell supplemented.
** = High density of private tubewells.

Table 41 data show differences between what farmers usually apply and what they would optimally apply if water were available. For example, farmers on the 4 watercourses at site 107, where tubewell water is easily available, reported differences in number of optimum irrigations required from 4 to 5 to as many as 14 or more. Most sample farmers (see Table 41) report from 4 to 5 irrigations as usual and indicate that 6-7 irrigations would be optimal. Note that the majority of farmers at site 107, with 26 private tubewells, report 8-9 irrigations as "usual" and 12 or more for optimum. Farmers at 110, also with 26 private tubewells, report 6 to 7 irrigations for both usual and optimum. However, this is a low annual atmospheric evaporative deficit area and one watercourse is not served by a canal. Public tubewell command farmers tend to report higher values for both "usual" and "optimum" irrigations than nonpublic tubewell command farmers except for those watercourses served by a high density of private tubewells.

Table 42 displays cumulative percentages of farmers applying various numbers of irrigations by the density of private tubewells on watercourse commands. Data in Table 42 indicate that numbers of irrigations for crops can be expected to increase as farmers receive more water. However, when more water is available farmers will need to help to learn how to apply the right amounts at the right time. Farmers, by applying excess water to crops, can decrease yields substantially.

III. FARMERS' KNOWLEDGE OF SOIL-WATER-PLANT RELATIONSHIPS

In order to apply irrigation water efficiently, an irrigator must have some knowledge of soil-water-plant relationships. The farmer must know generally about the penetration of water and plant root systems into the soil, crop water requirements, critical stages of plant growth, and varying water requirements at each stage.

Table 42. Number of irrigations and density of tubewells on watercourse commands (irrigations for HYV of wheat only).

Private tubewell supplementary equivalents	No. of farms reporting	Cumulative percentages of farmers using estimated number of irrigations excluding preirrigations					
		< 3	4-5	6-7	8-9	10-11	12+
None							
usual	126	39.7	81.8	92.9	96.9	96.9	100
optimum	135	5.9	58.1	84.8	92.9	95.9	100
Under 3							
usual	62	29.0	74.2	91.9	95.1	95.1	100
optimum	62	4.8	35.4	51.1	95.4	95.0	100
3-6							
usual	77	16.9	57.2	78,0	94.9	98.8	100
optimum	78	1.3	30.8	68,0	75.9	83.6	100
7 or more							
usual	43	7.0	16.3	34.9	60.5	79.1	100
optimum	45	2.2	8.9	26.7	44.5	60.1	100
Weighted totals							
*usual	308	27.3	65.0	80.9	91.0	94.5	100
**optimum	320	4.0	40.1	66.0	82.4	87.7	100

*x^2 value 116.7 - 21 df significant at .001 level.
**x^2 value 103.6 - 21 df significant at .001 level.

Note: Private tubewell equivalents result from counting public tubewells serving one command area as 3 private tubewells and public tubewells serving 2 commands as 2 private tubewells and combining these with the number of private tubewells on watercourse commands.

A. Which crop utilizes most water?

Farmers were first asked to compare crops according to their total water requirements for a full cropping season--wheat vs. cotton, and cotton vis a vis berseem. Figure 13 displays the farmers' reports. It is surprising that of 371 farmers reporting, 54 percent reported that wheat requires more total water than cotton (false), and 7 percent report both crops as utilizing the same amounts--also false. Only 32 percent reported correctly that cotton requires more total irrigation water than wheat for a full crop cycle.5/ While there are differences in relationship to climatic zones, they are not so great as to conclude that wheat in rabi season utilizes more total moisture than cotton. A greater percentage of farmers on commands dominated by cotton at sites 102, 107, 112 and 114 reported cotton as using more total water than farmers on other commands. However, for cotton versus berseem, 90 percent of the farmers reported correctly that berseem utilizes more water than cotton. Only at site 116, where no cotton is cultivated, were a large percentage of the farmers in doubt. Fifty percent of the 20 reporting farmers stated they did not know due to lack of cotton cultivating experience.

B. Most critical irrigation for HYV of wheat?

Farmers were asked to give their views about the most critical irrigation for wheat HYV's after pre-irrigation. Of the 358 farmers reporting for the total sample, 41 percent reported the first irrigation or kor which usually takes place 15 to 25 days after sowing the crop. Thirty-five percent reported the irrigation just before heading begins. These judgements reflect recommendations widely propagated by the Agriculture Department via farm radio and extension workers.

5/Total water requirements in the Punjab using the Blaney-Criddle method are given in acre inches for the following: cotton 33"; wheat 16"; and berseem 48". (See Watenpaugh and Hussain, 1966: Appendix Tables 1-5.)

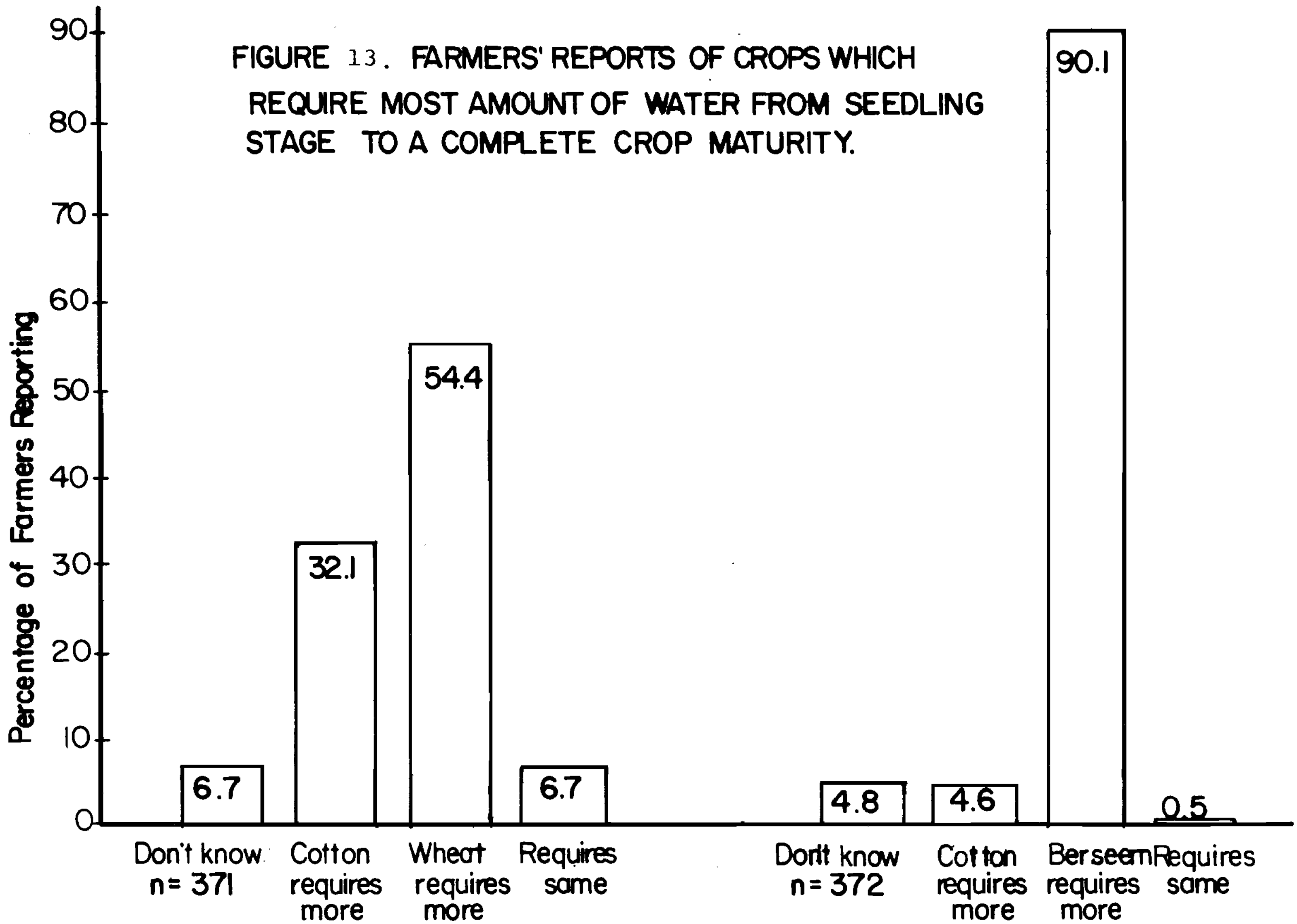

FIGURE 13. FARMERS' REPORTS OF CROPS WHICH REQUIRE MOST AMOUNT OF WATER FROM SEEDLING STAGE TO A COMPLETE CROP MATURITY.

Figure 14 shows the views of farmers as to the most critical irrigation by agro-climatic regions. Over 50 percent of the farmers in the low moisture deficit area and the low to medium moisture deficit region report kor or the first irrigation as most critical and about 40 percent in the "high" zone give this report.

C. Farmers' Views About Stages of Growth of Cotton Plants and Water Requirements

Farmers were presented with pictures of four stages of growth of a cotton plant -- 1) seedling, 2) first flower, 3) flowering and first boll formation, and 4) full boll formation (Watenpaugh and Hussain, 1966: Table 1). Figure 14 shows farmers' views about cotton growth stages and water requirements in relationship to agro-climatic region. Under the full boll stage when irrigation should be stopped or greatly reduced, note that in all 4 agro-climatic regions from 60 to 71 percent of the farmers state that the highest levels of irrigation are required. At the seedling stage when irrigation demands are relatively low, 8 to 16 percent of the farmers in the low to medium, medium, and high evaporative deficit regions state that this stage has the highest irrigation demand.

Table 43 displays sample farmers' perceptions of cotton water requirement during four stages of development.

D. Farmer's Estimates of Depth of Infiltration of Irrigation Water

Farmers were also asked to provide estimates of the depth of water infiltration into soils. The specific question was: "Given five inches of water ponded in one of your basins, how deep would you estimate it would infiltrate into the soil?" This was an attempt to see if their concepts corresponded to estimates of root system penetration into soil. Responses

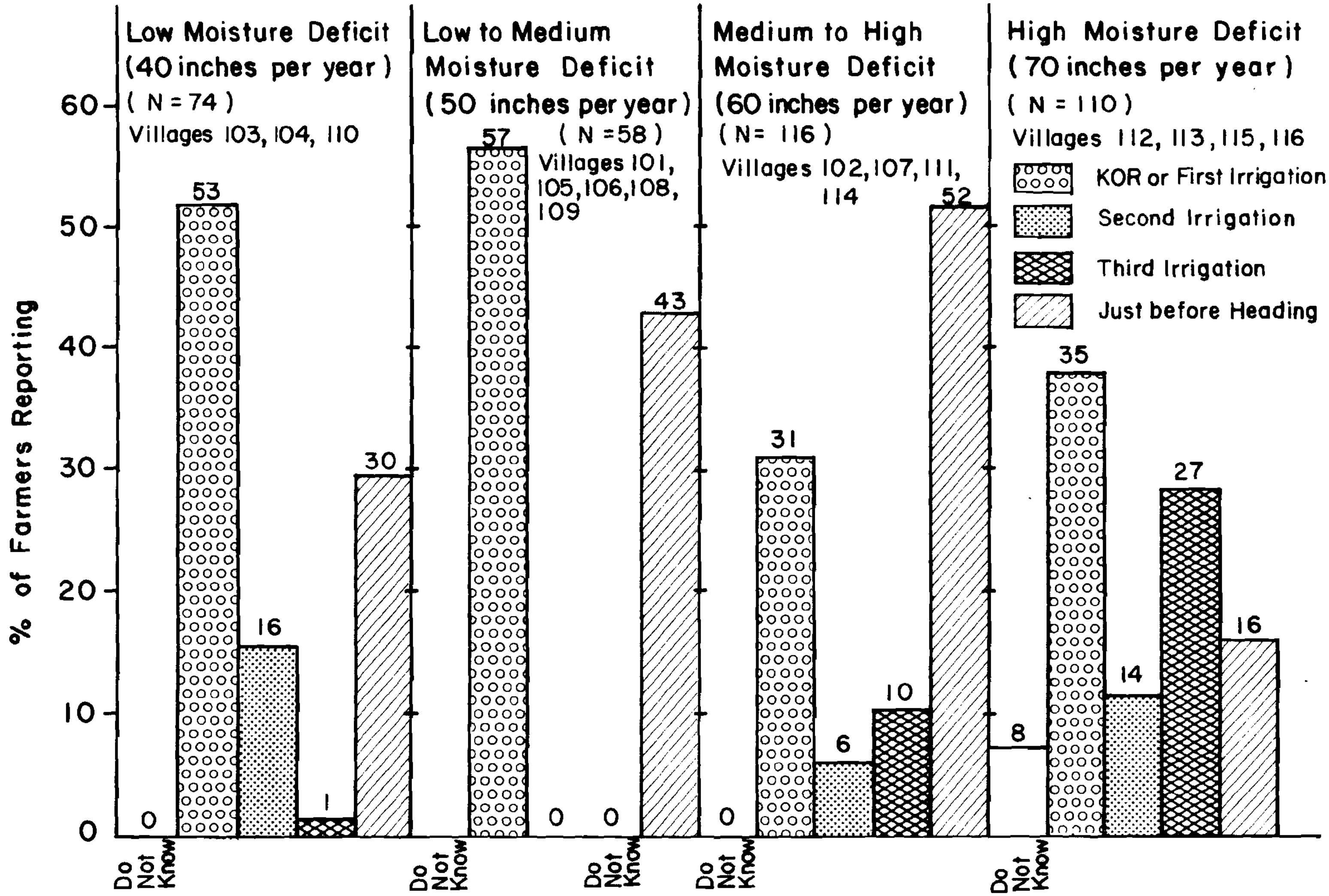

FIGURE 14. FARMERS REPORTS OF MOST CRITICAL IRRIGATION FOR WHEAT AFTER PRE-IRRIGATION BY AGRO- CLIMATIC REGIONS

Table 43. Farmers' reports of water required at four growth stages of cotton.

Water to apply	No. reporting	Stages of growth: Seedling (about 6")	First flower	Flowering and first boll formation	Bolls fully formed
		%	%	%	%
"None"	315	55.9	16.4	5.6	1.9
"Least"	315	34.6	62.9	28.5	32.1
"Most"	315	9.5	20.8	65.8	66.0
Totals	315	100.0	100.0	100.0	100.0
Actual Demand		Low	Moderate	High	None

Fifty farmers who did not know and 24 who did not provide usable responses are excluded from the table.

Table 44. Farmers' estimates of depth of infiltration of five inches of water ponded on their fields into soil profile.

Estimate depth of infiltration (inches)	Number reporting	Percentage reporting	Cumulative percentage
< 6	38	11.5	11.5
6.0 - 11.9	59	19.8	29.3
12.0 - 17.9	92	27.8	57.1
18.0 - 23.9	44	13.3	70.4
24.0 - 29.9	46	13.9	84.3
30.0 - 35.9	9	2.7	87.0
36.0 - 47.9	19	5.7	92.7
48.0 and over	6	1.8	94.5
Don't know	18	5.5	100
Total	329	100.0	

are presented in Figure 15. Across all physical soil types, sample farmers report estimates as shown in Table 44.

We note that about 60 percent of the farmers estimate depths up to or less than 18 inches. Only 10.2 percent of the respondents render estimates in excess of 30 inches. When farmer estimates are examined by general physical soil types on respondent farms in Figure 15, one notes the modal depths reported. For example, 30 percent of the farmers with sandy loam soils surprisingly report depths of 6 inches or less, and only about 30 percent report depths of 18 inches or more.

Many factors other than physical soil texture influence infiltration rates--soil structure, the presence of organic matter, root channels, cracks, small animal burrows, soil salinity and alkalinity which may result in sodic, hardpans, or strata in the soil profile. For most soils there is infiltration over a 50 cm. depth. Of 157 observations on 20 watercourses at the 50 cm. depth the rates of infiltration ranged from about 30 cm. to 99 cm. per day with an average of about 45 cm/day (Gibb, 1966; p. 367-375).

E. Farmers' Estimates of Root Depth Penetration for Selected Crops

As has been shown, farmers perceive a shallow depth of infiltration of water whatever the soil conditions. In order to examine further farmer's concepts of depths of moisture and relationship to irrigation, they were questioned in structured interviews as to their estimates, in inches, of root system penetration of five major crops. The responses are presented graphically in Figure 16 for cotton, sugarcane, rice, wheat and berseem. It is evident that for all crops farmers have a general concept that root systems for most crops penetrate from less than 6 to only about 12 inches into the soil profile. Actual responses for wheat, rice, and berseem (Egyptian Clover) were in the range of 2.5 to about 3.5 inches, a fact not

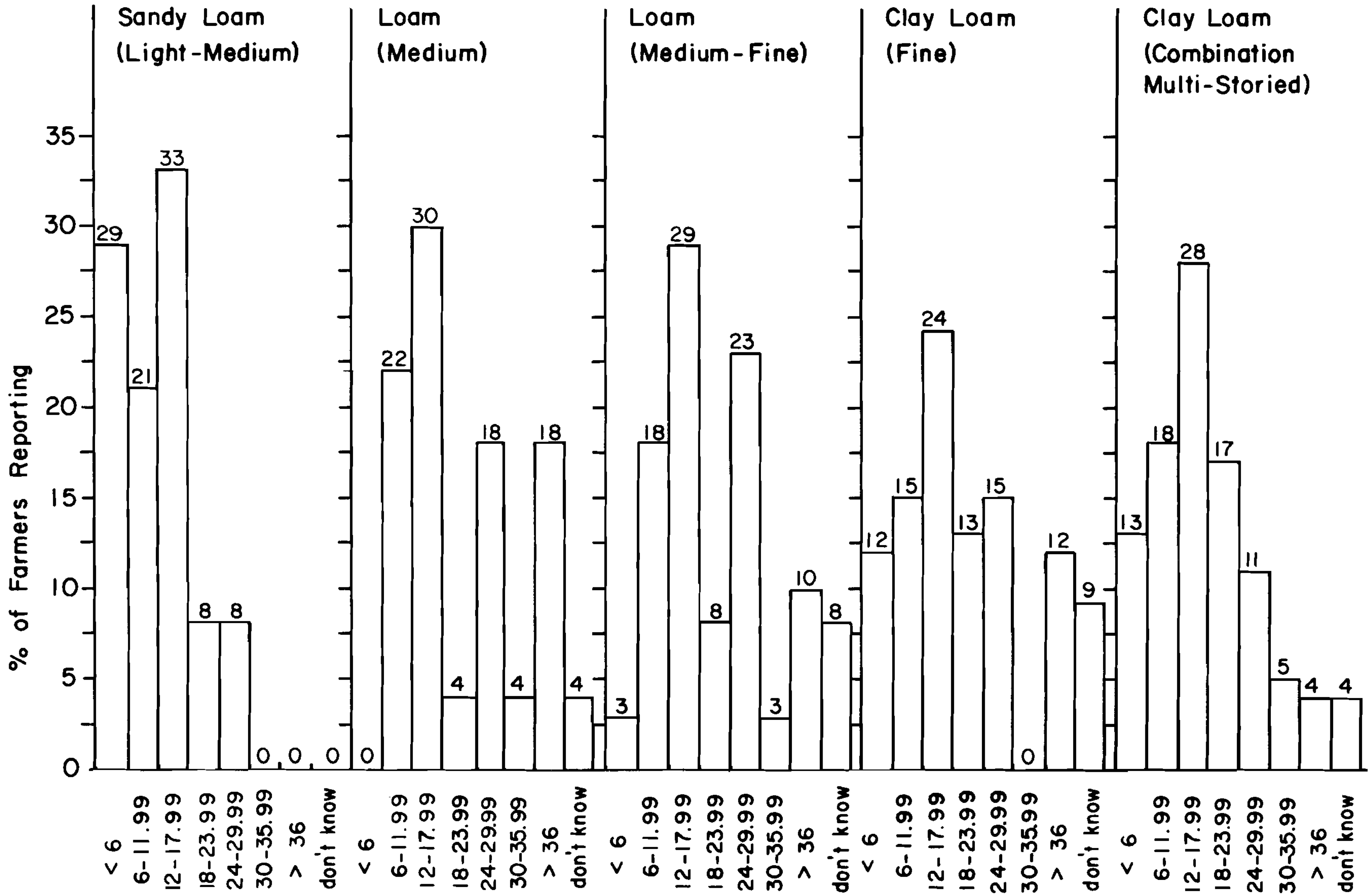

FIGURE 15. FARMERS' ESTIMATES OF INFILTRATION DEPTH OF FIVE INCHES OF WATER PONDED ON THEIR FIELDS

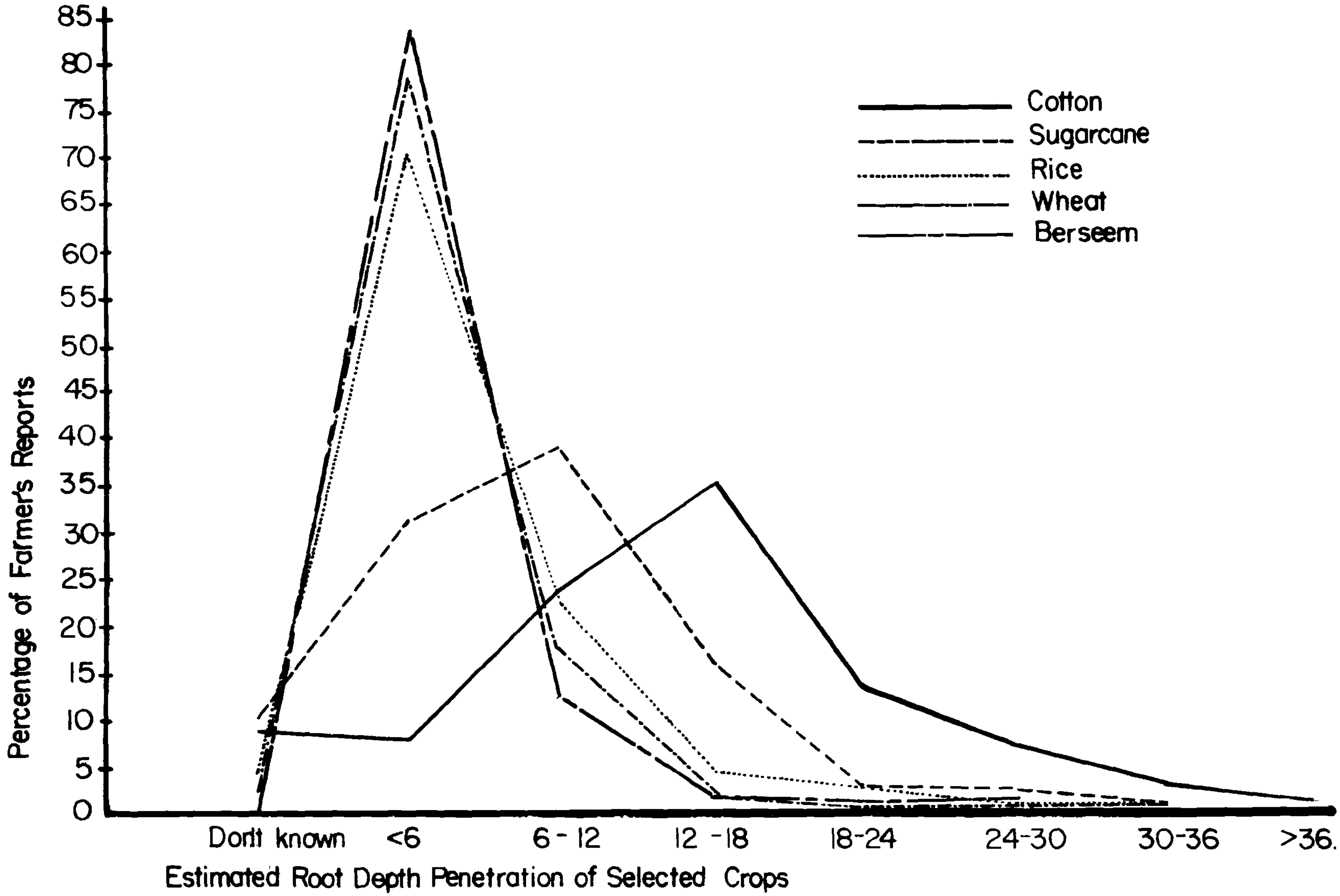

FIGURE 16. FARMER'S REPORT OF ESTIMATED ROOT DEPTH PENETRATION FOR VARIOUS CROPS.

revealed by the large intervals employed in the Figure 16. It is known that root systems of all these crops penetrate to 36 or more inches. Cotton and berseem root systems often extend to 72 or more inches in good soils.

While the lack of farmer knowledge is documented about root system penetration and depths of water infiltration, we are not sure how this relates to over and underirrigation. It is possible that farmers apply more or less water than is required at times because they do not have a concept of soil moisture storage. The lack of such a concept may be a reason why farmers simply observe soil surface characteristics. It was observed during evaluations that some farmers were amazed that king tubes would reveal soil moisture in samples from four foot depths.

At the time of the survey, a field day was conducted on a nonsample watercourse command by the Agriculture Department to demonstrate the importance of land leveling and improved irrigation practices. Since survey data had indicated that farmers do not have a well developed concept of soil moisture storage or the ability of root systems to penetrate to great depths to utilize available soil moisture, a soil profile observation pit was dug to demonstrate to farmers the depths which both roots and irrigation water move into the soil profile. When farmers observed this for themselves they reported that this was the first time they had ever believed that it was possible for roots to penetrate so deeply. There was discussion for days among farmers about this new discovery.

While we do not know how this lack of knowledge may be related to over and underirrigation and consequent waterlogging and salinity, it is probable that concepts of shallow root systems and water infiltration may explain why farmers tend to overirrigate cotton after the crop has matured. An urgent need exists for farm level extension personnel who understand soil-water-plant relationships. To the researchers' knowledge, no effort has been made to help farmers understand these relationships except in a few limited experimental areas.

F. Extension Field Assistants' Lack of Knowledge of Root Depths

Farmers, of course, should not be expected to understand rooting depths or depths of water infiltration because they have never been exposed to this information. Nor have members of the extension staff. During the watercourse survey in Sargodha District there was an opportunity to administer some of the same questions about soil-plant-water relationships to extension field workers.

Table 45 reveals the responses of 19 field assistants to the question, "Give your estimates in inches of the rooting depths of the following crops." Extension field workers, like farmers, have had little or no training in such subject areas; they too know little about crop rooting systems and water infiltration. For example, from 60 to 90 percent report that crops such as maize, wheat, rice, berseem and potatoes have root systems which penetrate no more than 6 inches into the soil (see Table 45). Attempts to improve the availability of irrigation water must be accompanied by a concerted effort to provide farmers the knowledge of how to more effectively utilize the water.

IV. ACTUAL AMOUNTS OF WATER APPLIED BY SAMPLE FARMERS

In contrast to farmers' estimates, the actual weighted average amounts applied by 312 farmers are presented in Table 46. Note that farmers at site 106 (public tubewell) applied a median amount of 4.0 to 4.5 inches while farmers at site 101 applied a median of 3.0 to 3.5 acre inches. Four public tubewells at sites 105, 108, 109 and 111, each serve two total watercourse commands; therefore, farmers on these commands have

Table 45. Field assistants' estimates of rooting depths of the following crops.

Depth of root penetration (inches)	Number reporting for each crop						
	Cotton	Maize	Rice	Wheat	Berseem	Lucerne	Potatoes
3	-	10	5	7	7	1	4
3- 6	1	7	7	10	6	4	8
6-12	4	1	1	-	1	2	4
12-18	2	-	-	-	-	2	1
18-24	2	-	-	-	-	-	-
24-36	6	1	1	1	-	-	-
36-42	1	-	-	-	-	-	-
42-48	-	-	-	-	-	-	-
48 or more	3	-	1	1	1	3	-
Don't know or no response	-	-	4	-	4	7	2
Totals	19	19	19	19	19	19	19
Estimated actual depth	5'-6'	3'-5'	9"-12"	4'-5'	3'-3.5'	5'-6'	1.5-2.5'

Table 46. Actual acre inches of water applied by sample farmers by type of command and village site.

Type of command and sites	No. farms report-ing	Cumulative percentages of measured acre inches of water applied by farmers: 2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0+
Perennial									
101	14	7.1	21.4	42.8	64.2	71.3	85.6	100.0	-
102**	6	16.7	16.7	66.7	83.4	83.4	100.0	-	-
103	5	100.0	-	-	-	-	-	-	-
104	27	40.7	66.6	66.6	85.1	88.8	88.8	96.2	100.0
106*	7	14.3	28.6	28.6	28.6	28.6	57.2	100.0	
107**	32	40.6	68.7	81.2	84.3	90.6	96.9	100.0	
109*	11	9.1	36.4	54.6	63.7	72.8	72.8	81.9	100.0
110**	27	48.1	66.6	77.7	81.4	88.8	92.5	96.2	100.0
112	33	36.4	63.7	72.8	81.9	84.9	91.0	94.0	100.0
113	25	44.0	60.0	84.0	96.0	100.0			
116	22	68.2	86.4	86.4	95.5	95.5	100.0		
Nonperennial									
105*	7	14.2	71.4	71.4	71.4	71.4	71.4	85.7	100.0
108*	4	50.0	50.0	50.0	50.0	50.0	100.0		
111*	22	63.6	77.2	81.7	81.7	81.7	86.2	90.7	100.0
114	33	57.6	69.7	72.1	75.7	78.7	84.8	87.8	100.0
115	37	43.2	56.7	72.9	81.0	83.7	83.7	86.4	100.0
Weighted Totals	312	43.5	62.2	72.5	80.4	84.0	88.3	92.7	100.0

*Denotes public tubewell supplemented commands.
**Denotes private tubewell supplemented commands with six or more tubewells.

more limited water supplies and also receive supplemental water only on alternate canal warabundi schedules. Sites 103, 112, 113, 116, 114, and 115 have no tubewell supplements and the majority of sample farmers at these sites applied under 2.5 inches of water. The majority of farmers at sites 103, 116, and 115 applied less than 2.0 acre inches. Of the three commands with densities of private tubewells equalling 6 or more (sites 102, 107 and 110) have median intervals of 2.0 to 2.5 inches, and 3.0 and 3.5 inches. Sites 102 and 107 are located in the medium high annual atmospheric evaporative deficit area of about 60" and 110 is located in the low deficit area of about 40" per year.

A. Water Supply Situation

Table 47 displays data regarding measured acre inches applied by head and tail farmers under varying water supply situations. In general, the water supply situation alone explains very little of the variation in amounts of water applied. Different locations of private tubewells along command reaches mask differences between head and tail farms. Note that only in one case was the median acre inch value for tail lower as compared to head farmers and this was on a public tubewell supplemented command. The large ranges in acre inches applied result from farmers leaving the field after starting an irrigation. For example, the two large extremes of 19.8 and 19.7 acre inches were applied by two farmers at sites 115 and 112. The first was applied to a rice paddy and the second to a preirrigation for planting sugarcane. The first allowed the field to be irrigated for 360 minutes with a nakka discharge of .3 cusecs; the second allowed water to run for 100 minutes with a field inlet discharge of .8 of a cusec. Farmers often simply turn the water into a field and leave. On some occasions we have observed farmers start an irrigation late at night and

Table 47. Acre inches of water applied by water supply situation.

Water supply situation factors	No. of farms	Mean acre* inches of water applied	Median acre inches applied	Range of acre inches applied
1. Tubewells				
None	159	2.4	2.1	.2-19.7
Private	114	2.6	2.1	.1-19.8
Public	24	3.5	2.7	1.1- 7.5
Both	15	2.1	1.4	.1- 4.7
2. Position of farm on command				
Head	97	2.9	2.4	.2-19.7
Middle	41	2.7	1.9	.7-12.8
Tail	58	2.1	1.9	.1-17.0
3. Farm field inlet nakka Q in cusecs				
up to .20	57	1.4	1.3	.1- 4.1
.21-.40	53	2.3	1.8	.2-19.7
.41-.60	52	2.9	2.6	.8-19.8
.61-.70	24	2.3	2.1	.1- 4.4
.71-.90	43	2.9	2.2	.7- 9.8
.91-1.0	10	2.3	2.1	1.2- 3.4
1.1 and over	71	3.3	3.1	1.1- 7.7

*Data represent the weighted means of several evaluations for sample farms.

allow the water to run until morning or until the next farmer wanted his turn.

Under item (2), Table 47, the measure for farm location is the engineers' measurement--i.e., the length of each watercourse was divided into thirds.

B. Seasons and Days Since Last Irrigation

Table 48 provides the acre inches of water applied by season. In May through August, when the evapo-transpiration rates are high for all kharif (summer) crops and especially cotton, rice, and sugarcane. Note that the mean applications equal 3.0 acre inches for these months vs. 2.2 to 2.3 acre inches for other months. Under item (2), Table 48, there is a relationship between days since the last irrigation and the acre inches applied. This will be shown more clearly in the regression model where other variables are controlled.

C. Type of Irrigation

The particular type of irrigation as well as crop maturity, season, and human variables are influential in determining amounts of irrigation water applied. See Table 49 for the presentation of data relating types of irrigation to amounts of water per irrigation.

V. SUMMARY REGRESSION ANALYSIS OF SELECTED FACTORS AND ACRE INCHES OF WATER APPLIED

Several regression models were used to search out the factor which explain the variation in amounts of water (acre inches) applied by sample farmers. The numerous variables which influence farmer's decisions to apply various amounts of irrigation water are so complex that the list becomes almost unmanageable. The final regression model, a product of a step-wise method, explains about 33 percent of the difference in acre

Table 48. Acre inches of water applied by season and by days since last irrigation.

Time of irrigation	Farms Eval- uated	Mean acre inches of water applies	Median acre inches applied	Range of acre inches applied
1. Season				
Nov., Dec., Jan., Feb.	127	2.3	1.9	.1-19.7
March, April	51	2.2	2.0	.2- 5.3
May, June, July, Aug.	120	3.0	2.6	.7-19.8
Sept., October	13	2.2	1.9	1.0- 4.5
2. Days since last irrigation				
< 10	84	2.4	2.1	.1- 7.7
11-20	105	2.3	2.0	.5- 8.8
20 or more	112	2.9	2.4	.1-19.8

Table 49. Acre inches of water applied and type of irrigation.

Types of irrigation crops	No. of farms evaluated	Mean acre inch applications	Median acre inches applied	Range of acre inches applied
Preirrigations	55	3.3	2.9	.7-19.7
Sugarcane	24	3.4	2.8	1.0- 5.5
Cotton	5	2.7	2.3	1.2- 5.4
Mixed crops	58	2.4	2.2	.1- 6.5
Fodder	81	2.3	1.9	.2-12.8
Wheat	67	2.0	1.9	.4- 5.4
Gardens	7	3.7	3.2	1.9- 7.7

inches applied by sample farmers. Other variables not included in the final regression model are listed but not discussed in detail.

The model used is:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 \; .... \; b_9x_9$$

where a and b are the parameters to be estimated.

x_1 = field nakka Q (discharge) in acre inches

x_2 = dummy variable, preirrigation + sugarcane + cotton + garden = 1; wheat, fodder, other = 0

x_3 = number of days since last irrigation

x_4 = depth of inches of farmers' estimate of water infiltration into soil

x_5 = dummy variable for irrigations from May to September = 1

x_6 = minutes of water applied adjusted with basin field size

x_7 = distance in measured feet to mogha outlet

x_8 = dummy variable -- type of tubewell supplements - none = 0; private TW = 1; public TW = 2

x_9 = use of tubewell (dummy variable) -- no use = 0; some use (hire) = 1; and TW ownership = 2

Table 50 presents the factors found to be most influential. As seen in the table, the six variables are presented in order of importance.

The more water available at the field outlet, as measured by flumes, has a correlation coefficient of .38 with acre inches and explains over 14 percent of the difference in amounts applied by sample farmers.

The particular type of irrigation, such as preirrigation for sugarcane, cotton and other crops, correlates positively with acre inches applied (.34). When controlled by water available at the farm at time of irrigation this variable explains 8 percent of the variation. Days since the last irrigation, when controlled by the nakka discharge and type of crop,explains about 5 percent of the difference in amounts applied. The simple correlation was .27--a value which is reduced when other variables are controlled.

Table 50. Regression Analysis: Acre inches of water applied and selected variables.

Steps in step-wise multiple regression	Variables	Beta	S.E. of Beta	t ratio	Multiple R	Multiple R^2	Final F ratio
1	Field nakka Q	.7714	.1777	4.34**	.377	.142	18.84***
2	Type of irrigation	.6320	.2246	2.81*	.473	.224	7.92***
3.	Days since last irrigation	.0163	.0045	3.62**	.520	.270	12.97***
4.	Farmers' estimate of water infil- tration	.1293	.0519	2.49*	.541	.292	6.21**
5.	Season of irrigation	.4625	.2141	2.16	.552	.304	4.67*
6.	Adjusted minutes of irrigation	-.0002	.0001	2.00	.564	.318	5.16*
7.	Distance to mogha	-.00005	.00004	1.25	.570	.324	1.43
8	Type tubewell supplements for command	-.0714	.1309	.55	.571	.326	.30
9	Use of tubewell	-.0320	.0970	.33	.571	.327	.11

***Denotes significance at .001 level.
**Denotes significance at .01 level.
*Denotes significance at .05 level.

Fourth, the farmers' estimates of how deep into the soil profile of medium loam soils five inches of ponded water will infiltrate is positively and significantly related to the amounts applied to crops when other variables discussed above are controlled--yet, this variable contributes little to the reduction of unexplained variance in water application. The season of irrigation (summer months of May through September versus other months) is also positively related to acre inches applied. The simple correlation is .29, but, when controlled by other variables, this factor adds only a little over one percent to the total difference explained. Minutes of irrigation explained very little of the differences in amounts applied. However, note that the relationship is inverse, that is, the more time the less the quantity applied. Farm inlet discharges are often as low as .1 or less; it may require hours to irrigate a basin. Often engineers had to remain at fields, where nakka discharges were .1 to .2 cusecs, for as much as 6-8 hours before an irrigation was completed. This was especially true at tail farms and where the source of irrigation water was jhallar water lifts and Persian wells.

Other variables shown in Table 50, such as distance to the mogha, type of tubewll supplements available on the command and general use of tubewells combined, explained less than one percent of the difference in acre inches applied when the other variables discussed were controlled. Other variables, not included in this regression model, which were not found to be important were field levelness, type of command, day-night irrigations, agro-climatic regions, soil moisture deficiency and density of tubewells on commands. Six variables explain about 32 percent of the differences in amounts applied.

Overall, the more water available at the farm outlet the more farmers tend to apply in irrigations. Farmers do act rationally in their judgments of what crops need more water and when they need more water. However, it is naive to expect farmers without adequate extension and information services to know more precisely about improved irrigation practices. Farmers face considerable constraints built into the present irrigation system where small farmers, especially, have little or no control over water supplies. Without a strong farm level set of integrated intensive extension inputs by trained field workers, one can expect only one result--that farmers will neither improve water use efficiencies or greatly increase present low crop yields. The key is to provide farmers new production possibilities and a continuous flow of adequate information so that they can increase crop output with decreasing per unit input costs. In no agricultural sector in the world has this been possible simply by providing more water.

VI. FARMERS' VIEWS ABOUT MAJOR SOURCES OF WATERCOURSE CONVEYANCE LOSSES

Farmers in Pakistan are perceptive about many of the constraints that confront them. While they often do not know the technical aspects of many of their irrigation problems nor the technical solutions, they often are able to identify problem areas that are significant to them. For example, sample farmers were asked in interviews to give their views of the major sources of loss of canal water from the mogha outlet to fields. Though each command area presents different problems, we have grouped the sample watercourses by village sites and present farmers' views of major sources of conveyance losses in Table 51. Our purpose here is to understand the major factors, as perceived by farmers, in order to compare these with the extent and magnitude of conveyance losses on individual watercourses.

Table 51. Farmers' reports of major sources of conveyance losses from mogha to farm field ditches by watercourses.

Watercourse Number	# of Farms	Percentages of Farmers Reporting Losses						
		Leaks & Spills	Vertical Ditch Seepage	Dead Storage	Grass, Trees Phyra-tophytes	Evapor-ation	Rodent Animal Insect Holes in Banks	Silt Deposits
101-2wc	15	13.3	-	13.3	13.3	-	33.3	26.7
102-1wc	9	-	-	11.1	55.6	22.2	-	11.1
103-1wc	16	-	-	31.3	12.5	6.3	-	50.0
104-3wc	36	25.0	2.8	33.3	27.8	5.5	-	33.4
105-1wc	8	12.5	-	25.0	-	-	-	50.0
106-1wc	12	50.0	16.2	16.7	-	-	-	-
107-3wc	55	12.7	3.6	12.7	21.8	-	9.1	40.0
108-1wc	9	11.1	-	55.6	22.2	-	-	11.1
109-2wc	14	21.4	-	42.8	21.4	-	7.1	7.1
110-3wc	27	25.9	11.1	29.6	11.1	-	3.7	14.8
111-2wc	24	41.6	25.0	12.5	4.1	-	4.1	12.5
112-3wc	28	28.6	10.7	50.6	7.1	-	-	3.6
113-3wc	26	7.7	15.4	30.7	38.5	-	-	-
114-4wc	39	25.6	17.9	35.9	17.9	-	-	2.6
115-6wc	36	25.0	25.0	38.9	-	2.8	-	2.8
116-4wc	24	12.5	58.3	12.5	8.3	-	-	-
Weighted Totals	378	20.6	13.5	28.1	16.1	1.6	3.4	16.7

Farmers, in interviews, often discussed solutions to some of the problems reported such as more regular and improved cleaning of watercourses and installation of pucca nakkas at watercourse junctions. However, they had no solutions for improper elevation of channels and ditch seepage. Why then, if farmers realize some of these problems, do they not organize to solve some of them without external assistance? First, farmers are unaware of the magnitude of these losses on earthen watercourses; second, there has been no concerted effort by the Irrigation Department to enforce regulations to insure that watercourses are cleaned regularly; third, farmers have not been given incentives for watercourse improvements nor have there been trained engineers or programs designed to help to solve these problems; fourth, until the recent CSU/AID research program findings there was an assumption in official circles that on-farm delivery efficiencies were relatively high. Fifth, farmers need help in developing their own water users organizations to promote effective cooperation for the control and improvement of the on-farm system.

VII. FARMERS' PERCEPTIONS OF FIELD LEVELNESS COMPARED WITH ACTUAL SURVEY RESULTS OF SAMPLE FARMS (See Table 52).

Farmers in Pakistan do understand the importance of level fields for irrigation as is seen from their efforts to level fields and their use of very small basins to control water. Farmers use the traditional krah or krahie for leveling. The krah is used with two teams of bullocks and is a board drag used to shape fields. The krahie is used with one team. The leveling operation is crude; the farmer tries to remember where the low and high spots were when he applied irrigation water. Earth is moved from spot to spot on the field depending on the farmer's judgment and skill. Several farmers reported that "Water tells us when our fields are level."

Table 52. Percentage of farmers reporting fields insufficiently level for good irrigation and percentage of actually surveyed sample farms with fields .2 of a foot or more off level.

Village sites	No. of farms	Percentage of farmers who report fields not sufficiently level for good irrigations	No. of farms	Percentage of sample farms with fields of .2 foot or more off level. (Survey results)
101	14	42.9	15	93.3
102	8	62.5	9	77.8
103	16	81.3	16	100.0
104	28	71.4	12	100.0
105	8	62.5	8	100.0
106	12	58.3	12	50.0
107	50	34.0	55	78.2
108	8	0.0	9	100.0
109	13	38.5	13	100.0
110	18	55.5	25	92.0
111	15	33.4	24	83.3
112	17	58.8	31	90.3
113	9	22.2	24	100.0
114	23	78.3	38	94.7
115	24	50.0	39	84.6
116	3	33.0	23	100.0
Weighted Totals	266	51.1	353	89.2

We often observed farmers trying to coax water over high spots during irrigations with their feet or cussie--a shovel-like implement.

Farmers were also asked if they perceived their fields to be sufficiently level for good irrigation. It is interesting that 49 percent of the 266 reporting farmers stated that their fields were sufficiently level while 51 percent reported that their fields were not level (see Table 52). The remainder of 123 farmers either did not know or did not report. This indicates that roughly half the farmers reporting are aware that their fields are not level and need attention. Many surveys in Pakistan have shown that fields are not level to the precision required for dead level basin irrigation. Unlevel fields result from silt accumulations flushed through the watercourse system which farmers clean from field ditches to incorporate into soils. Also methods of plowing and cultivation as well as digging earth to block watercourses for irrigations greatly contribute to unlevel fields.

Table 52 compares farmers' perceptions of fields being adequately level with the percentage of sample farmers' fields which are .2 of a foot or more off dead level. The purpose is to only compare farmers' general views about the need for improved land leveling with the need as determined by instrument surveying methods.

VIII. ACTUAL OBSERVATIONS OF FARMERS' BEHAVIOR DURING IRRIGATION EVALUATIONS

After about half of the watercourse survey had been completed, a check list was developed for engineers to record selected activities of farmers' behaviors during evaluation of field application efficiencies. These check lists were included in the irrigation evaluation record books and maintained by the engineers making evaluations. Though these behavioral data are not complete, it is important to understand some of the actions of farmers which may provide insights about how they can be assisted to improve present irrigation practices. Tables 53 and 54 provide these data.

A. Inspection and Repair of Leaks and Spills

Before and during an irrigation it is important that an irrigator inspect for leaks and spills and to make repairs along his field ditches and up the watercourse toward the mogha. For example, each nakka cut is a potential leak and these must be sealed by compaction. All junctions must be checked to assure that earthen dams are not leaking. Areas along the watercourse with insufficient free board must be improved to reduce spills. Farmers are also aware that occasionally other farmers might try to direct some of the water illegally. Farmers also have to check the bunds around the basin.

Table 53 shows that about 72 percent of the irrigators were active in inspecting for leaks and spills. Only small differences are noted between farm size and tenure classes. For farms over 25 acres of cultivated land there are too few cases to make generalizations. Table 54 examines these behaviors by tubewell supplements for commands and by those, farmers who report use of tubewells. The differences in inspection and repair of leaks and spills are not great except for farmers on commands with no tubewells and those with private tubewells as supplements. This may reflect the greater value placed on the available supplies. However, in terms of use of tubewell water, we find almost no differences. Other factors must be involved.

B. Who Irrigates: Farmer Operator, Servant or Small Boy?

As information in Table 55 shows, about 77 percent of the farmer operators themselves were observed irrigating their fields. However, about 18 percent of the irrigations evaluated were performed by servants, small boys (12 years of age or younger), or someone other than the farmer.

Table 53. Percentage of farmers who were observed in selected irrigation behaviors by farm size and tenure classes.

Farms Characteristics	Farms Reporting #	Percentage of Farmers Observed in the Following: Farmer Inspects for Leaks/ Spills	Farmer Repairs Leaks/ Spills	Farmer Himself Irrigates	Small Boy or Servant Irrigates	Irrigator Remains in Field Throughout Irrigation	Irrigator Leaves After Opening Field Nakka
Farm Size Class							
Under 2.5	60	80.0	76.7	81.4	13.1	61.7	31.7
2.5-7.49	46	65.2	65.2	87.0	11.1	52.4	27.9
7.5-12.49	50	70.0	74.0	78.0	19.6	70.2	25.5
12.5-24.99	47	68.1	68.1	62.5	27.3	56.8	40.5
25.0-49.99	7	85.7	85.7	71.4	33.3	100.0	-
50 & Over	1	100.0	100.0	0.0	100.0	100.0	100.0
Tenure Classes							
Owner	133	69.9	69.9	75.0	20.8	61.3	29.8
Owner-Tenant	31	83.9	80.6	75.0	22.6	80.6	13.3
Tenant	47	70.2	72.3	83.0	6.7	50.0	45.5
Weighted Totals	211	72.0	72.0	76.8	17.9	61.8	30.8

Table 54. Percentages of farmers observed in selected irrigation behaviors by water supply situation.

Water Supply Situation	Farms No.	Percentages of Farmers Observed in the Following: Inspects for Leaks/ Spills	Repairs Leaks/ Spills	Farmer Himself Irrigates	Small Boy or Servant Irrigates	Irrigator Remains at Field Throughout Irrigation	Irrigator Leaves Field After Opening Nakka
TW Supplemented WC Commands							
None	114	69.3	68.4	79.8	14.7	56.1	37.4
Private	69	79.7	82.6	81.2	17.2	66.7	20.0
Public	15	66.7	60.0	40.0	35.7	93.3	13.3
Both	13	61.5	61.5	69.2	30.8	53.8	38.5
Weighted Totals	211	72.0	72.0	76.8	18.0	62.0	30.1
Farmers' Reported Use of TW							
No Use	134	71.6	70.1	78.4	15.7	57.6	35.3
Buys TW Water	58	74.1	74.1	72.4	21.6	78.8	19.6
Owns TW	15	73.3	73.3	73.3	33.3	45.5	22.2
Weighted Totals	207	72.4	71.4	76.3	18.6	62.7	30.0

Table 55. Actual field observations of selected behavior of the irrigator and status of irrigation.

Status of irrigator	No. of obser- vations	Inspected for leaks and spills	Repaired leaks and spills	Returned to mogha for checking	Opened nakka field inlet and remained at field throughout irrigation
Owner-operators	134	57	62	37	75
Owner-operator's son (12 years or less)*	23	70	78	61	86
Tenant	63	73	73	35	50
Servant of landlord	18	56	50	6	50
Total	238	62	66	36	68

*Age of small boys were estimated by the engineers at time of the actual irrigation.

About 82 percent of the farmers irrigated themselves for farms under 12.5 acres but for farms with over 12.5 acres only 62 percent of the farmers irrigated themselves. As farm sizes increase, it is necessary to depend on others for the laborer's work of irrigation. This may be important because of 18 servants of landlords observed irrigating, 44 percent did not inspect for leaks and spills; 50 percent made no repairs to leaks or spills, only one-third of the servants returned to the mogha to check on water supplies. Half of the 18 servants simply came to the field, opened the nakka and departed (see Table 55). It is also interesting that 50 percent of the tenants and the servants of large landlords did not remain at the fields during the irrigation. Our field observations show that such behavior results in overirrigation and flooding.

C. Trading of Irrigation Turns

A detailed discussion of farmers' reports of trading irrigation turns appears in Volume V, Chapter 1. This is an extra-legal activity on systems with the legal regulated warabundi turn system and some officials deny its widespread existence. While 33 percent of the farmers report trading full turns, 68 percent report trading partial turns (see Volume V, Table 1).

In the execution of the field work, engineers taking measurements for irrigation evaluations on command areas night and day were able to record the practice of sharing and trading irrigation turns on a sub-sample of farms. In fact, the widespread practice of trading presented a major problem to the agricultural engineers. After the sample farm was chosen and the warabundi time noted, it was fairly often that that particular farmer had decided to trade his water allotment to another farmer. It became so costly to return to village sites to evaluate particular farms due to trading, that midway in the survey sampling procedure as described in Volume VI, Appendix 1 had to be changed. Tables 56 and 57 provide information about "exchange of irrigation turns" and "irrigators extending warabundi time for irrigations." These practices are examined by farm size and tenure class groups in Table 56 and by water supply situation in Table 57.

Table 56 shows that of the records kept on 186 farms, about 30 percent traded irrigation turns and over 30 percent of the farms observed extended their irrigation turn beyond the allotted time to complete irrigations. Long field experience is not necessary to understand this wide-spread practice. Farmers often require more than the allotted time to complete the irrigation of a particular field or crop. Since farmers have different planting periods and different crop mixes, the demand for water is not the same throughout a command area. Another factor in trading is related to tubewells. Often, due to poor topography, tubewell water will reach problem fields with better efficiency than canal water, therefore, farmers confronted with such problems often trade canal water for tubewell water.

It appears from Table 56 that larger farmers exchange irrigation turns slightly more than small farmers which may be explained by the trading of canal for tubewell water. No real differences are observable for extension of warabundi time in relationship to farm size classes. However, there is a slight tendency for owners to trade partial turns more than owner-tenants and tenants. Trading requires a network of mutual obligations established over time, such as the custom of vangar, seri and mangna; owners are more established than the tenants.

In terms of the water supply situation, there appears to be a higher propensity for trading irrigation turns on public tubewell supplemented watercourses than other types of watercourses. Though the sample size is

Table 56. Percentage of farmers observed in selected irrigation behaviors by farm size and land tenure classes.

Farm Characteristics	Percentage of Irrigators Observed in Activities				
	Exchange of Irrigation Turns	Irrigator Extends Warabundi Time for Irrigation	Farmers Observed Stealing Water	Farmers Observed Arguing Over Warabundi Turn & Time	Farmers Observed Fighting Over Water
Farm Size Class (Acres)					
Under 2.5	(n=57) 19.3	(n=53) 35.8	(n=56) 21.4	(n=53) 3.8	(n=53) -
2.5-7.49	(n=40) 32.5	(n=40) 32.5	(n=42) 11.9	(n=41) 2.4	(n=41) -
7.49-12.49	(n=45) 24.4	(n=44) 22.7	(n=44) 15.9	(n=41) 2.4	(n=41) -
12.5-24.99	(n=38) 42.1	(n=39) 33.3	(n=39) 20.5	(n=39) 5.1	(n=39) 2.6
25.0-49.99	(n=5) 40.0	(n=5) 20.0	(n=5) -	(n=5) -	(n=5) -
50 & Above	(n=1) 100.0	(n=1) 100.0	(n=1) 100.0	(n=1) -	(n=1) -
Tenure Classes					
Owners	(n=119) 28.6	(n=115) 31.3	(n=119) 15.1	(n=112) 3.6	(n=112) 2.6
Owners-Tenants	(n=27) 22.2	(n=26) 23.1	(n=26) 11.5	(n=26) 3.8	(n=26) 3.8
Tenants & Contractors	(n=40) 35.0	(n=41) 36.6	(n=42) 28.6	(n=42) 2.4	(n=42) 2.4
Totals	29.0	(n=182) 31.3	(n=187) 17.6	(n=180) 3.3	(n=180) .6

Table 57. Percentage of irrigators observed in selected irrigation behaviors by water supply situation and farmers' reports of use of tubewells.

Water Supply Situation	# of Farms	Percentage of Irrigators Observed in Activities									
		Farmers Observed Exchanging Warabundi Turns		Irrigator Extends Warabundi Time		Farmers Stealing Water		Farmers Arguing Over Waribundi Time		Farmers Observed Fighting Over Water	
Tubewell Supplements											
None		(n=107)	21.5	(n=105)	24.8	(n=109)	10.1	(n=102)	2.0	(n=102)	2.0
Private		(n=52)	26.9	(n=50)	32.0	(n=52)	17.3	(n=51)	3.9	(n=51)	2.0
Public		(n=15)	46.7	(n=15)	46.7	(n=14)	28.6	(n=14)	-	(n=14)	-
Both		(n=12)	83.3	(n=12)	66.7	(n=12)	75.0	(n=13)	15.4	(n=13)	15.4
TOTALS	186		29.0	(n=182)	31.3	(n=187)	17.6	(n=180)	3.3	(n=180)	.6
Farmers' Reports of Use of TW Water											
None		(n=124)	29.0	(n=123)	34.1	(n=126)	19.0	(n=121)	2.5	(n=121)	1.7
Buys Water		(n=50)	34.0	(n=49)	30.6	(n=49)	16.3	(n=48)	6.2	(n=48)	6.2
Owns TW		(n=9)	-	(n=7)	-	(n=9)	11.1	(n=7)	-	(n=7)	-
TOTALS	183		29.0	(n=179)	31.8	(n=184)	17.9	(n=176)	3.4	(n=176)	2.9

small, about 65 percent of farmers on public tubewell watercourses were observed trading turns as compared to about 23 percent of farmers in other types of commands. A similar relationship exists for trading partial turns. The better the water supply situation, the more prevalent is trading.

D. Stealing of Water, Disputes and Fights

Table 56 shows the percentages of farmers actually observed stealing water, disputes overheard between farmers over water, and actual fights about water distribution problems. It is not clear that there is any important relationship with these observed actions and farm size categories. However, tenants were observed stealing water more than other farmers. This may result from a greater water constraint on this category as compared to other farmers. Some tenants reported to interviewers that they did not receive their fair share of water from landlords. Very few cases of disputes and actual fights were observed, therefore, no generalization can be made. Table 57 shows more stealing, disputes and fights on public tubewell supplement watercourses than on either nonsupplemented or private tubewell supplemented watercourses. Also farmers who own their tubewells appear to experience fewer cases of stealing and fighting than other farmers, but the sample size is too small to draw conclusions.

E. Irrigation Behaviors and Selected Factors

Table 58 allows an examination of several farmer behaviors by position on command area, time of irrigation, and by command type.

In relationship to farm position on the command area, differences appear between tail farms versus head and middle farms. Slightly fewer farmers (about 10-12%) at the tail reaches were observed inspecting and repairing leaks and spills. Also fewer tail farms were irrigated by two or more individuals.

Table 58. Observed irrigation behavior of farmers by position on command, time of irrigation and type of command.

Position on watercourse command and time of irrigation	Observed irrigation behavior of farmers						
	Inspects leaks and spills	Repairs leaks and spills	Checks back to mogha	Remains at field during irrigation	Two or more farmers irrigating	Trading full turns	Stealing water*
1. Watercourse position							
Head (n=124)	69	71	31	62	24		
Middle (n=87)	69	71	60	70	23		
Tail (n=53)	58	58	43	60	13		
2. Night/day irrigations							
Night (n=56)	61	63	34	63			
Day (n=179)	63	64	42	63			
3. Season and night/day							
a) winter (n=141)	62	NA	40	51	NA		
b) winter/day (n=102)	64	NA	50	61	NA		
c) winter/night (n=39)	56	NA	13	26	NA		
d) summer (n=74)	50	NA	30	47	NA		
e) summer/day (n=67)	46	NA	26	44	NA		
f) summer/night (n=7)	86	NA	71	71	NA		
4. Selected types of commands							
a) Jhallar system (n=44)	75	80	73	52	57	20	2
b) Persian wells (n=93)	82	80	60	78	16	13	6
c) Public tubewell (n=52)	60	56	42	69	63	69	50
d) High density private tubewell (n=28)	64	64	NA	89	(n=12) 8	(n=12) 0	(n=12) 0
e) Excess water command (sites 113,116) (n=54)	41	43	35	48	44	35	17

*Only 7 observations of water disputes and 4 fights. Respectively 4 and 2 of these were at sites 114-115 nonperennial commands with a total of 43 Persian wells.

It was thought that irrigators applying water at night would be less careful than during daylight periods in irrigating. This does not appear to be the case (see Table 58). However, as shown in item 3 (Table 58), winter day and night behaviors differ in terms of inspection for leaks and spills, checking back to the mogha and remaining in the field. One must experience the sharp drop in night temperatures in this arid region to appreciate this factor. The data on behaviors for summer days and nights is misleading in that we have only seven cases for summer night irrigations.

In regard to various types of water supply situations and irrigation behaviors (the data under item 4 of Table 58), it appears that farmers on commands with public tubewells, high density of private tubewells (7+), or where there is an excess water supply situation, are less likely to come to inspect and repair leaks and spills and to check back to the mogha. It is also interesting that both the incidence of trading turns and stealing of water is greater on public tubewell supplemented commands than other types of commands.

F. Agricultural Castes and Irrigation Behaviors

The major agricultural castes, for which there are data on irrigation behavior, are displayed on Table 59. It must be remembered that no data exists for more than half of the sample farmers because the irrigation behavior check list was designed mid-way through the field work.

The Pathan, Rajput and Baluch farmers are not usually listed among the leading agricultural castes. It is obvious, from the incomplete data available, that about 30 to 35 percent fewer Pathans, Rajputs and Baluchs inspect and repair leaks and spills during the observed irrigations than other farmers. Especially in the case of Pathans and Rajputs, note that a very small percent of the farm operators irrigated themselves. In fact, of

Table 59. Summary of irrigation behaviors observed, by engineers, and selected agricultural castes/tribal groups.

Caste/ trival group	Obser-va-tions	Irrigation behaviors observed					
		Inspects leaks, spills	Repairs leaks, spills	Checks mogha	Remains at field	Two or more farmers irrigate	Operator irrigates himself
		(%)	(%)	(%)	(%)	(%)	(%)
Arian	40	70	65	40	65	5	95
Jat	38	74	79	37	63	37	87
Kakkis	24	75	75	58	79	33	96
Dogar	20	75	75	40	60	15	90
Pathan	9	44	44	22	44	11	11*
Rajput	7	43	43	29	57	29	43
Baluch	17	41	41	35	29	18	88
**Weighted totals	155	66	66	40	61	21	85

*Of the nine observations for the Pathan Group, eight of the irrigations were applied by servants.

**The presence of engineers conducting measurements on these farms undoubtedly was a big influence on the farmer irrigation behavior especially in the number of farmers who remained at their fields to observe the engineers.

the nine Pathan farms observed eight of the irrigations were applied by servants.

IX. FARMERS' KNOWLEDGE OF IMPROVED MANAGEMENT PRACTICES FOR HYV OF WHEAT

Earlier in this Volume (Chapter Three), data were presented about sample farmer utilization of recommended practices for high yielding varieties of wheat. A decade ago, at the inception of the HYV Programs, Clifton Wharton stressed the importance of new farming skills and knowledge:

> Farmers must learn new farming skills, and expertise of a higher order than was needed in traditional methods of cultivation. The new agronomic requirements are quite different as regards planting dates, and planting depths, fertilizer rates and timings, insecticide, pesticide, and fungicide applications, watering and many others. Unless appropriate extension measures are taken to educate farmers with respect to these new farming complexities the higher yields will not be obtained. (Wharton, 1968: 464-67)

This statement is most relevant today. Farmers lack information from extension and other sources, especially about the wheat HYV's--a fact which constitute a major constraint on improving yields (see Table 60).

Farmers were asked to give the recommended sowing dates (Joint Recommendations for Wheat Production, 1974-5: 618-26) -- in their agro-climatic regions -- for the Chenab 70 wheat variety. In Sind, the recommended dates are October 20 to November 20 and, in the Punjab, October 25 to November 20. Table 60 indicates that only about 35 percent of the sample farmers could give the proper range of dates. However, 18 percent were within plus or minus 4-5 days of the recommended dates.

When farmers were asked to give the recommended method of seedbed preparation (see Table 60), only about 33 percent gave a correct response--either the improved raja plow or tractor plowing. Likewise, only 43 percent of the sample farmers reported pora or drill as the recommended seeding methods. As to seeding depth, 62 percent of the farmers reported depths within plus or minus half an inch of the recommended depth.

Table 60. Percentage of farmers with knowledge of recommended practices for high yielding wheat varieties by farm size classes.

Farm size classes (acres)	(1) Range of seeding dates (n=346)	(2) Seedbed preparation (n=337)	(3) Seeding depth (n=336)	(4) Seeding method (n=338)	(5) Nitrogen rates (n=318)	(6) Phosphorus rates (n=316)	(7) Split application of nitrogen (n=316)	(8) Seed rates (n=304)
Under 2.5	37.9	14.8	25.0	53.6	6.7	8.3	18.0	68.4
2.5 - 7.49	27.1	22.8	30.8	42.3	23.6	33.3	43.7	55.9
7.5 - 12.49	29.5	34.1	29.9	37.9	34.2	39.5	48.1	61.3
12.5 - 24.99	36.1	45.7	34.9	40.0	33.8	41.8	44.3	59.3
25.0 - 49.99	62.5	68.8	43.8	37.6	37.6	81.3	75.0	56.3
50.0 and above	62.5	75.0	75.0	50.0	62.5	75.0	62.5	71.4
All sizes	34.4	32.9	32.1	42.9	27.3	35.8	42.1	60.9
Chi square values	x^2=32.3	x^2=65.9	x^2=11.1	x^2=25.3	x^2=57.9	x^2=55.9	x^2=24.4	x^2=12.9
Degrees of freedom*	10	15	10	20	20	15	5	15
Significance level	.001	.001	NS	NS	.001	.001	.001	NS

*Note that several categories were used in the crosstabs, therefore the degrees of freedom vary and are greater than simply "yes" "no" categories would require.

The question related to fertilizer rates was phrased as follows: "In order to gain good yields for Chenab 70, after either cotton, rice, or maize and without using any farmyard manure or green manure, how much nitrogen and phosphorus is recommended?" Under these conditions, the recommendations call for 125-50-0 to 150-75-30 nutrient pounds. However, using a much lower level, 100 nutrient pounds of nitrogen, only 27 percent could report 100 lbs or more. Also, only 36 percent of the farmers reported 50 or more nutrient pounds of phosphorus. Only 42 of the farmers knew about the importance of splitting nitrogen applications.

Farmers were asked to provide the recommended seed rate for late sowings of Chenab 70 variety. The recommended rate is from 45 to 50 seer for drill and broadcast methods, respectively. However, only 11 percent reported 50 seer and about 50 percent reported 40 to 49 seer. Both of these answers were considered correct.

These findings are very similar to those of another study of HYV of wheat growers earlier in the Punjab (Lowdermilk, 1972; pp 311-312), the data of which show that there is still need for more focus in helping farmers to increase knowledge of improved practices for wheat HYVs. The levels of farmer's knowledge about these practices is surprisingly low as well as is their utilization of recommended practices. New seed technology spread in Pakistan like a tidal wave. This was due to the perceived differences and experiences of obtaining higher yields from HYV seed and the ability to use traditional practices even while adopting the new seed. However, potential yields never were reached. Today, for the most part, traditional practices are still being used vis a vis the improved wheat varieties instead of the complete package of improved complementary practices.

X. FARMERS' KNOWLEDGE AND USE OF INSTITUTIONAL SERVICES

Farmers were asked about their knowledge, and use, of technical assistance services of individuals and agencies. Farmers reported purposeful contacts with extension workers and the patwari (revenue officer). This is meant to provide an estimate of how much farmers know about certain officials and how much they contact them for services.

Table 61 presents information about farmers' knowledge of officials' names and the location of their offices or residences. About 90 percent of the reporting farmers could not give the name of the Agricultural Assistant (A. A.) and 60 percent could not report the location of his office or residence. The A. A. is usually an agricultural graduate with a B. Sc. degree and has supervisory responsibilities for 8-12 field assistants. In the Lahore Region, the average coverage is about 1 Agricultural Assistant for 8355 farms or about 83,550 cropped acres. This amounts to about 1 Agricultural Assistant for 209 watercourses, given an estimate of 400 acres per watercourse. The Agricultural Assistant is faced with insurmountable problems in working with farmers. Reports have indicated his duties are primarily regulatory and often he has inadequate means of transportation.[6/]

The Field Assistant (F. A.) is the Agriculture Department's primary link with farmers. These workers are high school graduates (10 grades) with one or two years of general agricultural training in the Department's Training Institutes. While the quality of their work will be discussed at

6/A number of reports have documented the problems of the present extension system. See C. A. Svinth's report, "Strengthening Agricultural Extension in West Pakistan" (1965-1970), distributed by Planning Cell of Department of Agriculture, Lahore, November 1975. Also Lowdermilk, op. cit. pp. 318-319, 420-437. See also Dorcey Davey's reports on "Agriculture Extension in West Pakistan: Prospect and Progress," discussion papers, The Ford Foundation, Islamabad, March 5, 1970.

Table 61. Farmers' knowledge of agricultural service personnel.

Agricultural service personnel*	No. of farmers reporting	Knowledge of officials' name %	Knowledge of official's location %
1. Agricultural Assistant	381	9.7	38.5
2. Field Assistant	376	16.0	42.5
3. Fertilizer Agent	381	22.0	N.A.
4. Bank Official	379	6.9	N.A.
5. Canal Patwari	383	59.8	77.3
6. Canal Zilladar	383	11.2	49.8
7. Canal Sub-Divisional Officer	383	8.9	45.5

Table 62. Farmers' reports of contacts in a three month period with selected officials and agencies.

Contacts with officials or agencies	Number reporting	Number of contacts in 3 months			
		None %	1-2 %	3-4 %	5+ %
1. Agricultural Assistant	381	93.2	5.0	1.0	0.8
2. Field Assistant	376	88.6	8.5	1.9	1.1
3. Fertilizer Agent	381	89.7	9.8	0.5	--
4. Bank	379	95.2	4.0	0.3	0.5
5. Canal Patwari	383	68.8	23.9	4.5	2.9
6. Contacts with 1 and 2 above plus development assistants	382	85.1	10.7	3.4	0.8

*In the Integrated Rural Development Project areas and in the Mona (WAPDA) Development areas Development Assistants, Agricultural Engineers and Project Managers are assigned. These were sites 102, 103, 104, 105, 106, 108, and 109. Respectively 37, 20.0, and 8.8 percent of the sample farmers knew the names of these officials. However, only about 5 percent of the 125 farmers reported any contacts with any of them.

the conclusion of this section, these workers also face an impossible task. Low levels of training, inadequate supervision, inadequate housing and facilities, low pay, and lack of transportation--save their personal bicycles--represent only some of their constraints. A major problem is the ratio of field assistants (F. A.) to farms and cultivated acreage. In the Lahore Region for example, there is an estimated ratio of 1 F. A. for about 1245 farms and 12,400 acres or about 1 F. A. for each 31 water-courses.

Only 16 percent of the farmers could report the name of the F. A. assigned to their area and only 43 percent knew the location of his office or residence. In comparison, 22 percent of the farmers could give the name of a fertilizer agent and 60 percent knew their canal patwari. It is understandable that 77 percent of the farmers know the location of the canal patwari because this individual is responsible for checking all crops cultivated for each season and determination of canal water assessments. It is assumed that farmers know the location of fertilizer agencies and banks in small market towns, therefore, responses of farmers living in such centers is not reported in Tables 61 and 62.

The zilladar is employed by the Canal Department Revenue branch and inspects the work of patwaris. The Subdivisional Officer of the Canal Department is in charge of several canal distributaries and farmers contact this officer for the settlement of major canal water disputes, for changes in the warabundi turn system, and for other legal matters.

In Table 62 farmers' reports of contacts with some of these officials and agencies over a three month period are presented. Note that about 93 percent of the farmers report no contacts with the Agricultural Assistant and 89 percent report no purposeful contacts with Field Assistants in three months. Farmers' contacts with fertilizer agents are about the same as those with extension workers. Farmers report having more contacts with the patwari than with any other listed official or agency.

Minimum farmer contacts with extension workers is not surprising. A sample survey of 350 farms, in 1970, (Lowdermilk, 1972: 281-283) revealed that over a six month period, 81 percent of the farmers reported no contacts with the F. A., and 97 percent reported no contacts with the Agricultural Assistants. A recent intensive study (Lowdermilk, Clyma, Early, 1975) of a watercourse near Lahore revealed about 80 percent of the farmers had no contact with their extension worker in the preceding three months--his office was less than one mile from their village.

Larger farmers with more influence are expected to have more knowledge of and contacts with both Agricultural Assistants and Field Assistants than small farmers. To show these differences among farm size and tenure classes, summary Table 63 is presented. Table 63 reveals a significant relationship between farm size classes and knowledge as well as contacts with extension personnel. Had there been a larger number of large farmers in the sample this relationship is expected to have been much stronger. However, when tenure classes are examined the only significant relationship is that owners and owners-cum-tenants have more knowledge of the location of the field assistant.

Table 63 also shows the relationship between distance of the village site from a paved road and farmers' knowledge and contacts with extension workers. Since access to farms is a major problem for field workers with poor means of transportation, it is not surprising that farmers located under two miles from the paved road have more knowledge of the location of

Table 63. Percentage of sample farmers reporting knowledge of name, location and contacts with the Agricultural Assistant and the Field Assistant.

Farm Characteristics	Agricultural Assistant # of Farms	Knows Name	Knows Location	Any Contact Last 3 Mo.	Field Assistant # of Farms	Knows Name	# of Farms	Knows Location	Any Contact Last 3 Mo.
Farm Size Class									
Under 2.5	75	2.7	32.0	1.3	73	4.1	74	28.4	5.3
2.5-7.49	97	8.2	37.8	5.1	94	8.5	97	35.1	6.3
7.5-12.49	99	13.1	37.5	7.1	99	16.2	96	50.0	7.2
12.5-24.9	85	8.2	37.6	9.3	85	22.4	85	44.7	17.6
25.0-49.9	17	17.6	52.9	5.9	17	47.1	17	82.4	41.2
50 or More	8	50.0	100.0	50.0	8	75.1	7	85.7	50.0
		(X^2=22.0 5df)**	(X^2=15.7 5df)*	(X^2=38.8 15df)**		(X^2=47.2 5df)**		(X^2=26.9 5df)**	(X^2=49.1 15df)**
Tenure									
Owners	253	10.7	42.5	6.7	253	17.0	249	45.8	13.2
Owner-Tenants	56	7.1	35.7	5.4	55	14.5	56	50.0	7.1
Tenants & Contractors	72	8.6	26.8	8.5	68	13.6	71	26.8	91.5
								(X^2=10.0 3df)8	
Distance to a Paved Road									
No Distance	69	11.6	48.5	8.6	69	17.4	66	45.5	16.2
Under 2 Miles	176	6.8	41.8	5.7	171	12.9	176	47.2	12.1
2 - 4.9 Miles	81	11.1	29.1	8.6	81	19.8	79	31.6	11.2
5.0+ Miles	55	14.5	29.1	5.5	55	18.2	55	41.8	3.6
			(X^2=8.7 3df)*						(X^2=19.5 9df)*

* Denotes significance between .05 and .001
**Denotes significance at the .001 level or higher

extension workers than those located at greater distances.[7/] The Agricultural Assistant's duties are primarily administrative and supervisory, while the Field Assistant is the direct contact link of the Agriculture Department with farmers. It is noted that the closer to the paved road the greater the contacts farmers have with Field Assistants.

To provide a better picture of the actual contacts farmers have with any extension personnel of the Agriculture Department, Table 64 provides a summary of the combined contacts.

Several general observations can be made from Table 64. First, farm size, a fairly adequate proxy for status, power and influence in rural Pakistan, is usually significantly related to contacts with and knowledge about personnel who provide agricultural services to farmers. This is by no means a new insight. However, it suggests the importance of institutional changes in bringing more information and services to small farmers. As Gotsch has shown (Gotsch, 1972), mal-distribution of benefits is embedded in the structure of a highly stratified rural society. Small farmers and tenants cannot be expected to have more access to existing services until special programs are designed to meet the needs of these disadvantaged groups.

Tenure status is primarily important in relationship to knowledge of the fertilizer agents and canal patwari (see Table 65). Owner operators and owner-cum-tenants exhibited more knowledge of these service personnel than tenants. No significant relationship was found for knowledge and

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7/In an earlier study of the extension system in one tehsil, the average distance of 34 Field Assistants from the Agricultural Assistant's office was 8.6 miles. However, 20 percent of the Field Assistants lived over 10 miles away and several served villages 20 miles or more from headquarters. No Field Assistant owned a motor bike or motorcycle and no transportation was provided by the Department for the Agricultural Assistant except for a few special occasions (see Lowdermilk, 1972: 423).

Table 64. Percentage of sample farmers reporting contact with agricultural extension officials during the last three months.

Farm Characteristics	# of Farms	No Contact	1 - 3 Visits	4 - 6 Visits	7 or More Visits
Farm Size Class, Acres					
Under 2.5	75	97.3	2.7	0	0
2.5-7.49	98	87.8	12.2	0	0
7.5-12.49	98	89.8	5.1	4.1	1.0
12.5-24.9	86	75.6	18.6	5.8	0
25.0-49.9	17	58.8	29.4	5.9	5.9
50 or More	8	37.5	12.5	37.5	12.5
			(X^2=81.1,15df)**		
Tenure					
Owners	254	83.9	10.6	4.7	0.8
Owner-Tenants	56	87.5	12.5	0	0
Tenants & Contractors	72	87.5	10.0	1.4	1.4
Distance to a Paved Road					
No Distance	70	78.6	14.3	7.1	0
Under 2 Miles	176	86.9	11.4	1.1	0.6
2-4.9 Miles	81	81.5	9.9	6.2	2.5
5+ Miles	55	92.7	5.5	1.8	0
Weighted Totals	382	85.1	10.7	3.4	0.8

** Denotes significance at the .001 level or higher

Table 65. Summary table of levels of significance between selected variables and farmers' knowledge of and contacts with service personnel.

Type of agricultural service personnel	Summary of significant relationships using Chi square method		
	x^2 values Farm size classes	Tenure classes	Distance to paved road of village site
1. Bank official			
a. Knows none	x^2=43.2**(5df)	NS	x^2=13.1*(3df)
b. Contacts	x^2=30.3*(15df)	NS	x^2=18.4*(9df)
2. Fertilizer agent			
a. Knows none	x^2=33.6**(5df)	x^2=8.0*(3df)	x^2=45.4*(3df)
b. Knows location	x^2=16.0*(5df)	x^2=9.8*(3df)	x^2=30.5**(3df)
c. Contacts	x^2=48.0**(10df)	NS	NS
3. Canal Patwari			
a. Knows none	x^2=29.7**(5df)	x^2=11.5*(3df)	NS
b. Knows location	x^2=29.5**(5df)	x^2=18.3**(3df)	x^2=18.9**(3df)
c. Contacts	x^2=39.9**(15df)	NS	x^2=38.0**(9df)
4. Canal Zilladar			
a. Knows none	x^2=31.3**(5df)	NS	x^2=25.9(3df)
b. Knows location	x^2=29.3**(5df)	x^2=10.2*(3df)	x^2=13.6*(3df)
c. Contacts	x^2=30.8*(15df)	NS	x^2=20.0*(9df)
5. Canal SDO			
a. Knows none	NS	NS	x^2=10.9*(3df)
b. Knows location	x^2=14.5*(5df)	NS	NS
c. Contacts	x^2=30.8*(15df)	NS	x^2=20.0*(9df)

*Denotes significance between .05 and .001
**Denotes significance at the .001 level or higher; df = degrees of freedom.

contacts with either bank officials or canal SDO's because the number of farmers having contacts with the personnel were insignificant on the whole. These relationships also hold for farmers knowledge and contacts with other officials. The reader can further examine these relationships in Volume VI, Appendix V, Part A.

XI. SOURCES AND CHANNELS FOR INFORMATION FOR FARMER CLIENTS

Lack of adequate flows of agricultural information to and from farmer clients is a common problem, similar to the lack of other essential inputs and services in most low income nations. Seldom are these services integrated; piece-meal efforts are still the rule. Irrigated agriculture, especially, requires good linkages between farmers, Irrigation and Agriculture Departments as well as other agencies.

A. Essential Information from the Irrigation Department

Canal closures take place from time to time for emergency repairs, rationing of canal water, and annual repairs. Closures on perennial commands vary a great deal (see Table 66). November, December and January are primary months of closures for 11 to 14 days or more. However, closures often take place in other months, such as April and October. The incidence of closures for other purposes than annual cleaning pose more of a problem for the farmer. Efforts are made to publicize these closures in advance by the Irrigation Department, but this information does not generally reach the majority of farmers. Several farmers reported that they only learn about canal closures when no water appears in the main watercourse. Though further investigations are needed, we present the reports of farmers to several specific questions about advance information on canal closures. Figure 17 summarizes farmers' reports. About 70 percent of the farmers report "never" receiving advance information about closures for repairs.

Table 66. Mean, median and range of days of canal closures for 13 perennial command areas (1964-65).*

Months of years 1964-65	Mean days of closures	Median days of closure	Range of days of closure
October 1964	2.7	0	0 - 15
November	6.5	4	0 - 22
December	11.5	12	0 - 21
January 1965	13.4	17	0 - 28
February	2.8	0	0 - 13
March	1.9	0	0 - 14
April	5.7	5	0 - 16
May	2.2	0	0 - 9
June	1.0	0	0 - 7
July	2.3	2	0 - 8
August	0.9	0	0 - 3
September	2.6	1	0 - 8
October	9.5	8	0 - 23
November	13.7	16	0 - 29

*Gibb, Sir Alexander, et al., Vol. 10, op. cit. p. 109.

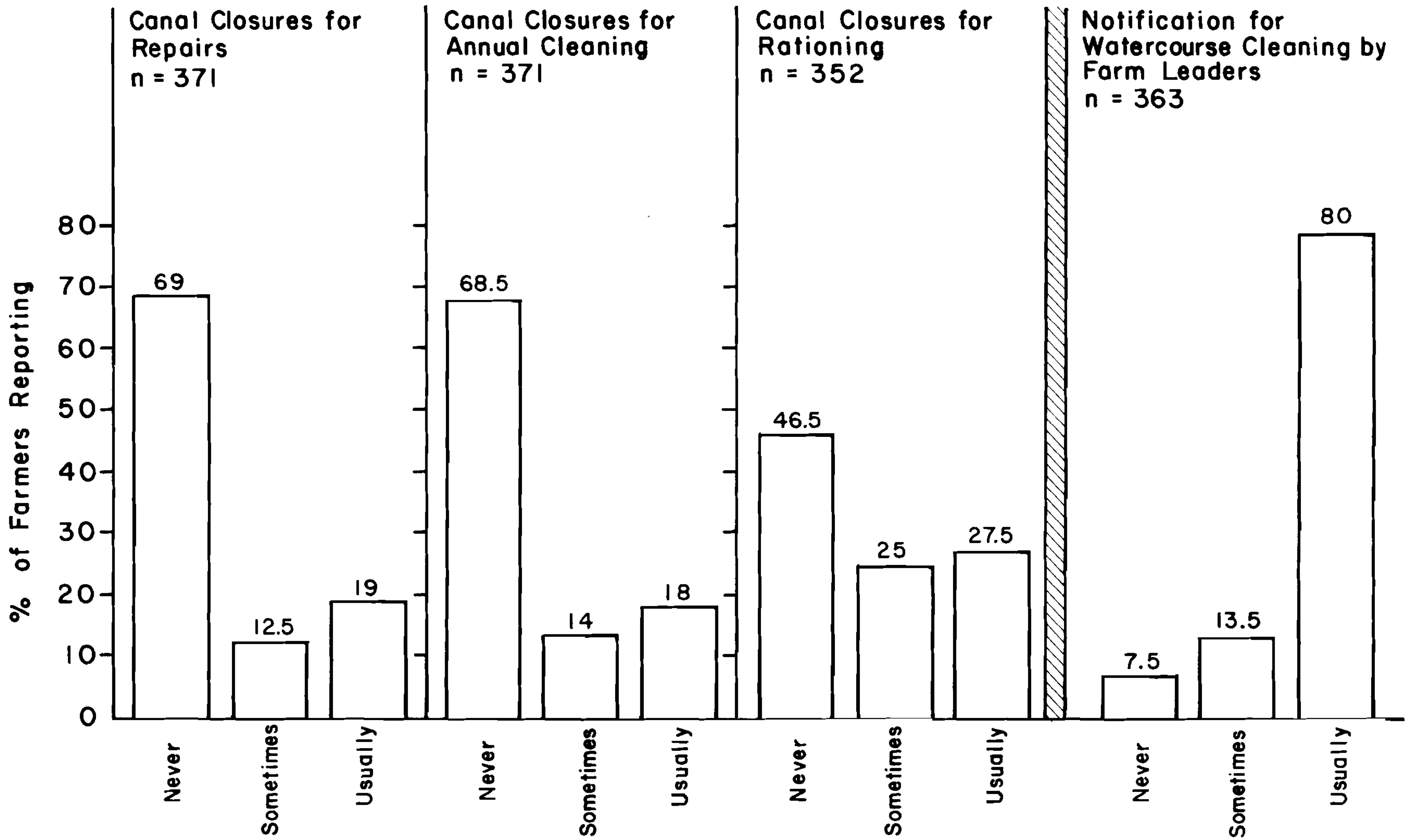

FIGURE 17. FARMERS' REPORTS ABOUT ADVANCE INFORMATION RECEIVED FROM IRRIGATION DEPARTMENT (ANY SOURCE) ABOUT CANAL CLOSURES AND ADVANCE NOTICE FROM FARM LEADERS ABOUT WATERCOURSE CLEANING

Other studies (Reidinger, 1974: 158; Lowdermilk, Clyma, Early, 1975: 63) also report the lack of information reaching farmers. However, it is also true that there is often little time to inform farmers due to closures resulting from heavy rainfall, floods, and other natural events. Closures, under such conditions, are made to avoid heavy silt deposits in canals and distributaries.

About 70 percent of the reporting farmers stated that they do not receive advance notice about closures for annual cleaning of canals (see Figure 17). This is surprising in that these closures usually take place in December and January for about two to three weeks. Farmers in general know about when the closures take place during this period of relatively low water demands. Though they are not unaware, there is often much variation between the beginning and end of the closure period and farmers seldom know the exact dates they will receive supplies. However, the Irrigation Department is constrained by lack of labor and other resources for maintaining canals on schedule.

Canal closures also take place due to overall shortage of irrigation water in the system. These rationing periods are usually predictable several months in advance of the closure periods. About 30 percent of the farmers report they usually receive advance information about the closures for rationing and 25 percent state that they sometimes receive such advance information.

The last column of Figure 17 is not related to the information about closure of canals but to advance information received by farmers about their own watercourse cleaning operations. Internal communication is usually good with about 80 percent of the farmers reporting that they receive this information. This information is usually made available by the village leaders reporting to their respective social groups, by the village chaukidar whose responsibility it is to disseminate such information, or by the public address systems located at most village mosques. The Irrigation Department would do well to develop linkages with these local sources and channels of communication to the farmers.

Reports of farmers suggest an area where there is a need for improving communication flows between the Irrigation Department and farmers. For an example, in an earlier study of 13 perennial and 7 nonperennial commands (Gibb, 1966: 109-110), the average days of closures were 65 and 185 days respectively. However, the range for the perennial commands was 45 to 124 days and for the nonperennial commands 137 to 241 days. The variability in timing of closures is high. Table 66 shows the variations between months for canal closures for 13 perennial commands. Note that the average days of closure are given for each month which reduces the wide variations among watercourses.

Table 67 provides information about the sources of information from which reporting farmers received advance news about impending canal closures. For the small percentage of reporting farmers who receive some of this information, the most important reported source is by minor officials of the Irrigation Department and radio or newspapers. This suggests that communication channels exist, but the linkages are weak. Though efforts are insufficient, the Irrigation Department prepares news releases for radio and local newspapers as well as leaflets. Also, local level department officials, such as patwaris, overseers, and others, have the responsibility of informing farmers of closures. The department might build upon the existing linkage with village numbardars who are responsible for notifying farmers of their irrigation assessments. In fact,

Table 67. Reported sources from which sample farmers receive information about canal closures.

Knowledge of canal closing for	No. reporting	% from department	% radio/ newspaper	% farmers	% other sources	Know fixed date of annual canal closure	Total %
Cleaning	82	56%	22%	18%	0	4%	100%
Repairs	51	39%	37%	18%	2%	4%	100%
Rationing	108	31%	51%	8%	2%	8%	100%

in the old Canal and Drainage Act of 1873 (Canal and Drainage Act, 1974: 81) there is a provision stating that important canal department notices are to be posted in a prominent village location. About 16 percent of the farmers reported that they gained information about closures for rationing of canal water through radio and newspapers (see Table 67). Farmers were also asked if they ever received advance seasonal reports of the canal supplies they might expect for making cropping decisions. Only 50 percent of the farmers reported that they sometimes or usually receive such information. Just as Pakistan has developed a system for flood warnings and weather reports which are given priority coverage by radio, it is conceivable that a method of giving seasonal forecasts of expected canal water supplies could be divised.

Table 68 provides data from farmers' reports which show that farmers with higher mass media scores receive more information about canal closures. In fact, the relationship is significant for all types of closures. The major components of the mass media exposure index are related to radio because only 17 of the sample farmers receive newspapers or magazines regularly and only 6 sample farmers own television sets. In contrast, 49 percent of the 379 sample farmers reported owning radios, and 56 percent report listening to radio on a regular basis. No significant relationship is found between the number of visits farmers made to towns and cities and receiving advance information about canal closures.

It might be expected that owner operators with larger holdings would have greater access to Canal Department information about closures than other farmers. However, this does not appear to be supported by data in Table 69. There is a tendency for larger farmers to receive

Table 68. Percentage of sample farmers reporting access to advance notice of canal closures for repair, cleaning and rationing by mass media exposure index and times visited a town or city in the last three months.

Urban orientation	Closures for repair				Closures for cleaning				Closures for rationing			
	# of farms	Never	Some-times	Usually	# of farms	Never	Some-times	Usually	# of farms	Never	Some-times	Usually
Mass media exposure index score												
0	165	79.4	12.1	8.5	167	77.2	13.8	9.0	160	51.9	30.6	17.5
1-4	111	58.5	13.5	27.9	99	69.7	14.1	26.2	101	48.5	23.8	27.7
5-9	73	65.7	10.9	23.3	73	63.0	16.4	20.5	71	72.2	15.5	42.2
10-18	20	55.0	5.0	40.0	20	50.0	5.0	45.0	18	16.7	22.2	61.1
		$(X^2=56.4, 30df)$*				$(X^2=53.8, 30df)$*				$(X^2=67.4, 30df)$		
Weighted totals	369	69.1	11.9	19.0	359	70.7	13.9	18.1	350	53.2	25.1	27.7
# of visits to a town or city in last 3 months												
None	27	55.6	3.7	40.7	25	60.1	8.0	32.0	26	23.1	38.5	38.5
1-2	78	69.2	10.3	20.5	80	66.2	12.5	21.0	72	41.7	23.6	34.7
3-5	104	66.3	17.3	16.3	104	64.4	18.3	17.3	100	55.0	22.0	23.0
6-7	58	75.9	13.8	10.3	58	81.0	10.3	8.6	57	56.1	28.1	15.8
8 or more	96	69.8	9.4	20.8	96	67.7	13.5	18.6	89	44.9	23.6	31.5
Weighted totals	363	68.6	12.1	19.2	363	68.0	13.8	18.1	344	47.4	25.0	27.6

*Denotes significance between .05 and .001.

Table 69. Percentage of sample farmers reporting access to advance notice of canal closures for repair, cleaning and rationing by farm size and tenure.

Farm characteristics	Closures for repair				Closures for cleaning				Closures for rationing			
	# of farms	Never	Sometimes	Usually	# of farms	Never	Sometimes	Usually	# of farms	Never	Sometimes	Usually
Farm class												
Size, acres												
Under 2.5	70	74.3	17.1	8.6	70	71.4	18.6	10.0	66	51.5	33.3	15.2
2.5-7.49	96	77.1	5.2	17.7	95	75.8	7.4	16.8	90	55.6	18.9	25.6
7.5-12.49	95	67.4	12.6	20.0	96	68.8	14.6	16.7	93	40.9	30.1	29.0
12.5-24.9	85	60.0	16.5	23.5	85	64.7	14.1	21.2	79	43.0	22.8	34.2
25.0-49.9	17	70.6	5.9	23.5	17	58.8	17.6	23.5	16	50.0	6.3	43.8
50 or more	8	37.5	0	62.5	8	25.0	12.5	62.5	8	37.5	25.0	37.5
		(X^2=24.7,10df)*										
Tenure												
Owners	251	68.9	13.1	17.9	252	67.1	15.1	17.9	238	47.1	24.8	28.2
Owner-tenant	54	77.8	7.4	14.8	53	84.9	7.5	7.5	51	49.0	27.5	23.5
Tenants & contractors	66	62.1	10.9	28.1	66	62.1	12.5	26.6	63	47.6	23.8	29.5
Weighted totals	371	69.0	11.9	19.1	371	68.7	13.5	17.8	352	47.4	25.0	27.6

*Denotes significance between .05 and .001

more information than smaller farmers though the differences do not appear important. Lack of information is a widespread problem for all categories of farmers.

B. Farmers' Use of Mass Media

In any agricultural sector with hundreds of thousands of widely dispersed farm business units, it is impossible for extension personnel or personnel from agro-business firms to adequately service large numbers of farmers directly. In Pakistan, the extension system is not only under staffed, poorly trained, supervised and organized, it is also constrained by lack of mobility. Therefore, it is important to assess the role of mass media as a potential in bringing to farmers some of the information they require. For example, while radio has weaknesses in transmitting complex agricultural information and is usually not influential in the trial and adoption stages of innovation, it is suited for helping farmers become aware of agricultural innovations. Radio ownership and exposure to the radio media has greatly increased in the rural areas of Pakistan as a result of the increased production and availability of low cost transistors. The Agriculture Department, through its Bureau of Agricultural Information in Lahore, has developed a useful and innovative radio program of 15 to 20 minutes aired in local languages each evening throughout Pakistan. Radio Pakistan, through its expanding regional stations, is placing increased focus on programs for rural people as a means to promote various development programs.

Table 70 provides a summary of mass media access and exposure as reported by farmers. About 50 percent of the 379 reporting farmers owned radios in 1975-76 as compared to only 21 percent of 350 farmers in a sample survey conducted in the Punjab Provice in 1970 (Lowdermilk,

Table 70. Summary table of mass media access and exposure reported by farmers.

Mass media item*	Number reporting	Percentage reporting
1. Ownership of radio		
Owns	185	48.8
Does not own	194	51.2
	379	100.0
2. Casual radio listening		
None	147	44.1
Some	186	55.9
	333	100.0
3. Times listened to radio programs for 30 minute periods last week		
None	147	44.1
1-2 times	124	37.2
3-5 times	30	9.0
6 or more times	32	9.7
	333	100.0
4. Farm radio exposure last week		
None	159	46.2
Some	185	53.8
	344	100.0
5. Obtains newspapers or magazines		
None	316	86.8
Irregularly	31	8.5
Regularly	17	4.7
	364	100.0
6. Read newspaper/ magazine last week		
None	295	88.3
1-2 times	28	8.4
3-5 times	5	1.5
6 or more times	6	1.8
	334	100.0

*Six of 370 reporting farmers owned television sets. Also note that the sample sizes vary for the items listed. Some of the questionnaires did not contain complete data.

1972: 324-327). This is one indication that radio ownership and use have greatly increased in five or six years. About 56 percent of the farmers report "casual" or listening to radio programs from time to time. In order to gain some estimate of the intensity of radio listening the question was asked, "How many times did you listen to some radio program for at least a 30 minute period during the last week?" Thirty-seven percent of the reporting farmers reported one to two times and about 20 percent reported three or more times of listening for 30 minute durations for the past week (see Table 70). Over 55 percent reported listening at some time over the period. One of the popular radio programs is the well-known farm radio programs which are specifically designed to help keep farmers informed of new and timely agricultural innovations and practices. As seem from the table, 70, about 54 percent of the farmers reported listening to this program at least once in the past week. These farmers usually could give the correct time and station and 13 percent were able to report the most recent farm radio subject in some detail.

Given the low level of education of sample farmers, only 13 percent reported obtaining any magazines or newspapers on either a regular or irregular basis (see Table 70). Also about 13 percent reported reading a newspaper or magazine in the last week.

Table 71 shows the differences in radio ownership and exposure to radio by all farm size and tenure classes.

Larger farmers own more radios but note that there is no significant difference between access to radios for listening. Also, owner operators and owner-cum-tenants own more radios than tenants, but tenant farmers have almost equal access to radios for listening. Given the wide dissemination of the cheap transistorized radio, over 50 percent of the

Table 71. Percentage of sample farmers owning radios or having regular access to radios by farm size and tenure classes.

Farm characteristics	No. of farms	Owns	No. of farms	Listens in the village
Farm Class Size, Acres				
Under 2.5	72	33.3	71	53.5
2.5 - 7.49	96	44.8	81	53.1
7.5 - 12.49	99	48.5	82	53.7
12.5 - 24.9	88	60.2	62	50.0
25.0 - 49.9	16	62.5	6	66.7
50 or more	8	87.5	2	50.0
X^2		81.1* (5df)		
Tenure				
Owners	253	53.4	192	57.3
Owner-tenants	55	49.1	43	46.5
Tenants & contractors	71	33.3	69	46.3
X^2		10.6* (3df)		
Weighted totals	379	48.9	304	53.0

*Denotes significance between .05 and .001.

sample farmers can be reached through the radio media. Though not shown in Table 71 no significant differences were found between farm size and tenure classes in their knowledge of the time, station, and subject matter of the farm radio program. Also, no important differences were found between these classes of farmers and the intensity of listening. In terms of other mass media such as magazines and newspaper use, which require literacy, there are significant differences between farm size classes and their regular and irregular acquisition of these mass media and their exposure to them (see Table 71). For example, of the farmers with holdings of under 12.5 acres, only about 6 percent receive newspapers and magazines on a regular or irregular basis as compared to about 31 percent of the farmers with holdings of over 12.5 acres. Of the 8 reporting farmers with 50 acres or more of land, half report obtaining newspapers or magazines for reading. The data indicate the relative importance of radio as well as the potential for its increased use in rural Pakistan as compared to printed media.

C. Farmers' Radio Program Listening Preferences

Farmers were asked to rank their preferences for the major types of radio programs aired in Pakistan. Of the 326 farmers reporting, the first choices of the largest percentage of sample farmers were musical programs followed by the farm radio program (see Table 72). However, when first and second choices are combined, the farm radio program ranks first followed by musical, world news, religious, dramatic and local new programs.

Table 72. Farmer's reports of radio program listening preferences.

Type of radio program	Number reporting	First choice	Second choice	First and second choices combined
		%	%	%
Farm radio	325	21.2	26.8	48.0
Musical	326	29.4	9.2	38.6
World news	326	11.3	17.2	28.5
Religious	326	8.0	5.2	13.2
Drama	325	4.9	5.5	10.4
Local news	326	3.4	6.7	10.1

D. Farmers' Uses of Sources of Information for Agricultural Information

Table 73 indicates the relative importance of various sources of information used by farmers in the trial and adoption stages of several improved grain varieties and agricultural practices. In rank order, the major sources of information for all innovations are other farmers, extension personnel, and farm radio. However, extension plays a major role in providing information especially in plant protection measures and the use of the rabi wheat drill. The Agricultural Department for many years was almost the sole source of insecticides and sprayers and it has been a major responsibility of field assistants to help farmers spray crops. Until recently, extension staff attempted to meet the needs of farmers for actually applying plant protection measures but this was found to be an impossible task. The Department also has made rabi wheat drills available to farmers in some areas and have used them in their demonstration plots. It must be emphasized that the reports in Table 73 refer only to the trial and adoption stages and no information was collected on when these activities took place.

Table 73. Summary of farmers' sources of information at trial and adoption stages for selected agricultural varieties and practices.

Improved practices or varieties	Total number reports from farmers	Percentage of reporting farmers using various sources of information				
		(1) Other farmers	(2) Farm radio	(3) Extension personnel	(4) Other sources	(2+3) Radio plus Extension
1. High yielding varieties (wheat, rice, bajra)	299	62.9	18.7	16.7	1.7	35.4
2. Plant protection measures (rice and cotton)	62	35.5	17.7	40.3	6.5	58.0
3. Line planting measures (cotton and rice)	110	48.2	25.5	24.5	1.8	50.0
4. Automatic rabi wheat drill	37	48.6	5.4	37.8	8.1	43.2
5. Phosphatic fertilizers	58	43.1	24.1	24.1	8.6	48.2
Weighted totals of all practices and varieties	566	54.1	19.6	22.9	3.4	41.7

In summary, farm radio is of growing importance. The advantages of radio for a country like Pakistan for transmitting certain types of information to help make farmers more aware and interested are tremendous. Radio access and exposure is high in the rural areas; it is low cost, can cover large mass audiences at great speed and messages can be made available in regional languages. Disadvantages result from the problem of feedback between senders and receivers and the fact that radio communications must be reinforced by interpersonal communications to create substantial attitudinal and behavioral changes. Radio might be used much more for informing farmers of canal closures and seasonal forecast of expected irrigation supplies. Special radio programs can be developed to support the on-farm water management improvement programs especially to arouse interest and increase awareness of benefits. It appears that much greater use can be made of radio than the brief 15 to 20 minute daily farm programs presently existing.

CHAPTER FIVE

INSTITUTIONAL AND ORGANIZATIONAL CONSTRAINTS

Preceding sections of this report have established that farmers are severely constrained by uncertainty of water deliveries in regard to both timing and quantity. Moreover, they are typically constrained by unlevel fields, by problems associated with marketing, credit, fertilizer, pesticides, and by lack of knowledge about basic irrigation practices. The irrigation and agriculture departments provide little effective assistance. The list of constraints pressing upon the farmer does not stop at this point. It is the objective of this chapter to examine constraints imposed by the lack of effective local level social organizations. Physical, agronomic and economic constraints can be relaxed only if local organizational problems are overcome.

Problems of irrigation are social because farmers must organize collectively to secure irrigation water, to transport it, divide it into usable shares, enforce rules for its application, pay for it, and dispose of unused portions. The kinds of social organizations, their patterns of power, decision making, conflict, and cooperation which people create and maintain for the social control of water, intimately affects the productivity of its use. Attempting to comprehend physical and agronomic problems of irrigation without probing into underlying social organization for irrigation is like attempting to understand deficiencies in plant growth without reference to conditions of climate. When water moves efficiently from rivers, through a network of canals, to plant root zones, it is because people have effectively organized a decision system capable of enforcing technically sound rules for pursuing the collective interest. Defects in the delivery and application of water are invariably associated with deficiencies in social organization.

Whereas the national and provincial irrigation bureaucracies may represent highly structured organizations for the diversion of water from rivers through a complex and sophisticated canal system, there is, in Pakistan, an absence of local counterpart organizations to provide for effective and efficient delivery of water through watercourses to fields. National and provincial bureaucracies are tightly structured and pursue detailed sets of rules for macro decision-making at the level of province, barrage, and canal, but farmers at the local level are unorganized and effective local level cooperation for water management is undercut. Detailed regulation and specialized organization at higher bureaucratic levels exists in tandem with under organization of watercourses. If farmers are to successfully relax physical, agronomic and economic constraints described in the foregoing chapters, farmers must cooperate effectively in local organizations which can provide improved watercourse structures and associated reductions in water loss and waterlogging and salinity. Such organizations could also promote land leveling, be the focal point for transmission of knowledge of improved practices and critical agricultural inputs.

This section will proceed in the following manner: First, it will be contended that central physical constraints faced by farmers represent "collective good" problems and that such problems can only be adequately resolved by effective farmer organizations at the watercourse and village level. Second, existing informal organizational mechanisms employed by farmers to provide two kinds of collective goods will be examined. The collective goods represented here are school and mosques.

Third, the discussion will document the lack of effective penetration of national and provincial organizational services into village farmer life. Fourth, it will be posited that farmers are constrained in important respects by their "biradari boundedness." It will be documented that in the absence of effective watercourse or other local organizations, farmers are constrained to work within narrow biradari (brotherhood) networks. These networks may be effective for securing cooperation from biradari members, but many farmers find it difficult to venture across their kinship lines to cooperate with nonbiradari members. Fifth, the question is asked; If farmers need to cooperate to improve their water management, what are the requisities of successful cooperation? There is no fully adequate theory of cooperation, and the long list of psychological, sociological, economic and physical variables, which impinge on cooperation, is so large as to far exceed the bounds of this study. Nevertheless, it can be poisted that farmers will have higher propensities to cooperate in water users organizations under certain conditions of conflict and distributions of power.

I. SOCIAL ORGANIZATION AND IMPROVING WATER MANAGEMENT--THE PROBLEM OF COLLECTIVE GOODS AND LACK OF INCENTIVE TO ORGANIZE

A "collective" or "public" good is one in which significant benefit cannot be denied to those who do not help bear the cost of providing the good (Olson, 1971). For example, an improved watercourse is a collective good because individual farmers will calculate as follows with regard to potential improvements. If one makes an investment of time, energy, and money to improve the section running through his land, and many other farmers do not do so, then the payoff of his work is negligible. On the other hand, if many others for some reason undertake lining and straightening on their sections he will still enjoy a share of the benefits if he does little or nothing. The "free rider" cannot be denied the additional amounts of water that would become available to him as result of the work of others. Therefore, the rational calculating individual will choose to do nothing either way--even assuming that he has information about potential benefits, and the know-how to make the improvements. This situation can only be mitigated by the presence of social organization with the power to enforce sanctions upon all members such that each can be assured that his contributions will be matched by some acceptable proportion of contribution by others who benefit.

Many aspects of irrigation systems represent collective good problems, but of particular interest to the researchers is the problem of watercourse improvement. Data reported in earlier sections of this study show that much valuable water is lost in poorly designed, constructed, and maintained watercourses. Delivery efficiencies are low across sample watercourses with few exceptions. How can village farmers be effectively organized to undertake watercourse reconstruction and to subsequently maintain the improved structures? Because this question was foremost in the minds of the researchers, a portion of the investigation was devoted to an examination of how villagers organize to provide the three kinds of collective goods already present in villages which farmers must buy and maintain themselves--mosques, schools, and watercourse cleaning/maintenance. (Mechanisms for watercourse cleaning are discussed in Volume III, Chapter One, Section V). This section of the report describes the mechanisms by which villages organize for the "collective goods" represented by schools and mosques, in order to reveal present patterns of problem solving and to inform further work on the problem of organizing farmers into effective farmer associations capable of undertaking watercourse improvement as well as other aspects of agricultural development.

II. METHODS OF ORGANIZING TO BUILD AND MAINTAIN MOSQUES

Punjabi villages typically are endowed with two kinds of mosques--1) private mosques erected by those who have both the required religious motivation and the financial resources; and 2) community (Jummah) mosques which are open for the use of at least major segments of the village if not all groups. The focus of the inquiry was on mosques of the latter kind--the type thought to require at least some minimal collective action to construct and to maintain. Table 74 displays the number and type of mosques found in sample villages.

There may be more than one community (Jummah) mosque for one or both of the following reasons:

a. In cases where both Sunni and Shia Muslims are found in the the same village, there will be a Jummah Mosque to serve each group. Cooperation in the support of mosques does not typically transcend this religious division. Shia is a minority religious sect in the rural Punjab and that is reflected by the fact that only three of the sample villages possess a Shia community.

b. Within religiously homogenous villages, there may be more than one Jummah Mosque because of conflict dividing hostile factions. This occurs, for example, in village 103 in which one Mosque is supported by Gujars and Kumbos while the second is maintained by Rajputs and Arians.

Table 74. Distribution of Mosques by sample village.

Village	Number Community (Jumah) Mosques Sunni*	Shia	Number of Private Mosques
101	1	0	0
102	1	0	9
103	2	0	0
104	1	1	0
105	1	0	0
106	0	1	6*
107	1	0	0
108	1	1	0
109	1	0	11
110	1	0	4
111	2	0	5
112	3	0	2
113	4	0	0
114	2	0	15
115	1	0	3
116	1	0	4

*Each sunni biradari has its own private mosque.

Mosques have been constructed in one of two ways in sample villages. A single influential leader has in two cases, (villages 110 and 113) organized construction, but in all other villages a 'Mosque committee' has been organized which consists of biradari leaders who collect resources from their respective brotherhoods and, together, cooperate in arranging for construction. The numbardar in village 110 assumed leadership for mosque construction and, over a three year time span, collected the necessary money for hiring a contractor. Village 106 has no community mosque as influential biradaris refused to cooperate with each other leaving each to build its own place of worship.

What methods are employed to secure financial resources for initial construction and maintenance? In all sample villages, key informants revealed that biradari leaders did the actual collection of money, grain, fodder, animals, building materials and commitments of labor. Everywhere informal but intense social pressure is the device by which commitments are secured. Gossip, to the effect that someone contributes less than a "fair share" relative to his community standing and resources, is the major mechanism of social control. Whatever their devotion to Allah, donors give to avoid shame and loss of personal prestige. When repairs are needed, in two villages, biradari influentials employ mosque loudspeakers to broadcast the amounts members of the respective brotherhoods have so far contributed, thereby, establishing a "friendly" rivalry and stimulating donations. In all villages, save three, key informants agreed that contributions were voluntary and no fixed tax was levied. However, in three sample villages, more formal arrangements have evolved. Key informants in two--101 and 107--note the existence of a "wash" system whereby a specified amount of money is exacted per acre of cultivated land--about Rs. 5-7 per acre per cropping season. Additional voluntary donations are solicited beyond these amounts. Farmers of village 109 have had a long standing contract with the government to breed horses for the army. Each breeder is expected to donate Rs. 100 per mare per year to the village Mosque and School fund.

Informants were asked whether there were farmers who avoided contributing to the Mosque and what, if any, sanctions were employed to punish holdouts. In no village are formal sanctions found, and only in a few instances do farmers refuse to give what is considered their "fair share."

III. METHODS OF ORGANIZING TO CONSTRUCT AND MAINTAIN SCHOOLS

All sample villages support at least a primary boys school, and most support primary schooling for girls. One supports schools for both sexes all the way through the secondary level (see Table 75).

Table 75. Distribution of schools in sample villages

	School					
	Primary (1-6)		Middle (7-8)		Secondary (9-10)	
Village	Boys	Girls	Boys	Girls	Boys	Girls
101	1	1	1	1	1	1*
102	1	1	0	0	0	0
103	1	1	1	0	1	0
104	1	0	0	0	0	0
105	1	1	0	0	0	0
106	1	1	0	0	0	0
107	1	1	0	0	0	0
108	1	0	0	0	0	0
109	1	1	1	0	0	0
110	1	0	1	0	0	0
111	1	1	0	0	0	0
112	1	1	0	0	0	0
113	1	1	0	0	0	0
114	1	1	0	0	0	0
115	1	1	0	0	0	0
116	1	1	1	0	0	0

*The girls' middle school was, at time of data collection, in process of expanding to offer a secondary school curriculum for girls.

Only two villages support a boy's high school.

In some villages, the government designated a parcel of land for locating a school; in other cases, villagers provided land, usually a donation from a generous land owner. In all cases, villages must organize to obtain some resources to construct the school building; the government often contributes some construction costs and typically pays the teacher's salary. Table 75 shows the distribution of schools by type in the sample villages.

As in the case of mosque construction, the biradari groups are the key mobilizing organizational unit, supplemented in village 102 by a Cooperative Farming Society which collects revenue from farmer payments. Some farmers in that village, however, have refused to join the cooperative society and they systematically refuse to contribute to the school fund or to a community mosque.

In the matter of securing a continuing flow of funds for maintenance, the schoolmaster typically contacts biradari leaders at harvest time when money and produce is most plentiful. In cases where mosques are equipped with loudspeakers, biradari influentials and the schoolmaster broadcast the contributions of rival biradaris thereby spurring competition. Where electronic amplification is not available, biradari leaders place social pressure on fellow kinship members to make contributions which are judged equitable, given the person's social and financial standing. In all sample villages, informants agree that few individuals choose to resist the social pressure to contribute. Again in villages 101 and 107, a quasi-formal "wash" system of financing is found in which farmers contribute to the school in direct proportion to their land holdings. The rate varies from village to village, there is no formal mechanism by which the "tax" is enforced, and the money is collected within biradari units by biradari leaders. Informants indicate that the system generates school revenue at the rate of approximately Rs. 1 to 2/acre per cropping season.

In no village is there any voluntary adult labor for school maintenance. Funds, and contributions in produce, are collected and given to the headmaster who then converts the resources to cash and hires a contractor or local labor depending on the magnitude of the job. School children provide labor for minor school improvements.

Rudimentary informal forms of village cooperation exist for securing and maintaining collective goods--mosques and schools. No formal organization with taxing power exists. Written contracts are nowhere employed to formalize agreements. Everywhere the social unit through which cooperation is mobilized is the biradari or brotherhood kinship group. Where biradaris are badly split one from another, serious problems of village cooperation emerge.

Where biradaris split within over an issue of enforcement of a sanction, the biradari leaders face the unpleasant choice of attempting to force application of the sanction at the risk of serious internal biradari antagonisms or of withdrawing the sanction. In such circumstances, the sanction is likely to be compromised or withdrawn.

Some form of formal farmer organization must be constructed if farmers are to be able to contract, in a legally binding manner, with outside organizations technically competent to undertake major watercourse realignment and lining projects. Such projects will require that farmers enter into formal and enforceable contracts with each other and with contractors. Existing informal arrangements among influential biradari leaders are inadequate to the task of contracting with public or private contractors, for collecting revenue for payment, and to serve as a vehicle by which improved water management knowledge can be directed to farmers from the agricultural extension service.

Whatever specific forms the formal farmer associations eventually assume, it is clear that they must adapt to the reality that the farmer acts primarily as an agent of a biradari group.

IV. LACK OF INSTITUTIONAL SERVICES AT THE FARM LEVEL

Resolving water management problems requires effective local farmer organizations. Yet, examination of local village organization for schools and mosques reveals that village level organizations do not exist which are capable of uniformly applying sanctions. Biradari kinship groups are the functioning informal organizations and they vary widely in their capacity to meet the demands of providing organizational frameworks for the provision of community "public" goods. But, farmers are not only constrained by the lack of local organization, they are additionally burdened by the absence of effectively organized services in banking, agricultural extension, and irrigation.

Evidence regarding the lack of extra-village institutional services is marshalled from sample farmer responses to a series of questions having to do with their knowledge of, and contacts with, ten kinds of local officials who have responsibilities for working with farmers:

a. Agricultural Assistants-Department of Agriculture, Extension Service.
b. Field Assistants-Department of Agriculture, Extension Service
c. Development Assistants-Integrated Rural Development Program
d. Agricultural Engineers-Integrated Rural Development Program
e. Project Managers-Integrated Rural Development Program
f. Bank Officials
g. Fertilizer Agents
h. The Canal Patwaris-Irrigation Department

i. The Canal Zilladars-Irrigation Department

j. The Canal Sub-Divisional Officers-Irrigation Department

Respondents earned a point on an Institutional Services index for identifying the location of any given officials' office or residence. Two points were awarded for the correct naming of any given official. In addition, points were granted to each respondent on a sliding scale for having had contacts with officials within the preceding three months. In all, a respondent could acquire 110 points by identifying the location of at least one representative of each category, by correctly naming at least one such representative, and by reporting frequent contacts within the preceding 90 days. (The Institutional Services Index is reproduced in Volume VI, Appendix I.) Figure 18 displays the distribution of sample farmer scores on the Institutional Services index. The scores are skewed sharply. Overwhelmingly, farmers receive low scores by virtue of the fact that they report little or no contacts with officials and they most typically cannot name them or identify their location. Forty-one percent of the sample farmers score no points on the index, and 93 percent earn 50 or fewer points. Of the listed officials, the canal patwari is most likely to be known and contacted. Next most likely to be identified is the fertilizer agent followed by the Agricultural Engineer and Field Assistant.

Probing further into the problem of lack of institutional services for farmers, Table 76 displays scores on the index broken down by farm size class. Inspection of Table 76 shows that although 86 percent of the sample farmers score 15 or fewer points on the 110 point index, larger farmers do report a higher level of knowledge and contact in reference to institutional services. The contingency coefficient (C)

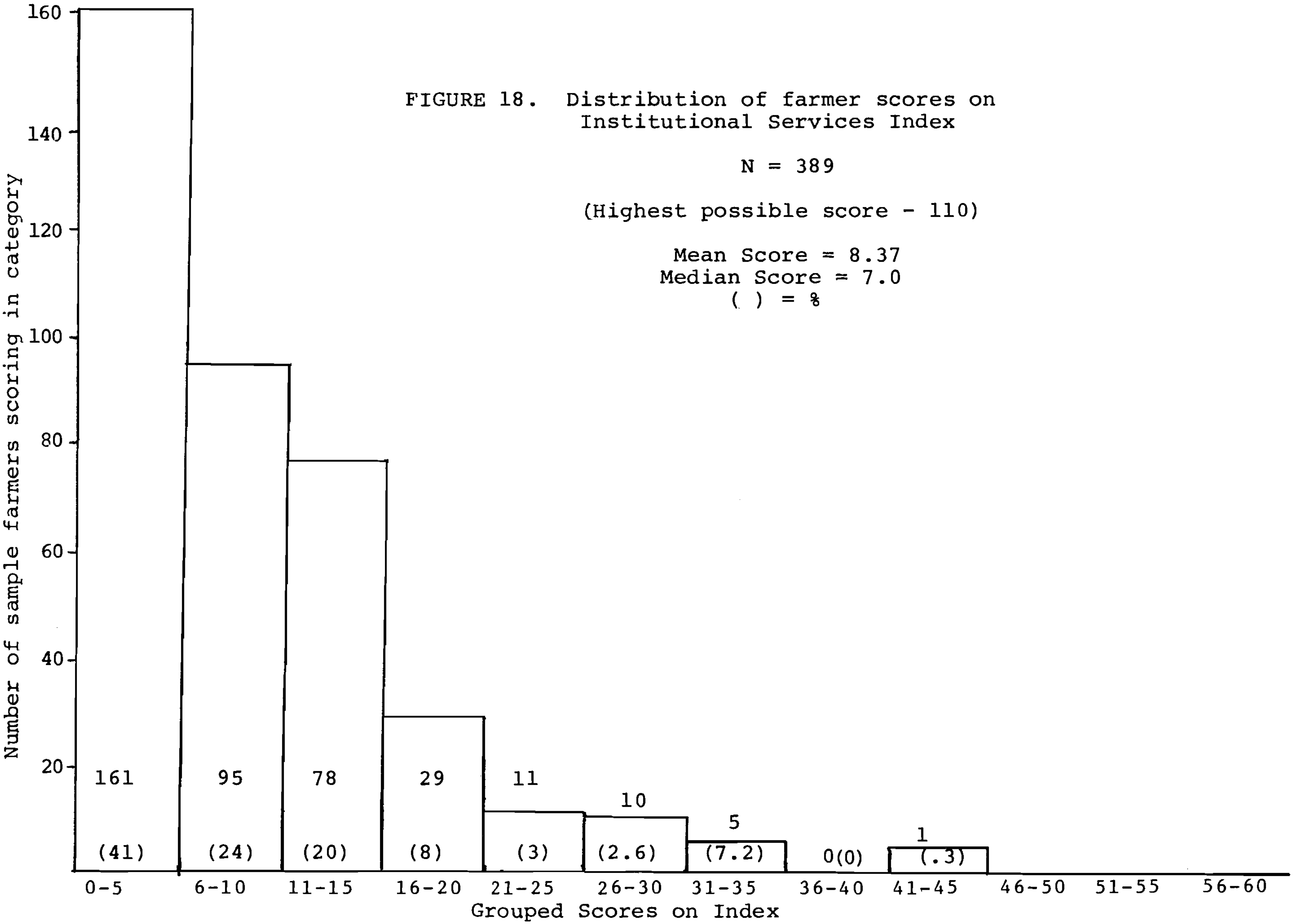

FIGURE 18. Distribution of farmer scores on Institutional Services Index

N = 389

(Highest possible score - 110)

Mean Score = 8.37
Median Score = 7.0
( ) = %

Table 76. Institutional service index scores by farm size category.

Institutional service index score	Percent in farm size category (acres) ≤ 2.49	2.5-7.49	7.5-12-47	12.5-24.9	25-49.9	50+	Row percent
0-5	12.9	12.3	9.0	6.9	.3	0	41.4
6-10	4.1	7.2	6.4	5.9	.8	0	24.4
11-15	1.8	3.9	7.2	5.9	1.3	0	20.1
16-20	1.0	.8	2.1	1.8	1.3	.5	7.5
21-25	0	.8	.8	.5	.3	.5	2.8
26-30	0	.5	0	1.0	.3	.5	2.3
31+	0	0	.3	.5	.3	.5	1.5
							100%

N = 389

$X^2 = 132.6$

d.f = 30

p = .00001

C = .50

reveals a moderately strong relationship between increased farm size and reports of increased institutional service. The "p" value reveals that the relationship would occur by chance less than one time in ten thousand. Smaller farmers report poorer services than larger ones, but this fact should not mask the low level of institutional services reported by farmers in all farm size categories.

If one examines that sub-set of institutional services having to do with providing farmers with information about canal closures for cleaning, repair, rationing, and seasonal redistribution, one finds that again, the farmer is constrained by the lack of service (see Table 77). Sample farmers were asked as to whether they "never," "sometimes," or "often" received information about canal closures. Water is a critical factor in crop production, and the Irrigation Department is explicity mandated to inform farmers of impending scheduled canal closures; yet, farmers are poorly informed. A respondent who often receives advance information from the Irrigation Department by any means could potentially score 16 points on the index (see Access to Canal Information Index, Volume VI, Appendix I). Inspection of Table 77 reveals that, overall, the average sample farmer scores only 3.3 points. No farmer in the sample scored half of the potential on the index, but average scores increased as farm size increased. Larger farmers do have greater access to information about impending canal closures than do smaller operations, but lack of information constraints sample farmers of all sizes.

Table 77. Mean sample farmer scores on access to canal information index by farm class (range of possible scores = 0-16)

Farm Class Size (acres)	Mean Score	N
All Sizes	3.33	388
≤2.49	2.29	77
2.5-7.49	2.81	99
7.5-12.49	3.62	99
12.5-24.49	3.98	88
25.0-49.99	4.12	17
50.0-74.99	7.25	8

V. COOPERATION AND BIRADARI ATTACHMENTS

Sanctions are rewards for behaving in approved ways and punishments for violations of expectations. In Pakistani villages, sanctions are primarily applied and enforced by biradari leaders within brotherhood groups. It might be expected that farmers find it difficult to cooperate with farmers of other biradaris for the simple reason that violations of agreements can be much more easily punished when the violator is a member of the same biradari. However, as one's power and influence increases one might expect that one's ability to put pressure on other biradari leaders for enforcement of sanctions would also increase.

An index of "biradari boundedness" was constructed from 11 items on the interview schedules which pertain to matters such as consultation about farming problems, cooperation in watercourse cleaning, borrowing money, borrowing tools and implements, trading water, and requesting assistance for approaching officials such as the SDO, Overseer, patwari (see Biradari Boundedness Index, Volume VI, Appendix I). If a farmer respondent were to indicate that he would not go beyond his biradari for any assistance with regard to any index items, the respondent would receive a score of 100 meaning he was 100 percent biradari bounded. Conversely, a score of zero percent would indicate that the farmer in question would be willing to cross biradari lines to secure assistance in all matters reflected on the index.

Table 78 displays data showing the relationship between "biradari boundedness" and size of farmer holdings. Seventy-nine percent of the farmers are moderately to highly bounded by biradari ties. Small farmers show a slight tendency to be more bounded but the difference is only marginally significant and there is little strength to the relationship.

VI. CONSTRAINTS OF SOCIAL CONFLICT

Conflict is omnipresent in social life; it cannot be eliminated in any society. Questions about conflict divisions have not so much to do with their elimination as with their organization vis a vis each other--are allies on one issue, allies on all issues--and with the presence of organizational authorities to guide, control, and resolve conflict among opposing parties.[8/] Irrigation systems are inevitably involved in, and generate, social conflict. Any set of rules for delivery and distribution of water will affect parties unevenly. Some farmers will be advantaged at costs to others, some values promoted, other values will be undercut. Benefits for farmers at the "tail" of a watercourse may clearly disadvantage those toward the "head," that which assists "small" farmers

8/The pattern of conflict cleavages or divisions is more important than the sheer number of conflicts per se. Data about conflict patterns--the extent of polarization--are not available at this time for the sample villages, but such data are being gathered as part of on-going research efforts in Pakistan. Future reports will show the relationship of conflict to successful water management improvement efforts.

Table 78. The relationship of biradari boundedness to farm size.

N=337

Biradari boundedness score		Farm size category <2.4	2.5-7.49	7.5-12.4	12.5-24	25-49	50+	Row sum	Row percent
Low	0-30	17	22	20	12	0	1	72	21
Moderate	31-70	16	37	38	37	6	4	138	41
High	71-100	27	29	26	33	9	3	127	38
								337	100

$X^2 = 16.7$
d.f. = 10
p. = <.10
C = .22

may be opposed by larger ones; what members of one kinship group may enthusiastically endorse, members of competing biradari groups may just as heartily reject. It is no accident that conflict management, control, and resolution is a significant function of irrigation organizations everywhere. Yet, in Pakistan, local level formal irrigation organizations do not exist which could serve to manage the inevitable conflict. When local level informal biradari mechanisms fail to provide acceptable conflict control and resolution, farmers either have to accept an unhappy circumstance which may undercut their productivity or they must go well beyond the village to physically and socially remote agencies--the police, courts, or Irrigation Department. The costs of pursuing conflict in the courts or irrigation bureaucracy can be a substantial burden even for the larger farmers. Smaller operators are largely unable to muster the resources for prolonged recourse to agencies beyond the village, especially when their opponents posses more wealth, prestige, and power.

Sample farmers and key informants were asked about village conflict patterns. Specifically, they were requested to identify conflict cleavages between groups (who fights with whom), the dominant issues which make up the cleavage (what opponents fight about), the dates started and terminated, mechanisms of resolution, degree of resolution, and the degree of hostility which was generated.

To be counted, conflicts must represent a cleavage in the social network. The term, as used here, excludes personal dissatisfaction, jealousies, and pique which do not affect the social or community web. To be counted, there must be issues which involve at least a small group of people who agree as to the nature of the issues, and there must be consequences for the group, not just for a particular individual.[9/]

Ninety-nine conflicts meeting these criteria were reported in fifteen of the sample villages. The distribution of conflicts is displayed in Figure 19, which reveals that water related conflicts constitute approximately 44 percent of the reported village divisions. Water theft is the source of more village conflict than any other type followed closely by land disputes.

It is beyond the purpose of this report to characterize in any detail the specific conflict stories. Yet, a brief characterization of conflict in a few sample villages will convey the importance of conflict and its' relationship to agricultural production and community cooperation for water management improvement.

Village 101 is characterized by major cleavages dividing the Mulana biradari from the Jatalia and the Dinga over land and water conflicts, but respondents indicate that those three biradaris will subordinate their differences in opposing the Ghilards' quest to obtain water rights on a preferred watercourse. At the risk of over-simplifying, the Ghilard family owns land which cannot, for topographical reasons, be effectively irrigated from its designated watercourse. The Ghilard leader has consistently, without success, attempted to secure water from a second watercourse which could potentially serve his plots. Since 1960, the Ghilard has spent over Rs. 10,000 to gain favor with government officials and other biradari leaders. A marriage of the Ghilard's daughter was

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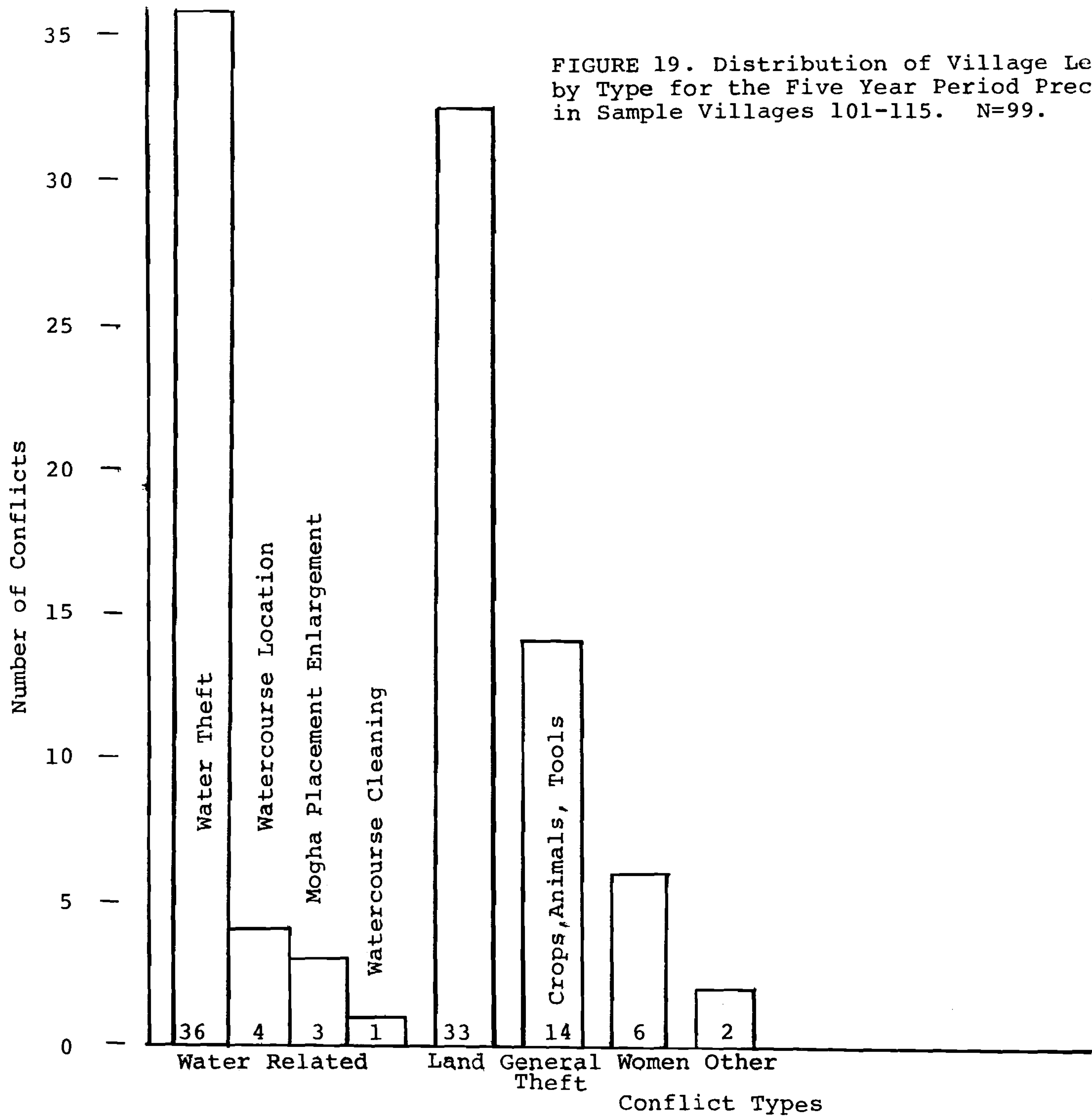
9/Investigators have made an effort to avoid double counting of reported conflicts--something easy to do as respondents tend to mention the same cleavages over and over again. Information taken regarding the parties involved, the dates, the issues, allow one to avoid duplication in counting.

FIGURE 19. Distribution of Village Level Conflicts by Type for the Five Year Period Preceding Interviews in Sample Villages 101-115. N=99.



arranged and consummated on the promise that rights on the preferred watercourse would be forthcoming. All efforts have failed. Violence has probably been contained only by the fact that the Mulanas, Jatalia and Dingas present a united opposition to the Ghilards. Yet, the opposing parties are locked into continuing expenditure of resources to block each other from attaining their respective objectives.

In village 102, the Jam Jat biradari takes a unanimous stand on one side versus Rid Jats, Pahore Jats and Arians who stand united in opposition. This has its roots in a bitter land dispute over which at least two antagonists have been killed and has overlapped a cleavage between cooperative society members vs. noncooperative farmers. Jam Jats, without a single exception have refused to participate in the cooperative farming effort which has been controlled by their antagonists.[10/] Because the cooperative society has played a major role in financing the local school, the Jam Jats have refused to contribute to it--placing another cleavage right on top of the land and cooperative fights. This tendency toward high polarization was exacerbated in 1974-75, when the engineers of the CSU field party--attempting to initiate construction of an improved watercourse--dealt exculsively with the anti-Jam Jat leaders. Although a most innocent oversight, the direct consequence was that the watercourse improvement project was abruptly halted midway through the construction phase by Jam Jat resistance.

The most talked about event in village 104 for years has been the attempted land consolidation scheme promoted by the Revenue Department in the mid-1960's. The village has one agricultural caste--Dogar--but

10/At partition, areas evacuated by fleeing Hindu farmers were allocated by the Cooperative Farming Society to incoming refugee farmers as well as to locals. The cooperative society retained title to the land.

has been deeply divided over land ownership questions between the Chung and Khamba biradaris. The Revenue Department's attempt to push ahead with the consolidation project resulted in physical combat, the killing of a Khamba man, and the jailing of two influential Chungs. The deep cleavage persists and continues to divide farmers who would find it most difficult to cooperate in any united effort to improve water management.

Village 109 is deeply split over a complex set of issues involving water stealing, land ownership disputes, and women. Attar and Moqul biradaris have been opposed since 1952, but things escalated abruptly in 1971 when Bowras, allied with the Attars and Kahoots, joined Moquls. Respondents agree that at least 22 men were directly involved in the fightings when violence peaked in that year.

There are sample villages which are not highly polarized into such hostile corps--villages 103, 105, 106, 113, and 114 for example.

It is not a matter of determining that there are necessarily fewer conflicts present, but it is a matter of determining that whatever the quantity of conflict, cleavages are arranged in such a manner that they do not repeatedly re-enforce each other to the point of making bargaining and negotiation difficult and violence probable. This is not to imply, however, that even non-polarized conflicts are unimportant and can safely be ignored by agents of change. For example, the researchers learned that in village 106, when invited to show a film on land owned by an influential Balwany, the Tarragarrah group would refuse to attend. The agent of planned change cannot afford to ignore conflict when polarization is low--on the contrary, the objective must be to design and implement programs of change in such a manner as to undercut tendencies toward polarization. To achieve this, the change agent must be careful to 1) establish credibility with groups on all sides of the cleavages--something most difficult when cleavages are highly polarized, and 2) insure that both costs and benefits of planned programs are shared with relative equity by groups on all sides of the cleavages. To introduce a change program which places the benefits largely on one side of an existing cleavage and to direct the disadvantages largely to the other side is to increase conflict polarization and flirt with social disruption, lack of cooperation, and program paralysis no matter how technically feasible and/or economically justifiable the program.

What agencies of conflict resolution are employed by farmers? Table 79 reveals the distribution of conflict types and the highest agency involved in the control of the conflict. Biradaris are involved in all conflicts. But there are occasions when informal biradari mechanisms are insufficient; disputants involve agencies beyond the village.

In sum, conflicts sufficiently important to divide groups of farmers into opposing factions have been found in all sample villages for which conflict data were reported. Some villages are more deeply divided than others. For all types of conflict, informal biradari mechanisms were brought into play and they constituted central devices for conflict control and resolution. Land and general theft conflicts tended to escalate to higher authority beyond the village more than did conflicts regarding theft of water, which was the single largest source of village division. Farmers, in all sample villages for which data are available, are constrained by the fact that they find cooperation difficult, if not impossible, in some cases, across deep cleavages. They must invest scarce resources to oppose other groups which could otherwise be employed for their own economic and social development.

Table 79. Conflict frequency and highest agency of resolution by type of conflict for the five year period preceeding interviews in sample villages 101-115.

Conflict type	Frequency	Agency of resolution			Biradari*
		Court	Police	Irrigation Department	
Water theft	36	9	3	2	22
Watercourse location	4	3	-	-	1
Mogha placement enlargement	3	2	-	-	1
Watercourse cleaning	1	-	-	-	1
Land	33	19	2	-	12
General theft (crops, animals, implements)	14	5	5	-	4
Women	6	3	-	-	3
Religion	0	-	-	-	-
Other(rights of way for roads and paths)	2	1	-	-	1

*Note: On occasion biradari leaders meet as panchayat members to control and resolve conflicts.

Conflict is found in all societies and is a central fact of life in all irrigation systems, but Pakistani farmers labor under the additional burden of not having the benefit of formal conflict resolution organization easily and inexpensively available at the local level.

VII. THE DISTRIBUTION OF POWER/INFLUENCE

Sample farmers were asked to rate each watercourse farmer, including themselves, in response to the two part question: How much influence/power does a farmer have in matters of 1) watercourse cleaning and 2) settling watercourse disputes?[11/] The scores obtained yield a power score for every individual farmer on the sample watercourses--even those not falling within the stratified random sample. The distribution of influence scores for both the total population of farmers on the sample watercourses and for the study sample is displayed in Figures 20 and 21. Only in the case of sample farmers, of course, could data

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11/See for discussions of power and influence in Punjabi villages Inayat Ulah, Perspectives in the Rural Power Structure In West Pakistan. Development Research and Evaluation Group. United States A.I.D. Mission to Pakistan, April, 1963. Also, Muhammad Rafique Raza, Two Pakistani Villages: A study in Social Stratification, Lahore, University of the Punjab, 1969. Much confusion still exists over precise meaning of concepts of power and influence. A variety of scholars have attempted to arrive at conceptually clear definitions. One of the most useful approaches, in our judgement, is that of Bachrach and Baratz who define power in terms of the ability to invoke the threat of sanctions upon another party in order to secure that party's compliance. Influence, on the other hand, has to do with securing compliance without employing the threat of sanctions, but through use of techniques of logical or moral persuasion. See, Peter Bachrach and Morton S. Baratz, Power and Poverty: Theory and Practice. London, Oxford, 1970, p. 17-38.

Because the measures which were taken on the watercourse did not sort out to what extent a particular biradari or individual farmer's score was based on or estimates of ability to control sanctions, this report consistently refers to both power and influence. There is little doubt, however, that in the case of high scoring biradaris or individual farmers, that a major portion of the score probably can be attributed to control over sanctions--power--credit, contacts with officials, ability to withhold food or animal fodder in times of shortage, and ability to threaten armed force.

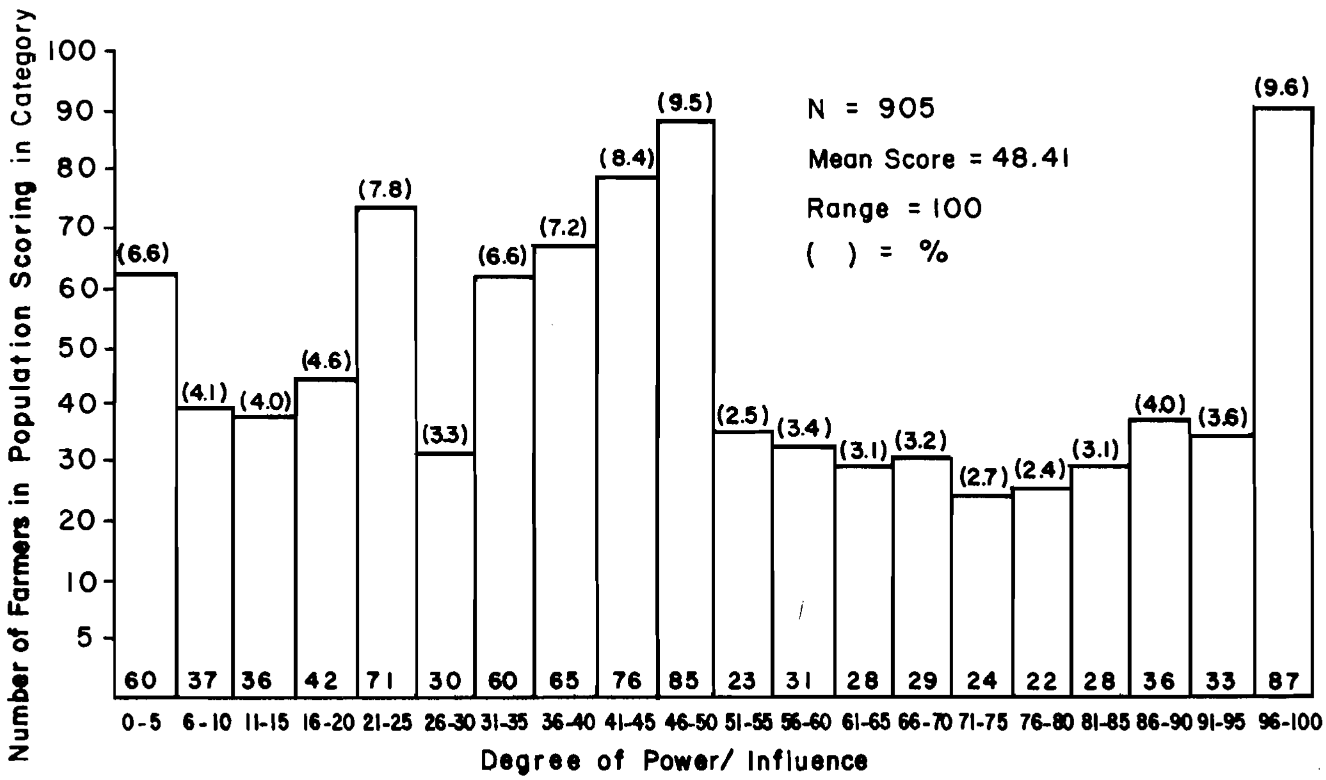

Figure 20. Distribution of Power/Influence Scores for Total Population of Farmers on Sample Watercourses.

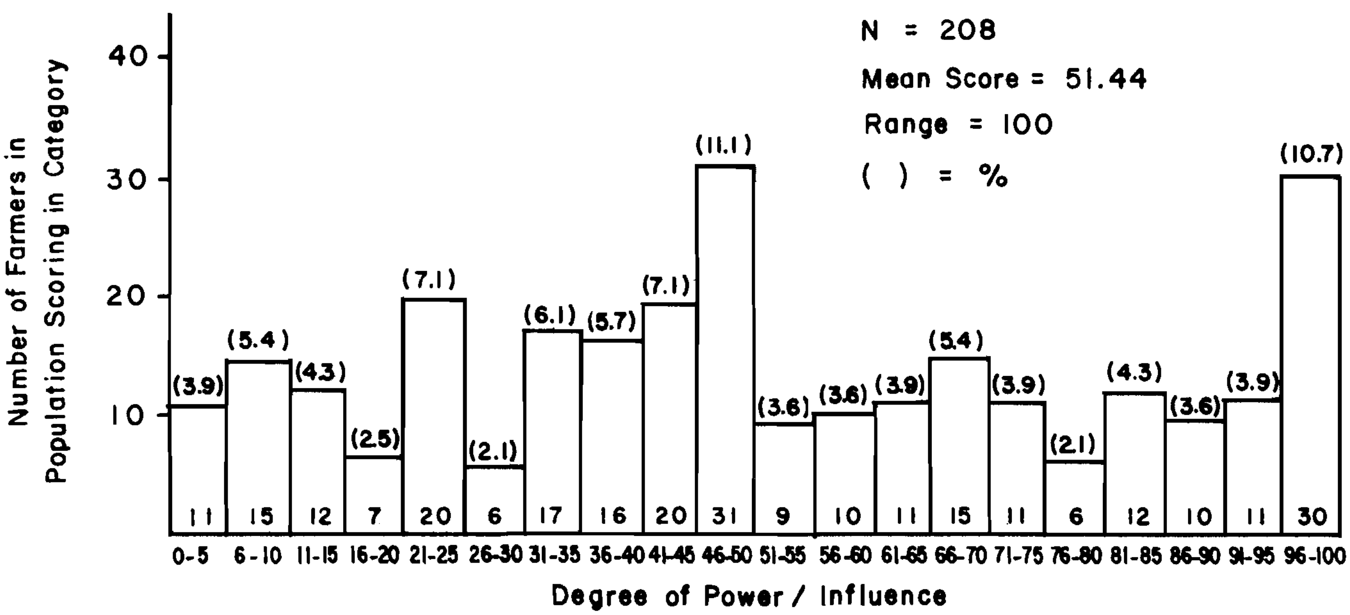

Figure 21. Sample Farmer Distribution of Power/Influence of Farmers on Sample Watercourses.

be gathered about farming operations, farmer knowledge, farmer irrigation behavior, and other personal characteristics. By exploring sample farmer data, it is possible to learn something about the characteristics of powerful and influential farmers.

Looking first across the entire sample of farmers, Table 80 shows the association between farmer power/influence scores and selected farmer characteristics. The major finding displayed is that farmer power is positively associated with size of landholdings, adoption, and access to media.[12/] Yet, there is little strength to these associations--they are uniformly weak even though the probability of the association by chance alone is low in all relationships.

A few additional comments about Table 80 are in order. More powerful and influential sample farmers have no more access to information about canal closures and schedules than do their less powerful counterparts. As a matter of fact, the correlation is negative, although it is not statistically significant. Also, it is worth noting that more powerful and influential sample farmers do not tend to have much more farm management knowledge than lower scorers on the influence scale. Although more powerful farmers tend to realize improved farm and water management techniques than do less powerful farmers, their knowledge of such techniques is very little greater. With regard to irrigation practices in the field where farmers were observed, a farmer's power is slightly negatively associated with the exercise of responsible care in applying water. Although the relationship between farmer power and careless irrigation practice is weak, it would occur by chance less

12/Since responses to the two parts of the question were identical, values for the two parts have been collapsed into one for purposes of reporting results. To avoid the clumsiness inherent in the repeated use of the hyphenated "power/influence," power and influence will be used as synonyms in the text.

Table 80. Sampe farmer power/influence by selected farmer variables.

Farmer power/influence is associated with	N	Pearson product moment correlation	Pearson r^2	Spearman rho r_s
Area owned (acres)	282	.276**	.076	.337**
Area cultivated (acres)	281	.282**	.080	.289**
Adoption index	281	.252**	.064	.229**
Access to canal information index	282	-.039	.002	-.057
Man's media access index	281	.224**	.050	.210**
Man's media exposure index	282	.206**	.042	.205*
Farm management knowledge index	282	.135*	.018	.140*
Farm management utilization index	282	.194**	.038	.183*
Irrigation responsibility index	168	-.167*	.028	-.148*
Years of education	268	.258**	.067	.235**
Water management knowledge index	282	.063	.004	.051*
Water management utilization index	282	.209**	.045	.214**

*Significant at the .01 level
**Significant at the .001 level

than one in a hundred times. Finally, Table 80 shows that more influential farmers tend to be slightly more highly educated. The relationship is weak, but would occur by chance less than once in a thousand times by random chance alone.

The biggest surprise in Table 80 is the uniformly weak relationships between the social power attributed to sample farmers and their land holdings. Table 81 shows the distribution of land holdings by farm size category as it relates to farmer power/influence. Again, one finds a modestly positive association but not the kind of relationship one expects to find in an area where land has always been thought to be a major, if not primary, source of power and influence. Why is power/influence not associated with land holding size in a much stronger way? Power is measured at the watercourse level. The meaning of any given land holding will vary from watercourse to watercourse. Conceivably, on some watercourses, a farmer with ten acres could wield substantial influence vis a vis his neighbors who own less. Yet, on another watercourse, 10 acres of land holding would be much too little given that other watercourse members own larger amounts. Therefore, the meaning of a given number of acres can vary widely among watercourses and the relationship of land to power/influence "washes out" when farmers from across the sample watercourses are analyzed as one unit. To obtain a more discriminating look at land and power, the analysis proceeds watercourse by watercourse.

Two problems are encountered in singling out watercourses individually. First, the number of sample farmers on any single watercourse is small--ranging from a minimum of 3 to a maximum of 23 (see Table 82). The second problem consists of the fact that this section

Table 81. Relationship of sample farmer power/influence to farmer landholding size

Degree of power/ influence	Farm size category (acres); ( ) = %					
	<2.4	2.5-7.49	7.5-12.4	12.5-24.9	25-49.9	50+
0-17	14 (5.0)	13 (4.6)	9 (3.2)	4 (1.4)	1 (.4)	0 (0)
18-34	12 (4.3)	8 (2.8)	9 (3.2)	8 (2.8)	3 (1.1)	1 (.4)
35-51	16 (5.7)	19 (6.7)	17 (6.0)	19 (6.7)	4 (1.4)	0 (0)
52-67	8 (2.8)	7 (2.5)	8 (2.8)	11 (3.9)	0 (0)	0 (0)
68-83	5 (1.8)	10 (3.5)	8 (2.8)	13 (4.6)	4 (1.4)	0 (0)
84-100	3 (1.1)	10 (3.5)	13 (4.6)	17 (6.0)	2 (.7)	6 (2.1)

N = 282
X^2=48.34
d.f.=25
p =<.005
C = .38

Table 82. Number of sample farmers on sample watercourses.

Mean number of sample farmers on sample watercourses	8.66
Median number	7
Modal number	7
Range	20
Minimum number	3
Maximum number	23

Watercourse N=42

Sample farmer N=282

of the report will balloon out of proportion if detailed data are presented for each watercourse. The answer to the first problem resolves the second. Those watercourses with fewer than nine sample farmers will be eliminated from the presentation leaving a subsample of 12 watercourses for consideration. Of the 12 remaining, there are 3 for which no social power data were gathered. Therefore, a subsample of nine remains for which required data exists and which afford an "n" of nine or more farmers.[13/]

Even by analyzing only selected watercourses with the greatest number of sample farmers, the relatively small "n" increases the probability that any given relationship between two variables may occur by chance alone. Table 83 displays the relationship between sample farmer power and acres of land owned. Of the 12 watercourses represented in Table 83, 6 are characterized by strong positive associations between power and land owned.[14/] Two watercourses are characterized by farmers with weak but positive associations and four (watercourses 104-2; 111-1; 116-1, and

13/Note: Three additional villages with "n's" less than nine--114-1, 116-1, and 116-4, are included on Tables 83 and 84 to help shed light on cases in villages 114 and 116 wherein there exist low or negative correlations between power and land cultivated on the watercourses with a minimally adequate "n".

14/Note on reading Tables 83-90. The Pearson product moment correlation coefficient (r) expresses the strength of relationship between two variables. The value can vary from +1 (perfect positive association) to zero (no association) to -1 (perfect negative association). The "r" value, when squared (r^2) indicates the proportion of the variation in one variable which is explained by its linear association with the second variable. The "p" value expresses the probability that the "r" value could be expected to occur by chance. A p value of .01, for example, would indicate that the associated r value would be expected to occur by chance alone one time in one hundred. By convention, a given relationship (r or r^2) is said to assume statistical significance if the p value is equal to or less than .05. One should never assume that because a relationship lacks statistical significance at a high level, that the relationship must necessarily lack substantive interest or significance.

Table 83. Relationship between sample farmer power/influence and area owned.

	Power/Influence is associated with area owned	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
Village - Watercourse	103-1	16	.46	.035	.21	-.07	.394
	104-1	14	.71	.002	.50	.83	.001
	104-2	17	-.15	-.279	.02	.03	.458
	106-1	12	.38	.109	.14	.57	.026
	108-1	9	.74	.011	55	.89	.001
	111-1	11	-.16	.320	.03	.09	.39
	112-1	13	.26	.199	.07	.25	.203
	114-1	6	.97	.001	.94	.60	.105
	114-3	10	.47	.084	.22	.27	.22
	116-1	7	-.31	.247	.10	-.29	.266
	116-2	11	.59	.028	.35	.64	.017
	116-4	3	-.88	.161	.77	-.87	.167

116-4) reveal that land owned is inversely related to power/influence although weakly so in all cases there are high probabilities that these are chance outcomes. A comparison with Table 84 shows that in two of these four cases--104-2 and 116-1--the same negative or lack of relationship appears between power and land cultivated. In essence, land ownership or cultivation has little meaning for the power or influence attribution on these watercourses. However, the social networks on watercourses 111-1 and 116-4 show strong positive relationship between power and land under cultivation. Inspection reveals that these two watercourses are characterized by high tenancy. Many tenant farmers may receive relatively high power/influence scores because they cultivate large amounts of land for absentee landlords. In effect, an owner-operator may have less influence on 111-1 or 116-4 than a tenant farmer who stands in for a large landlord. Land can be associated with power and influence in at least two different ways--owners can directly benefit from the resources which land confers and tenants farming large acreages for absentee landlords can, at least in certain instances, exercise power/influence on behalf of the landlord. Overall, Tables 83 and 84 are consistent. Land owned and land cultivated are both positively associated with power/influence on the majority of watercourses.

It is possible to examine other correlates of power/influence on a watercourse by watercourse basis. Again, only a selected sample of watercourses can be employed due to the small number of sample farmers on the majority of watercourses on which data were collected. Tables 85-90 display the correlates of power/influence disaggregated to the watercourse level. Overall, the same patterns hold up as

Table 84. Relationship between sample farmer power/influence and acres of land cultivated.

	Power/Influence is associated with total acres of land cultivated	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
Village - Watercourse	103-1	16	.54	.016	.29	-.12	.33
	104-1	14	.76	.001	.58	.83	.001
	104-2	17	-.14	.294	.02	-.03	.459
	106-1	12	.33	.146	.11	.57	.026
	108-1	9	.70	.018	.49	.45	.112
	111-1	11	.62	.022	.38	.27	.214
	112-1	13	.84	.001	.71	.71	.004
	114-1	6	.97	.001	.94	.35	.250
	114-3	10	.14	.346	.02	.35	.161
	116-1	7	-.64	.463	.00	.01	.493
	116-2	11	-.17	.309	.03	-.23	.247
	116-4	3	.99	.006	.98	1.0	.001

Table 85. Relationship between farmer power/influence and distance from the mogha.

Power/Influence is associated with distance from mogha		N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
Village - Watercourse	103-1	0	-	-	-	-	-
	104-1	8	.38	.179	.14	.78	.012
	104-2	14	-.02	.477	.00	.08	.389
	106-1	7	-.66	.053	.44	-.70	.042
	108-1	4	-.13	.434	.02	-.20	.401
	111-1	11	.21	.272	.04	-.15	.335
	112-1	13	.33	.133	.11	.49	.044
	114-1	6	-.18	.368	.03	-.14	.394
	114-3	10	.62	.029	.38	.54	.053
	116-1	5	.26	.334	.07	-.05	.468
	116-2	9	-.50	.086	.25	.50	.088

found in the pooled data for all watercourses. It might be speculated that social influence would be associated negatively with distance from the mogha--either because more powerful farmers would seek the advantages of being proximate to the mogha or because the inherent advantages of being close to the source of supply is in itself a source of social power. Table 85, however, refutes this notion--save for two cases, 116-1 and 116-2 where the influentials do tend to be located toward the mogha. However, watercourse 114-3 shows the opposite relationship; the greater the distance from the mogha the greater the influence. In 7 of the 11 watercourses on Table 85 there is no relationship between power and watercourse location.

Is power/influence associated with years of education? Only in two of the nine cases represented in Table 86; for the most part the relationships are either negative (104-2) or nonexistent.

Do sample farmers who are judged to be more powerful have more farm management knowledge than their less influential counterparts? Only in three cases are strong positive associations revealed between power and farm management knowledge--112-1; 114-1; and 116-1; (see Table 87). Strong negative relationships appear between these variables as shown in the cases of 104-1 and 104-2. For the most part, knowledge of good farm management practices is only weakly related to power and these weak relationships have high probabilities of occuring by random chance. Overall, there is little basis for concluding that there is any relationship between farmer power and farm management knowledge.

If, on most watercourses, farm management knowledge is not strongly associated in any positive manner with social power, one might expect that there would be little association between power and irrigation

Table 86. Relationship between farmer power/influence and years of education.

Power/Influence is associated with education (Village - Watercourse)	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
103-1	16	.16	.283	.03	.15	.288
104-1	14	.34	.120	.12	.37	.096
104-2	17	-.55	.011	.30	-.41	.051
106-1	12	.36	.124	.13	.67	.009
108-1	9	.69	.024	.48	.53	.071
111-1	11	.77	.003	.59	.55	.039
112-1	13	.08	.404	.01	.23	.223
114-1	4	-	-	-	-	-
114-3	10	-.29	.205	.08	-.18	.315
116-1	7	-	-	-	-	-
116-2	8	-.01	.487	.00	-.14	.361

Table 87. Relationship between sample farmer power/influence and farm management knowledge.

Power/Influence is associated with farm management knowledge	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
Village - Watercourse						
103-1	16	.21	.218	.04	-.03	.459
104-1	14	-.70	.003	.49	-.73	.002
104-2	17	-.43	.043	.19	-.44	.040
106-1	12	.27	.197	.07	.43	.084
108-1	9	.35	.179	.12	.43	.126
111-1	11	.32	.165	.10	.22	.260
112-1	13	.50	.041	.25	.39	.094
114-1	6	.59	.108	.35	.31	.273
114-3	10	.34	.168	.12	.15	.342
116-1	7	.61	.071	.37	.52	.117
116-2	11	.08	.407	.01	.34	.152

efficiency. In essence, this expectation is confirmed by Table 88. There is no significant positive relationship between farmer influence and mean farmer delivery efficiency weighted by the quantity of flow at the mogha outlet. Higher power scores among sample farmers are associated negatively, if at all, with irrigation responsibility (see Table 89). Farmers were observed during their actual irrigation turn and their behavior was recorded making it possible to construct scores reflecting the care exercised (see irrigation responsibility index, Volume VI, Appendix 2). For those nine watercourses for which data exist, and for which the number of sample farmers observed is minimally acceptable, there is no relationship between power and responsibility in three cases; and there is a strong negative relationship approaching statistical significance in five cases. In only one case (114-3) do the more powerful sample farmers display a propensity to be more responsible irrigators.

Yet, sample farmers who are reputed to be more influencial do tend to score higher on the adoption index. On the whole such farmers may not possess more farm management knowledge, but they are more prone to adopt improved implements, seeds, and practices in 9 of the 11 watercourses for which data is displayed on Table 90.

In sum, then, individual power/influence on watercourse social units tends to be strongly associated with land ownership and/or cultivation in the majority of instances, more powerful farmers tend to have greater propensities to adopt innovations. They have only a slight tendency to have experienced more education, and that tendency is strongly reversed in specific watercourse units. On the majority of watercourses for which data exist, farmer power is either unrelated or

Table 88. Relationship between farmer power/influence and weighted mean farm delivery efficiency.*

Power/Influence is associated with weighted mean farm delivery efficiency (Village - Watercourse)	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
103-1	2	-	-	-	-	-
104-1	8	-.01	.497	.00	-.07	.431
104-2	12	-.37	.120	.14	-.36	.123
106-1	6	.36	.243	.13	.33	.259
108-1	4	.47	.264	.22	.40	.301
111-1	11	-.20	.282	.04	-.25	.228
112-1	13	-.17	.291	.03	-.21	.247
114-1	5	.19	.378	.04	.00	.500
114-3	10	.30	.202	.09	.18	.311
116-1	5	.37	.272	.14	.15	.403
116-2	8	.44	.137	.19	.18	.332
116-4	3	.31	.399	.10	.50	.334

*Weighted on mogha Q

Table 89. Relationship between farmer power/influence and irrigation responsibility index.

Power/Influence is associated with irrigation responsibility (Village - Watercourse)	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
103-1	1	-	-	-	-	-
104-1	6	-.01	.493	.00	-	-
104-2	8	.03	.469	.00	-	-
106-1	1	-	-	-	-	-
108-1	2	-	-	-	-	-
111-1	10	0.42	.114	.17	-.46	.091
112-1	12	0.46	.064	.21	-.24	.232
114-1	6	-.70	.059	.49	-.17	.375
114-3	10	.64	.021	.41	.72	.009
116-1	6	-.64	.084	.41	-.72	.055
116-2	8	-.40	.166	.16	-.21	.312
116-4	3	-.55	.313	.30	-.50	.334

Table 90. Relationship between sample farmer power/influence and adoption of innovations.

	Power/Influence is associated with adoption	N	Pearson product moment correlation	P=	Pearson r^2	Spearman rho r_s	P=
Village - Watercourse	103-1	16	.61	.006	.37	.39	.06
	104-1	14	.55	.020	.30	.68	.004
	104-2	17	-.17	.254	.03	-.30	.119
	106-1	12	.49	.052	.24	.61	.019
	108-1	9	.65	.030	.42	.40	.143
	111-1	11	.55	.040	.30	.26	.222
	112-1	13	.48	.048	.23	.56	.024
	114-1	6	.88	.011	.77	.20	.350
	114-3	10	.47	.086	.22	.33	.180
	116-1	7	.77	.022	.59	.66	.054
	116-2	11	-.25	.234	.06	.26	.223

inversely related to farm management knowledge. There is no overall tendency for influential farmers to be located toward the head of watercourses, they do not obtain higher farm delivery efficiencies and there is some probability that they are distinctly less likely to be careful in their irrigation behaviors as measured by the irrigation responsibility index.

Individual farmer power/influence analysis reveals something about the attributes of particular farmers, but now it is possible to proceed to an analysis of watercourse network characteristics. We approach the watercourse network, as distinguished from the individual farmer, with two concepts:

a. Centrality of power--a dimension which tells what percentage of farmers on a given watercourse score some specified amount of the potentially highest influence score--90%+, 80%+, 70%+, 60%+, 50%+. The definition and methodology for calculating "centrality" is presented in Volume VI, Appendix 2. Obvisously, farmers who score 90%+ of the potential score are more "central" in the watercourse decision network than are farmers who score 30% of the potential. The centrality dimension reveals how many influentials at what levels (90%+, 80%+, 70%+,--50%+) are present in a watercourse network ranked cummulatively downward. It is conceivable that everybody on a watercourse could score high or low on the measure--e.g., on watercourse "x", zero percent of the farmers might score fifty or more percent of the potentially highest power/influence score, whereas on watercourse "y", all of the farmers might score in excess of fifty percent of the potential.

The centrality score for watercourse "x" would therefore be zero and for watercourse "y" would be 100--at the 50% level.

b. Equality (concentration) of power/influence--a dimension which defines the extent to which power/influence is distributed equally among farmers in the watercourse network. The methodology is discussed in Volume VI, Appendix 2. This score answers the following question: If one proceeds downward from the top of a ranked frequency distribution of farmer power/influnce scores, how many farmer scores does it take, when summed, to equal or exceed 50 percent of the sum of all scores. A condition of greatest possible equality will be obtained if it takes exactly the top 50 percent of farmer scores to equal 50 percent of the sum of all farmer scores. A condition of greatest possible inequality will occur if it only takes the top single farmer's score to equal or exceed 50 percent of the total scores--something which will occur when many farmers are given low or zero ratings.

Whereas an equality score may reveal equality when all farmers are equally weak or when all are equally powerful, it must be employed in conjunction with the centrality score which reveals the degree to which there is weakness or strength along a sample watercourse.

Watercourse level data for power centrality and equality are presented in Table 91 for all watercourses except the three in village 107 for which no influence data were collected. Table 91 data are graphically arrayed in Figures 22 and 23.

As a watercourse network attains scores which move it vertically on the grids, a greater percentage of the watercourse population of

Table 91. Power/influence centrality and equality scores by sample watercourses.

Village watercourse	N*	Centrality score 80%	Centrality score 50% +	Equality score
101-1	16	12	44	37
101-2	28	18	25	21
102-1	34	12	35	32
103-1	16	6	69	50
104-1	63	55	77	27
104-2	64	52	72	27
104-3	18	25	60	39
105-1	17	18	53	35
106-1	39	38	68	38
107-1	-	-	-	-
107-2	-	-	-	-
107-3	-	-	-	-
108-1	40	15	42	25
109-1	29	27	45	31
109-2	19	26	58	37
110-1	29	3	17	41
110-2	28	29	75	39
111-1	35	0	11	26
111-2	13	23	31	23
112-1	28	0	7	21
112-2	8	0	12	12
112-3	23	4	4	26
113-1	15	87	87	47
113-2	22	27	32	27
113-3	21	14	76	43
114-1	21	5	5	9
114-2	28	43	68	35
114-3	42	5	12	29
114-4	29	3	10	45
115-1	24	21	33	25
115-2	33	15	48	30
115-3	24	4	21	33
115-4	14	0	7	21
115-5	12	8	8	25
115-6	12	42	50	33
116-1	26	4	12	46
116-2	22	23	50	36
116-3	19	0	100	53
116-4	8	25	75	37

*NOTE: Because sample farmers estimated the power/influence for all watercourse farmers, the 'n' for each watercourse equals the population of farmers on the watercourse. Therefore, the centrality and equality scores are constructed from data on the entire watercourse farmer population, not just sample farmer data.

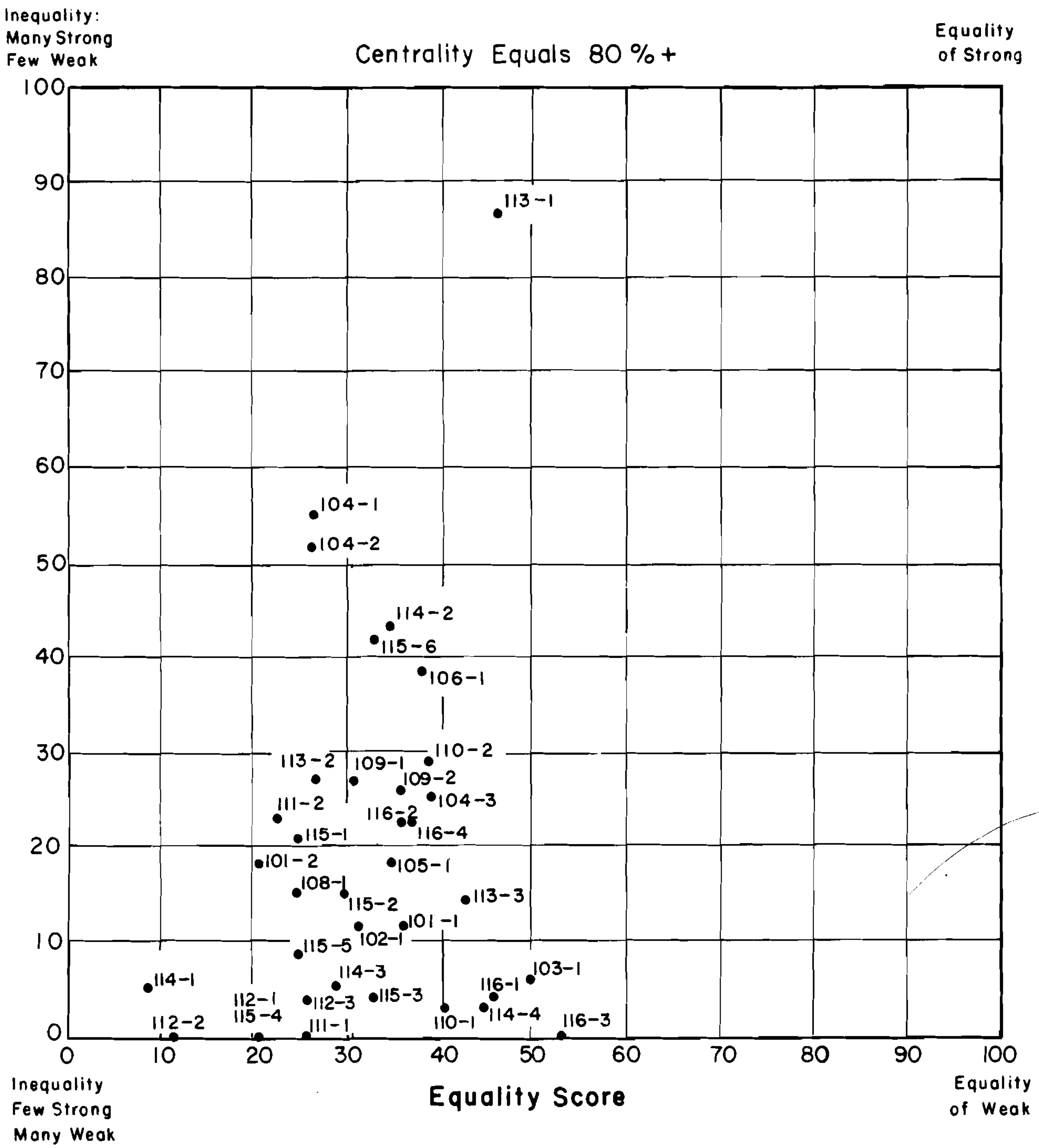

Figure 22. Distribution of power/influence on watercourses representing 15 villages.

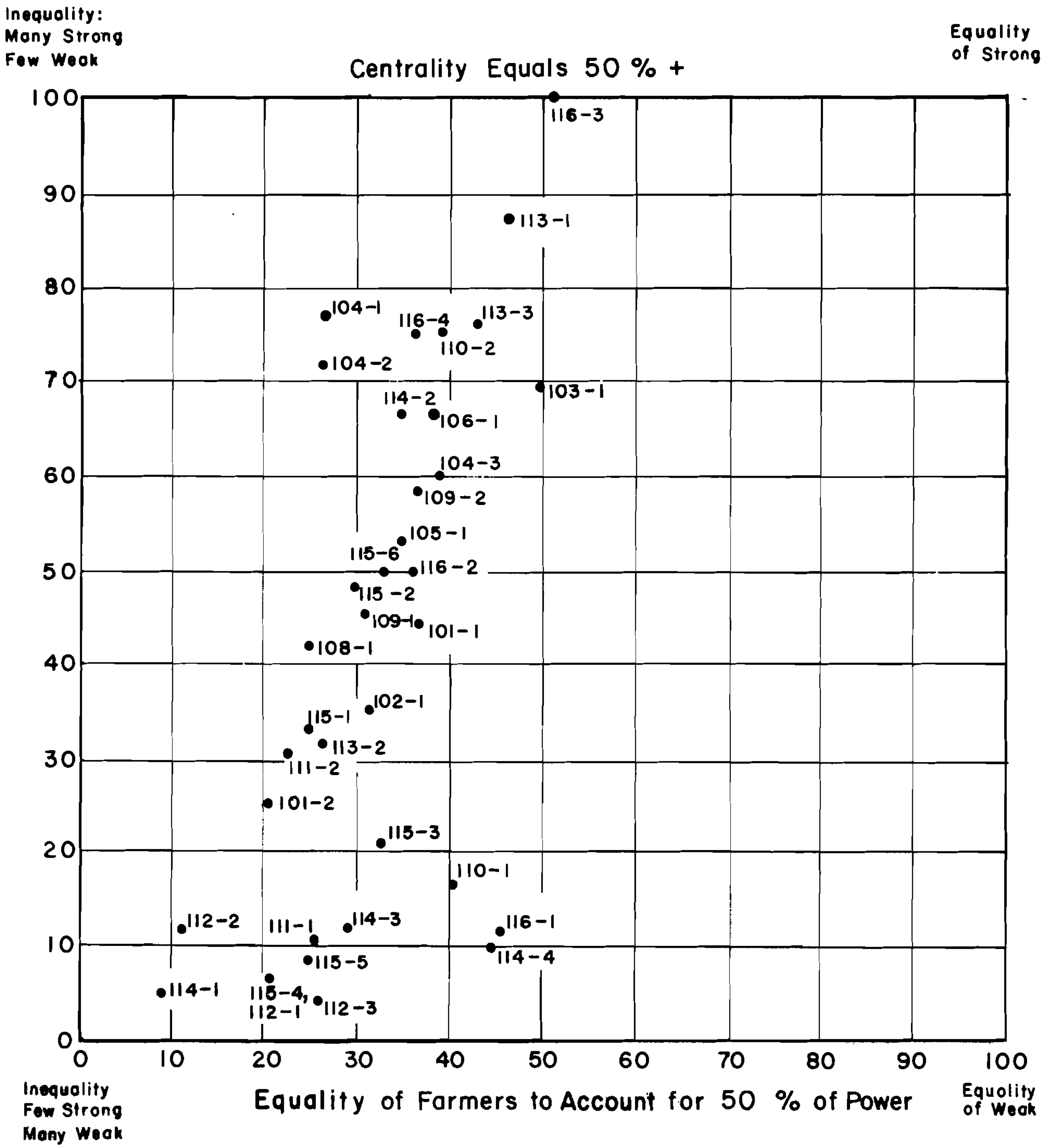

Figure 23. Distribution of power/influence on watercourses representing 15 villages.

farmers score 80 percent or more their potential power score (Figure 22) or 50 percent or more as on Figure 23. As a network moves horizontally toward the right, greater equality of power distribution is indicated. The four corners of the grid represent extremes of four possible combinations of centrality and equality. A watercourse social network placed on the upper left of the grid would have many farmers scoring highly on the power/influence measure, but there is also substantial inequality as determined by the fact that it takes relatively few of the most powerful farmers to account for 50 percent or more of the power/influence attributed to farmers on the watercourse.

Watercourses approaching the upper right of Figure 22 and 23 represent a combination of powerful farmers who are roughly equal in power. Here we find the equality of the strong. The lower left sector of the grids, however, represent those watercourse networks wherein only a few powerful dominate the many weak in a context of great inequality. Here only a few farmers score 80 percent of their potential or more on Figure 22, or, in the case of Figure 23, only a few score more than 50 percent of their potential. The lower right quadrant reflects a combination of attributes such that there are few or no farmers who achieve more than 50 or 80 percent of their potential on the power score, but there is relative equality among the powerless.

As village watercourse systems move on the diagonal from the lower left designating great inequality where only a few farmers achieve high centrality and where only a few account for 50 or 80 percent of the attributed power to the upper right of Figures 22 and 23, one would expect more receptivity of the social networks to farm water management organizational efforts. The underlying premise is that organization building efforts will be more productive and sustainable when members can mutually sanction each other as opposed to those situations of great inequality in which the "weak" have little chance to effectively sanction the strong. In such conditions, the weak can only withdraw as much as possible from entanglement with the strong--something which undercuts effective organizational participation. Granted, networks on the lower left, because they are dominated by the few, could be moved to organization effort by the will of a few highly central leaders. But, because the few powerful can violate organizational rules with relative impunity, the less powerful will have little incentive to sacrifice for the organization. The "weak" may be coerced into organization efforts initially, but, knowing that they cannot police the minority of the strong, they tend to have greater disincentives to long term organizational commitment and participation.

In networks with characteristics represented on the upper right sectors of the grids, initial organizing efforts can be expected to be more problematic as there is greater opportunity for any sub-set of farmers to exercise "veto power" over opponents who emerge across any given conflict cleavage. But if conflict cleavages can be kept depolarized, it can be hypothesized that a condition of many highly central farmers of relative equality can provide the social base for effective long term organizational success. Overall, therefore, the working hypotheses are:

a. The more a watercourse social network takes on the properties of the lower left hand sector on Figures 22 and 23 the more dependent organizing efforts will be on the support of the few powerful farmers who, if persuaded about the advantages of water management improvement programs are in a position to quickly initiate programs but such farmers will face increasingly serious problems of organizational functioning. Even scrupulous observance of organizational rules by the powerful will not overcome the suspicions and reluctance of the less powerful to cooperate fully on a sustained basis.

b. The more watercourse social networks take on the properties of the upper right hand sector, the greater the potential for any existing conflict cleavages to be divisive and to compromise organizing efforts, but if divisive conflict is not present or is overcome, the greater the potential for sustaining continuously adaptive and viable organizations.

The importance of further research to test and refine these general hypotheses cannot be over-emphasized. It must be clear that these hypotheses are not confirmed by research to date--they are only suggested by it. Additional research must be undertaken. One promising way to proceed would be to select a sample of social watercourses or village units including those violating the criteria of power and conflict and those conforming to the criteria. Then researchers could compare the dynamics of organization building in each sub-sample. Organizational efforts could be attempted in each sub-sample under controlled conditions to test the null hypotheses that conflict and power criteria have no effect on farmer propensity to organize effective local water management organizations. The working hypothesis is that organizations will be more quickly established and more effective in social networks which are not polarized by conflict, which have more equal power distributions, and a stronger base for leadership as measured by power centrality. But it will take systematic research to establish that the suggested criteria are appropriate guides to planned organizational development in water management.

What preliminary evidence can be brought to bear on the hypotheses that power distributions are important for the problem of organizing farmers for improved water management? Some tentative insights can be provided by comparing two existing sub-samples of watercourse social networks. Five networks represent the upper right quadrant of Figures 23--116-3; 113-1; 113-3; 110-2; and 104-1. This is to say that each water-course network is characterized by a high level of centrality and equality in the power distribution. This sub-sample is called the "pluralist" group. On the other hand, five watercourse systems from the lower left quadrant can be selected to represent the opposite characteristics of few farmers possessing much centrality and of great inequality in the power distributions. The villages selected for this highly stratified sample are 112-1; 112-3; 114-1; 115-4; and 115-5; they are labeled "elitists."

To first gain an overview of the landholding characteristics of the "pluralists" and "elitists", Table 92 displays the distribution of tenancy status and range of land ownership sizes in the two watercourse sub-samples. Since land is highly associated on watercourses with power, it is no surprise to see that among the pluralist sub-sample there is a much higher percentage of owners and relatively fewer tenants than exist in the elitist sub-sample. In addition, one sees on Table 92 that the elitist sub-sample is characterized by a greater range from the smallest to largest farmer than is the pluralist sub-sample.

Table 92. Distribution of tenancy status and range of land ownership size area.

	N	Pluralist	N	Elitest
Tenancy				
Owners	35	79.5%	26	57.8%
Owner-tenants	3	6.8%	10	22.2%
Pure share tenants	6	13.6%	9	20.0%
Land ownership				
Largest farm	41	38.2 ac	45	155.8 ac
Smallest farm	41	7.2 ac	45	5.4 ac

Table 93. Pluralist and Elitest watercourse sub-samples as compared by differences in mean irrigation water losses.

	N	Pluralist Mean loss/ 1000 ft	N	Elitest Mean loss/ 1000 ft	t value	One-tailed probability
Water loss per thousand feet of watercourse	35	18.0	43	29.3	-2.0	.02

It can be contended that watercourse cleaning and maintenance require cooperation, and that cooperation is facilitated by at least rough equality among farmers. Given great inequality in a relationship, smallness creates incentives to withdraw as much as possible from relationships which can become exploitive to the disadvantage of the less powerful. Sustained cooperation can be increasingly difficult to maintain as inequality of the cooperators increases--at least under conditions where the less powerful party has opportunities to withdraw from cooperation. One indirect indicator of effective cooperation in watercourse cleaning is water loss per thousand feet of watercourse. Table 93 reveals that, in fact, the pluralist sub-sample of watercourses have water losses significantly lower than the elitest sub-sample. There is a possible spurious association here--other uncontrolled variables may account for the difference in water losses, but the hypothesis that power distributions affects willingness to engage in cooperative action is worthy of further investigation.

Proceding further, one might expect that farmers in pluralist networks might more energetically seek and obtain knowledge about improved farming operations. Table 94 shows that, among farmers sampled, this is the case. Farmers living and working in networks characterized by pluralism--greater centrality and equality--do obtain significantly higher average farm management knowledge index scores than do sample farmers living in elitest social networks.

Because great differences of power and influence between farmers in a social network can be associated with exploitation of the weak by the powerful and can be associated with inequality in access to services such as extension, credit, and improved seeds and fertilizers one might

Table 94. Pluralist and elitest watercourse sub-samples as compared by differences in mean farm water management knowledge index scores.

	N	Pluralist mean score	N	Elitest mean score	t value	One-tailed probability
Farm management knowledge index	41	11.2	45	8.5	2.1	.02

Table 95. Pluralist and elitest watercourse sub-samples as compared by differences in mean crop yields per acre.

Yield in maunds/acre	N	Pluralist (maunds)	N	Elitest (maunds)	t value	One-tailed probability
Wheat	36	20.5	36	16.9	1.7	.04
Rice	19	19.7	4	9.7	1.6	.05

expect the sub-sample of social networks which are pluralist in nature to be more productive as measured by crop yields per acre. Table 95 reveals exactly that for both wheat and rice although caution is in order about drawing conclusions in the case of rice because of the small number of rice farmers in the sample. Might the differences in yields per acre be attributed to water availability? Table 96 contains the data about the differences among the pluralist and elitist sub-samples for two indicators of water availability:

a. Farm delivery efficiency which measures the amount of water lost between the watercourse inlet (mogha) and the farm where the irrigation evaluation was taken.

b. A composite variable that combines the number of private tubewells on a watercourse with an additional weighted factor when a public tubewell is present.

Means for farm delivery efficiency and presence of tubewells show little difference between pluralist and elitest sub-samples.

Unfortunately the limits of the study did not permit time series measurement of surface water discharge rates that could be related to crop yields. Consequently, water availability and its relationship to yields must remain inconclusive. But, on the basis of the above data on delivery efficiency and presence of tubewells, one can draw a tentative conclusion: While the pluralist and elitest sub-samples of farmers reveal little difference in delivery efficiency or tubewell water availability farmers in pluralist social networks produce significantly greater yields of wheat and rice per acre. Pluralist farmers tend to apply more nitrogen fertilizer than do the elitist, but the differences are not great (see Table 97). Yet, "pluralist" farmers may produce

Table 96. Pluralist and elitest watercourse sub-samples as compared by differences in mean scores on water availability indicators.

	N	Pluralist	N	Elitest	t value	One-tailed probability
Farm delivery efficiency	35	52.8	44	51.7	.23	.41
Tubewells present (public & private)	41	0.34	46	0.33	.11	.45

Table 97. Pluralist and elitest watercourse sub-samples as compared by differences in mean pounds of organic fertilizer applied to wheat and rice.

	N	Pluralist	N	Elitest	t value	One-tailed probability
Nitrogen applied to wheat	38	51.4	43	46.6	.6	.27
Nitrogen applied to rice	26	43.1	7	7.3	2.9	.001
Phosphorus applied to wheat	38	6.7	43	17.2	-2.2	.92
Phosphorus applied to rice	25	0	11	0	0	0

more per acre because they have, on the average, not only more farm management knowledge (Table 94) but they also tend to adopt improved seed varieties of wheat and rice to a significantly greater extent than farmers in elitest social networks (see Table 98).

In sum, then, the material in this chapter has suggested that social organizational variables are critical to effective local water management. Improved watercourses, to increase delivery efficiencies and reduce waterlogging, represent collective goods which can only be constructed and maintained by farmers organized to control the potential free rider who would rationally seek to secure benefits of watercourse improvement without paying a proportionate share of the costs. Sample villages do not have formal organizations to provide mosques and schools but rely on informal social pressure operating within and among biradari (brotherhood) groups to secure a minimum flow of resources to these community enterprizes. When biradari mechanisms fail to control conflict, farmers have no other local organization to which to turn for conflict resolution. They are faced with the unhappy alternatives of spending resources locally to prevent opponents from realizing their objectives, or they may spend resources to pursue conflict resolution in relatively remote agencies and courts--each option frequently drains resources from more productive purposes.

Because farmers must cooperate to form local watercourse associations to provide improved watercourses, to serve as a focus for agency technical assistance, to enhance local capacity to secure conflict resolution, the question arises as to what variables might enhance local cooperation. To explore this in a preliminary manner, two subsamples of village watercourse networks were examined--one pluralist,

Table 98. Pluralist and elitest watercourse sub-samples as compared by adoption of improved wheat and rice varieties

	N	Pluralist	N	Elitest	t Value	One-tailed Probability
Chenab 70 Wheat	41	.73	44	.41	3.1	.001
High Yielding Rice	41	.36	40	.12	2.6	.006

the other elitest--and the data tentatively suggest that those villages in which farmers enjoy the greatest centrality and equality of power are those which are the most productive and most able to sustain successful local level watercourse organization if they are not polarized by re-enforcing lines of conflict cleavages. Farmers in pluralist networks are more productive, have more water management knowledge, and suffer from less waterloss per thousand feet of watercourse. Yet, they do not enjoy any significant advantage with regard to tubewell ownership or control.

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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.

<u>Conflict Cleavage</u> - Line of division between opponents over an issue.

<u>Conveyance (Delivery) Efficiency</u> - 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.

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

<u>Cropping Intensity</u> - 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.

<u>Cropping Pattern</u> - The combination and sequence of crops grown on a given farm over a year's time.

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

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

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

<u>Delivery Efficiency</u> -- See Conveyance Efficiency.

<u>Delta</u> - Amount of water applied for an irrigation.

<u>Depth of Application</u> - 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.

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

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

<u>Distributary</u> - 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.

<u>Duty</u> - The area irrigated per unit of water per season of the year.

<u>Evaporative Moisture Deficit</u> - Estimated annual atmospheric evaporation.

<u>Evapotranspiration</u> - 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 North West 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